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WEED CONTROL IN TRANSPLANTED AND DIRECT SOWN BRASSICA CROPS

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Summary Experiments are described in which trifluralin, propachlor, nitrofen, C7019 and simazine were evaluated for weed control in direct drilled and transplanted brassica crops. Trifluralin incorporated before sowing or transplanting the crop was by far the best herbicide on a weed population in which Fumaria officinalis, Stellaria media and Chenopodium album were the species of major importance. Propachlor, C7019, and simazine were in general much less effective, while nitrofen alone or mixed with chlorpropham was intermediate. None of the herbicides adversely affected the growth of transplanted crops but they all gave occasional minor checks to direct drilled crops.

INTRODUCTION

Following promising reports at the 8th British Weed Control Conference on the efficiency and safety of propachlor and trifluralin for weed control in brassica crops in England and Ireland, these herbicides were examined under conditions in the east of Scotland. Simazine and C7019, (2-azido-4-isopropylamino-6-methylthio-s triazine) were also tested and nitrofen alone or in mixture with chlorpropham was used as a standard herbicide treatment in a number of experiments.

METHODS AND MATERIALS

All the experiments were carried out on a medium sandy clay loam soil using randomised block designs with four replicates of each treatment per block. Trifluralin was incorporated to 2 in. depth by rotovation not more than 3 days before the crop was sown or transplanted. All other herbicides, with the exception of nitrofen in the transplanted sprout experiment were applied within a few days after sowing or transplanting the crop. Herbicide treatments are given in the text or in the appropriate tables. Weed counts were made on 2 or 3 x 1 yd^2 quadrats/plot and regular visual assessments of percentage weed control were made. Crops were scored for vigour on a 0-10 scale (10 = normal healthy crop, 0 = no crop) and germination counts made on 2 whole rows/plot. Each plot was 6 ft wide and crop records were taken on 2 adjacent rows/plot. Row length ranged from 11 ft - 25 ft, depending on the crop and there were guard rows on either side of the recorded rows. All doses are given as lb or oz/ac a.i.

RESULTS

Experiment 1 Cabbage (cv. Winter Monarch) sown on 27th April, 1967 was treated with trifluralin at 1 and 1½ lb/ac and with propachlor at 3.9 and 5.85 lb/ac. Trifluralin controlled the major weeds better than propachlor, and by 31st May still gave 94% weed control at the 1 lb rate; the two propachlor treatments were scored 72% and 75% at this time. Propachlor at either rate did not control Fumaria officinalis nor did it effectively control either Stellaria media or Chenopodium album. The control plots were hoed later that day (31st May) and those treated with propachlor at both doses were hoed just over two weeks later. Both sets of plots had to be hoed again on 4th July to control Stellaria media and Poa annua which had re-rooted. Plots treated with trifluralin at both doses required only one light hoeing on 4th July to control large plants of Capsella bursa-pastoris - virtually the only weed species on these plots. The 50% higher rates of trifluralin and propachlor gave no worthwhile increase in range or duration of weed control over the standard rates. There were no significant differences between the herbicide and the control treatments in germination counts, weight of cabbage cut per acre or average weight per cabbage. (Table 1)

Table 1

Expt. 1 - Germination count and yields of marketable cabbage

Treatment	Dose lb/ac a.i.	Germination count/ yd row	Wt Cabbage cut tons/ac	Average wt per cabbage oz
Control	-	27.5	26.9	48.3
Trifluralin	1.0	33.3	29.6	49.8
Trifluralin	1.5	23.1	27.9	49.0
Propachlor	3.9	32.1	26.3	42.8
Propachlor	5.85	27.6	27.9	49.8
Sig. diff. (P = 0.05)		NS	NS	NS
Coeff of variation %		23.8	10.9	15.1

Experiment 2 Cabbage (cv. Winter Monarch), Brussels sprouts (cv. Cambridge Special) and cauliflower (cv. All the Year Round) were drilled in transplant nursery beds on 21st April, 1967. Each herbicide plot was split to give 4 rows of each crop. Treatments are shown in Table 2. The control plots were hoed on 1st June. All the herbicide treatments gave acceptable weed control until the crop was lifted for transplanting on 21st June. Scores of percentage weed control on the herbicide treatments at transplanting were nitrofen - 76%, trifluralin - 95%, propachlor - 75% and C7019 - 81%. Plots treated with trifluralin were again by far the best with only a few plants of Capsella bursa-pastoris, Trifolium repens and Senecio vulgaris present. Nitrofen and propachlor did not give adequate control of

Stellaria media and a few plants of this species also survived on plots treated with C7019. Fumaria officinalis and Polygonum convolvulus were resistant to propachlor and C7019 and the latter did not completely control Poa annua. Germination was very uneven, particularly in the cauliflower and although there was an indication (Table 2) that nitrofen reduced plant

Table 2

Expt 2 - Germination counts 6/6/67 and vigour scores 16/6/67

Treatment	Dose lb/ac.a.i.	Cabbage		B. Sprouts		Cauliflower	
		G	V	G	V	G	V
Control	-	98	10.00	110	10.00	141	9.25
Nitrofen	3.0	67	9.25	84	8.00	117	8.50
Trifluralin	1.0	93	10.00	101	10.00	140	8.75
Propachlor	3.9	70	9.00	104	8.75	139	8.75
C7019	2.0	83	8.00	90	8.50	89	5.75
Sig.Diff. (P = 0.05)		NS	1.03	NS	1.00	NS	1.05
Coeff of variation %		22.3	7.3	22.6	7.4	26.4	8.4

G - Germination count/9 ft row length
V - Vigour 0-10 (10 = normal healthy crop, 0 = no crop)

numbers in all crops, that C7019 did so in cauliflower and propachlor in cabbage, there were no significant differences between any of the herbicide treatments and the untreated controls. A similar trend occurred in scores of crop vigour taken just before transplanting. All crops treated with C7019, particularly cauliflower, were significantly reduced in vigour. Brussels sprouts were significantly checked by nitrofen and also by propachlor. Trifluralin had no adverse effects on any crop. A representative selection of plants from each plot was transplanted into clean ground at 2 x 2 ft spacing to see whether plants could out-grow any initial check due to herbicides. Once the plants had recovered from the initial shock of transplanting, they all grew away vigorously and by harvest time no visible treatment effects could be detected, nor were there differences in weight of cabbage cut, weight of sprout plants, yield of sprouts harvested or size and quality of cauliflower curd.

Experiment 3 Cabbages (cv. Winter Monarch) were transplanted on 26th June 1967 and herbicide treatments applied the next day. Double rates of simazine and C7019 were included to assess the tolerance of the crop. (Table 3). Control plots rapidly became very weedy and were hoed on 5th August. The two simazine treatments and 2 lb/ac C7019 had fallen to 65% by 17th August and were hoed that day. The main weeds on these plots were Stellaria media, Chenopodium album and Fumaria officinalis. Plots treated with trifluralin or 4 lb/ac C7019 remained at around 90% weed control until harvest and did not require supplementary hoeing.

At harvest on 12th January, there were no significant differences between treatments in weight of cabbage cut/plot, or average weight per cabbage (Table 3).

Table 3

Expt 3 - Transplanted cabbage 1967 - harvest yields

Treatment	Dose lb/ac.a.i.	Wt. cabbage cut/plot. tons/ac	Wt/cabbage oz
Control	-	26.0	59.9
Trifluralin	1lb	25.2	59.2
Simazine	6oz	25.4	58.5
Simazine	12oz	27.9	63.3
C7019	2lb	26.8	63.0
C7019	4lb	25.1	59.0
Sig. diff (P = 0.05)		NS	NS
Coeff of variation %		9.2	8.4

Experiment 4 Brussels sprouts (cv. Cambridge Special) were transplanted on 8th June 1967. Trifluralin (1 lb/ac), propachlor (3.9 lb/ac) and simazine (6 oz/ac) were applied immediately after planting, but nitrofen was applied on 4th July as a post-emergence weed control treatment. A weed survey made on 18th July showed that trifluralin, with 80% weed control, was again the best closely followed by the late treatment with nitrofen, which severely checked almost all the major weed species apart from Stellaria media. This species was also poorly controlled by propachlor and simazine and together with Chenopodium album and Fumaria officinalis was the main reason for the scores of 67% and 63% respectively on these two treatments. All plots were weeded at this stage and the crop left to grow on without further competition. No visible check attributable to herbicide treatment was noted and the crop rapidly formed a light-excluding canopy. At harvest there were no significant differences between treatments in yield or size of sprouts per plant or per plot.

Experiment 5 Cabbages (cv. Winter Monarch), Brussels sprouts (cv. Irish Elegance) and a commercial strain of calabrese were drilled in transplant nursery beds on 11th April 1968. Treatments are shown in Table 4. The untreated control plots were hoed on 10th June. Weed assessments on the herbicide treatments on 27th June shortly before lifting, showed that propachlor and nitrofen plus chloropropham still gave 75-80% weed control, while trifluralin was only just adequate at 70% and C7019 had fallen to 65%. The relatively low score on the trifluralin treatment was due to the presence on the trial site of a high population of Matricaria matricarioides which proved completely resistant. Propachlor and C7019 effectively controlled this species and nitrofen plus chlorpropham checked it. There were very few other weeds on plots treated with trifluralin or with nitrofen plus

chlorpropham. Propachlor and C7019 failed to give adequate control of Stellaria media, Fumaria officinalis, Chenopodium album and, particularly in the case of C7019, Veronica persica and Poa annua.

Crop vigour scores were made on 31st May and the whole crop was lifted on 4th July and graded according to size. (Table 4).

Table 4

Expt 5 - Crop records

Treatment	Dose lb/ac.	Cabbage			B. Sprouts			Calabrese		
		V	N	%T	V	N	%T	V	N	%T
Control	-	10	214	77.6	10	178	76.6	10	165	76.7
Trifluralin	1.0	9¾	203	70.6	9¼	136	73.1	9½	147	67.1
Propachlor	3.9	8½	147	66.6	8	136	73.3	7	128	77.7
C7019	2.0	10	205	72.3	10	179	77.2	10	178	73.4
Nitrofen plus Chlorpropham	3.0 0.5	9¾	240	67.7	10	159	72.3	10	168	70.9
Sig. diff (P = 0.05)		1.3	55	5.4	1.0	NS	NS	0.9	NS	NS
Coeff of variation %		8.9	17.6	4.9	6.9	22.4	8.2	6.4	24.4	9.4

V - Vigour 0 - 10
N - Total No. of plants lifted
%T - Percentage of transplant size

Propachlor significantly checked vigour on all three crops, particularly calabrese, and also gave the lowest plant numbers, but this difference was only significant in cabbage. Plant numbers varied considerably across the experiment and there were no significant population reductions attributable to any of the other herbicides. Plots treated with trifluralin, nitrofen plus chlorpropham and particularly propachlor all gave a significantly lower percentage of cabbages of transplantable size than control plots. The reasons were, however, different. In the case of trifluralin and nitrofen plus chlorpropham most of the remainder were too small to transplant, suggesting that growth of the crop had been checked. With propachlor, on the other hand, the majority of the remainder were too large to transplant, due to the thinner stand and better individual plant growth. There was no indication in this experiment that C7019 adversely affected the germination or growth of any of the three crops.

DISCUSSION

Trifluralin This gave either the best or equal best weed control in four out of the five experiments. In the 1968 experiment it completely failed to control Matricaria matricarioides, and in others it had no effect on Capsella

bursa-pastoris, Senecio vulgaris or Trifolium repens. However, control of the major arable weeds present was excellent. No yield reductions attributable to treatment with trifluralin were obtained in any trial, and growth of seedlings was not significantly checked in any direct seeded crops except with cabbage in 1968.

Propachlor This herbicide was disappointing in its general performance, due mainly to failure to control Fumaria officinalis and incomplete control of Stellaria media and Chenopodium album. Propachlor had no effect on the yield of transplanted crops but did adversely affect growth in some crops in the two experiments with nursery beds.

Nitrofen This herbicide applied at 3 lb/ac pre-emergence either alone or with chlorpropham was usually as good as or better than propachlor in controlling the weed population. The post-emergence treatment at 1 lb/ac on Brussels sprouts was extremely effective in keeping the weeds below the crop canopy. There was some evidence of crop damage in both the experiments with nursery beds.

Simazine Although this herbicide did not affect yield in transplanted Brussels sprouts or cabbage, the level of weed control, even at 12oz/ac was not adequate, due largely to the resistance of Chenopodium album.

C7019 Compared with propachlor the 2lb/ac rate was more effective on Fumaria officinalis, equally effective on Stellaria media and Polygonum spp, but very much less effective on Veronica spp. Both herbicides gave excellent control of Matricaria matricarioides. C7019 always left considerably more Poa annua on treated plots than any of the other herbicides. C7019 at 4lb/ac a.i. on the other hand, performed as well as trifluralin on transplanted cabbage without adverse effect on the crop. In the 1967 nursery experiment C7019 significantly affected vigour in all three crops, particularly cauliflower, but this effect was not repeated in 1968.

The results of these trials agree in general with the findings of research workers in other areas (Allott, 1966; Cassidy, 1966; Roberts and Wilson, 1966). All the herbicides used are occasionally liable to produce adverse effects on direct drilled crops under certain conditions not as yet fully understood and it is not possible to select one as being consistently safer than another. The local weed population will therefore be one of the major factors determining the choice of herbicide and in these trials this has favoured the use of trifluralin.

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WEED CONTROL TRIALS IN DIRECT DRILLED BRASSICA CROPS

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Summary In trials in 1967 - '68, propachlor 3.9 lb and propachlor 2.0 lb + nitrofen 1.2 lb for pre-emergence application and trifluralin 1.0 lb incorporated prior to sowing were the most selective treatments tested in drilled cauliflower, cabbage and Brussels sprouts. Cauliflower also showed considerable tolerance to post-emergence applications of propachlor and propachlor + nitrofen.

The addition of chlorpropham 0.5 lb to propachlor 3.9 lb caused severe crop check particularly on light soils but this mixture was generally less damaging and more effective than nitrofen 3.0 lb + chlorpropham 0.5 lb.

Severe crop injury and reduction in plant stand occurred in all crops with pre-emergence applications of 2-azido-4-isoproplyamino-6-methylthio-1, 3, 5-triazine (C 7019) in the dose range 2.0 - 4.0 lb. This material also showed poor selectivity as a post-emergence treatment in cauliflower. Neither 4-methylsulphonyl-2, 6-dinitro-N, N-dipropyl-aniline (SD 11831) 3.0 lb or methiuron 1.0 lb + chlorpropham 0.25 lb as pre-emergence treatments gave satisfactory weed control.

INTRODUCTION

The need for a safe, effective herbicide for pre-emergence or early post-emergence application in direct drilled brassica crops was outlined by Cassidy (1966). The position has changed little in the meantime, except that propachlor is now recommended for use as a pre-emergence or post-emergence treatment at the 3 - 4 leaf stage (Weed Control Handbook 1968). However, owing to the relatively short lived persistence of this herbicide in the soil and the resistance or partial resistance of many important weeds such as Polygonum spp., Sinapis arvensis, Fumaria officinalis and Chenopodium album, weed control in direct drilled crops is still a problem.

METHOD AND MATERIALS

Trials at Kinsealy were sited on a medium loam soil containing 25.6% clay and 6.9% organic matter. Sites in Co. Meath were also medium loams while the Carlow site was a free draining coarse sandy loam with 10% clay and 4.3% organic matter.

A randomized block design with four replicates was used except at the Meath site in 1968 where there were three replicates. Plot size was 10 x 2 or 3 yd. Sprays were applied with a pressure retaining knapsack at a volume of 40 gal/ac. All doses are given in lb/ac a.i. At least two visual assessments of treatment effect on crop and weeds were made. Plant counts or number of thinnings removed were recorded. Weight of thinnings and crop yields were also taken in some trials. Weed kill was assessed by counting survivors in a number of quadrats thrown at random in each plot.

RESULTS

Cauliflower - pre-emergence application

In 1967, seven treatments were applied immediately after sowing to a fine, reasonably moist seed bed at Kinsealy. Rainfall was less than $\frac{1}{3}$ in. in the week

following spraying with no further rain for two weeks. Treatments and results are given in Table 1.

Table 1

Effect of pre-emergence treatments on crop and weeds - Cauliflower, 1967
Var. All The Year Round drilled June 2

Treatment	Dose lb/ac	Yield tons/ac	Plant stand as % of control	Wt of thinnings as % of control	Assessments (July 7) Crop	Weeds
Propachlor	3.9	9.2	92	94	9.1	5.6
Propachlor + chlorpropham	3.9 0.5	9.6	89	105	9.2	7.9
Propachlor + nitrofen	2.0 1.2	8.5	97	108	9.4	8.3
Nitrofen + chlorpropham	3.0 0.5	9.6	102	116	8.9	8.4
Methiuron + chlorpropham	1.0 0.25	8.9	101	116	9.4	6.1
C 7019	3.0	9.6	66*	44*	5.6	9.9
SD 11831	3.0	8.6	90	80	9.1	4.4
Control (Hand-weeded)		8.7	100	100	10.0	1.9
S.E. of treatment mean (df=21)		0.8	-	-	-	-

Rating scale - Crop : 0(Complete kill) - 10(No damage)
Weeds: 0(Dense cover of weeds) - 10(No weeds)
* Significant at $P < 0.05$

C 7019 caused severe check to the crop and a significant reduction in plant stand. After thinning (5-6 leaf stage) excellent recovery occurred, and although maturity was delayed, total yield and curd size were not reduced compared to those from the hand-weeded plots. There was little difference in selectivity between the remaining treatments; all caused a slight initial check to the crop, but except for the nitrofen + chlorpropham treatment this had been outgrown three weeks after crop emergence.

The principal weeds in the trial were Fumaria officinalis, Chenopodium album, Senecio vulgaris, Poa annua and Capsella bursa-pastoris. C 7019 gave best control, plots still being almost weed free 5 weeks after treatment. Propachlor gave only moderate control; mixtures of propachlor + chlorpropham and propachlor + nitrofen were more effective. Most species except Poa were resistant or partially resistant to SD 11831. Methiuron + chlorpropham was also ineffective, Fumaria and Chenopodium being particularly resistant.

The treatments tested in 1968 are shown in Table 2. Trifluralin was rotovated-in to a depth of 2 - 3 in. prior to sowing. Although only slightly more than $\frac{1}{2}$ in. of rain fell during the week following spraying, crop check with C 7019 and chlorpropham + propachlor or nitrofen mixtures was greater than in 1967. Even at 2.0 lb, C 7019 caused severe reduction in vigour and stand and few plants survived at 4.0 lb. Good selectivity was shown by propachlor, propachlor + nitrofen and trifluralin. At the higher dose of trifluralin some check was evident in the early stages of growth.

The main weeds were as in 1967, with the addition of Stellaria media. Propachlor and propachlor + chlorpropham gave good control of all except Fumaria and Chenopodium. These were better controlled by propachlor + nitrofen, though this mixture was not as effective against Senecio and Stellaria. Nitrofen + chlorpropham gave fair to good control of all but Senecio.

C 7019 2.0 lb failed to control Capsella and had only a moderate effect on Senecio and Fumaria. Control of all species was much improved at a dose of 4.0 lb. Capsella and Senecio were also resistant to trifluralin.

Table 2

Effect of pre-emergence treatments on crop and weeds - Cauliflower, 1968
Var. All The Year Round, drilled May 15

Treatment	Dose lb/ac	Plant stand as % of control	Wt of thinnings as % of control	Assessments (July 3) Crop	Assessments (July 3) Weeds	% weed kill Senecio vulgaris	% weed kill Stellaria media
Propachlor	3.9	103	123*	9.0	7.8	100	90
Propachlor + chlorpropham	3.9 0.5	93	78	5.3	8.8	100	100
Propachlor + nitrofen	2.0 1.2	105	123*	9.3	8.0	80	55
Nitrofen + chlorpropham	3.0 0.5	103	62*	5.3	6.7	0	97
C 7019	2.0	74*	57*	5.3	6.0	53	80
"	4.0	14*	17*	0.5	9.0	93	95
Trifluralin	1.0	102	92	10.0	4.3	0	70
"	2.0	94	91	8.3	6.5	0	100
Control (untreated)		100	100	10.0	0.0	-	-

Rating scale as in Table 1. * Significant at $P < 0.05$

Cauliflower - post-emergence application

In 1967, propachlor and C 7019 were applied at different stages. A mixture of propachlor + nitrofen at the 1 - 2 leaf was also included. Treatments and results are given in Table 3.

Table 3

Effect of post-emergence treatments on crop and weeds - Cauliflower, 1967
Var. All The Year Round

Treatment	Dose lb/ac	Stage of application	Yield tons/ac	Plant stand as % of control	Wt of thinnings as % of control
Propachlor	3.9	Cotyledon	10.4	99	88
C 7019	3.0	"	2.7	26*	5*
Propachlor	3.9	1 - 2 leaf	7.7	93	74
C 7019	3.0	" " "	0.9	7*	1*
Propachlor	3.9	3 - 4 leaf	8.9	112	102
C 7019	3.0	" " "	2.0	35*	5*
Propachlor + nitrofen	2.0 0.9	1 - 2 leaf	12.9	109	100
Control (hand-weeded)			9.1	100	100
S.E. of treatment mean (df=19)			1.44		

Severe crop damage and plant kill occurred with C 7019 at all stages. This damage was particularly severe at the 1 - 2 leaf stage where over 90% of the plants were killed. The crop was also more susceptible to injury with propachlor at this stage; only slight crop check occurring at the other stages.

Very useful selectivity was shown by the mixture of propachlor + nitrofen and the highest yields were obtained with this treatment. This mixture gave more effective control than propachlor applied either at the cotyledon or 1 - 2 leaf stages.

Brussels Sprouts - pre-emergence application

In 1967, six treatments were compared at a site in Co. Meath (Table 4). Treatments were applied six days after drilling to a fine but very moist seed bed. Heavy rain immediately followed spraying and the weather remained inclement for some days afterwards.

Table 4

Effect of treatments on crop and weeds - Brussels Sprouts, 1967 -'68
Var. Sanda

Treatment	Dose lb/ac	Meath 1967 No. of thinnings[1]	Meath 1967 Assessments Crop	Meath 1967 Assessments Weeds	Meath 1968 Assessments Crop	Meath 1968 Assessments Weeds	% weed kill A	B	C	D	E
Propachlor	3.9	70*	8.0	7.0	9.2	6.5	58	48	11	38	82
Propachlor + chlorpropham	3.9 0.5	80	7.7	8.5	8.3	9.0	96	69	86	77	91
Propachlor + nitrofen	2.0 1.2	75	9.0	9.0	9.5	6.0	28	46	26	51	23
Nitrofen + chlorpropham	3.0 0.5	45*	7.2	8.5	8.7	7.3	68	61	71	69	16
C 7019[2]	3.0	36*	3.0	9.5	8.3	7.0	72	42	29	34	70
"	4.5	29*	1.5	10.0	6.4	9.2	93	78	0	79	75
Control (untreated)		100	10.0	1.5	9.0	2.7					

[1] % of control
[2] Doses of 2.0 and 4.0 lb used in 1968
Rating scale : Crop: 0(Complete kill) - 10(No damage)
Weeds: 0(Dense cover of weeds) - 10(No weeds)
* Significant at $P < 0.05$

A Stellaria media
B Chenopodium album
C P.convolvulus
D P.persicaria
E Sonchus oleraceus

Visual assessments made four weeks after spraying at the 3 - 4 leaf stage showed varying degrees of crop check and reduction in plant stand with all treatments. Two weeks later crop damage was less apparent except in plots treated with C 7019. This herbicide caused very severe injury and plant numbers were greatly reduced at both doses.

Least damage occurred with a mixture of propachlor + nitrofen. Propachlor and propachlor + chlorpropham also showed moderately good selectivity. The crop was less tolerant to an application of nitrofen + chlorpropham.

The main weeds at this site in order of prevalence were Sinapis arvensis, Chenopodium album, Polygonum persicaria, Poa annua and Stellaria media. C 7019 gave excellent control of these species. The mixture of propachlor + nitrofen was also effective; weed control was still over 80% 6 weeks after spraying. Control was less satisfactory with propachlor; Polygonum, Sinapis and Chenopodium showing resistance.

In 1968 the same herbicides were again examined on another site in the Meath area. At time of application the soil was reasonably moist and only small amounts of rain fell in the two weeks following spraying. Under these conditions crop damage with C 7019 at 2.0 and 4.0 lb was less severe than in the previous trial (Table 4). However weed control was not as effective. Visual assessment and weed counts made 6 weeks after spraying showed that poor control of Polygonum spp., and Chenopodium album was obtained at a dose of 2.0 lb. Weed control was much more effective at 4.0 lb but Polygonum convolvulus was still resistant.

Propachlor and propachlor + nitrofen, except for a slight check in the early stages, showed good selectivity. A more persistant reduction in crop vigour occurred with propachlor + chlorpropham. This mixture gave very good weed control and was equally effective to C 7019 at 4.0 lb. Less satisfactory control was obtained with propachlor and propachlor + nitrofen. Nitrofen + chlorpropham also checked the crop and weed control, particularly of Sonchus oleraceus, was not as good as with propachlor + chlorpropham.

Cabbage - pre-emergence application

In 1968, on a light soil in the Carlow area a number of treatments were examined for pre-emergence application on the variety Winningstadt. Trifluralin was applied and incorporated to a depth of 2 - 3 in. by discing 2 weeks before sowing.

Other treatments were applied five days after sowing. There was ample soil moisture at time of spraying and over 1 in. of rain fell during the following week. Treatments and results are given in Table 5. On this light soil only propachlor, propachlor + nitrofen and trifluralin 1.0 lb showed good selectivity.

Table 5

Effect of pre-emergence treatments on crop and weeds - Cabbage, 1968
(Var. Winningstadt, drilled April 25)

Treatment	Dose lb/ac	Plant stand[1]	Assessments (June 13)		% weed kill						
			Crop	Weeds	A	B	C	D	E	F	G
Propachlor	3.9	101	9.8	4.8	62	83	88	16	52	9	77
Propachlor + chlorpropham	3.9 0.5	110	5.0	8.0	81	91	92	23	95	86	95
Propachlor + nitrofen	2.0 1.2	89	9.5	6.5	82	64	37	0	95	67	73
Nitrofen + chlorpropham	3.0 0.5	51*	2.5	7.5	98	0	100	68	100	100	100
C 7019	2.0	42*	4.3	9.0	93	99	95	89	92	100	95
"	4.0	11*	1.0	10.0	96	100	100	93	100	100	100
Trifluralin	1.0	101	10.0	6.0	98	0	80	89	92	81	9
"	2.0	117	5.5	8.8	100	72	100	98	100	100	45
Control (untreated)			10.0	0.4							

[1] % of control
* Significant at P < 0.05
Rating scale : Crop: 0(Complete kill) - 10(No damage)
Weeds: 0(Dense cover of weeds) - 10(No damage)

A Chenopodium album
B Matricaria matricarioides
C Stellaria media
D Fumaria officinalis
E Polygonum persicaria
F Polygonum aviculare
G Capsella bursa-pastoris

Severe crop check and reduction in plant stand occurred with C 7019 at 2.0 lb. At a dose of 4.0 lb only a few plants survived. Plant stand and vigour were also greatly reduced with nitrofen 3.0 lb + chlorpropham 0.5 lb. Although no plant kill was obtained with propachlor 3.9 + chlorpropham 0.5 lb the crop still showed considerable check 6 weeks after spraying. Damage was similar with trifluralin 2.0 lb.

Chenopodium album and Matricaria matricarioides were the main species but Stellaria media, Fumaria officinalis, Polygonum persicaria, Polygonum aviculare and Capsella bursa-pastoris were also prevalent.

Best weed control was obtained with C 7019. On this light soil control was still satisfactory 11 weeks after spraying at a dose of 2.0 lb. Matricaria and Capsella were resistant to trifluralin but this herbicide gave good control of other species.

Because of the number of resistant weed species present, weed control was poor with propachlor. The mixture of propachlor + nitrofen was more effective but still did not give satisfactory prolonged control. The addition of chlorpropham 0.5 lb to propachlor gave much improved control particularly of Polygonum spp.

DISCUSSION

Brassica seeds, because of their uniform shape, are ideally suited for accurate precision drilling and many growers are now adopting this method in preference to transplanting. This change in production methods has highlighted the need for satisfactory chemical weed control.

The results with propachlor confirm those reported previously by Cassidy (1966) and Roberts & Wilson (1966). This herbicide usually causes a slight check to growth

in the initial stages with either pre- or post-emergence application but the crop quickly recovers and yield is not affected. However, the rather limited weed spectrum controlled by this material together with its poor contact and relatively short lived residual effect are drawbacks. The results obtained with propachlor 2.0 lb + nitrofen 1.2 lb suggest that this mixture is a suitable alternative to propachlor where Polygonum spp. are dominant.

Trifluralin 1.0 lb as a pre-sowing incorporated treatment showed excellent selectivity. This herbicide, which is now being used in transplanted crops, also appears to have considerable promise in drilled crops, a conclusion supported by the results reported by Allott (1966) on direct sown Brussels sprouts and cauliflower. The overall usefulness of trifluralin, however, is limited by the resistance of certain weeds, particularly Compositae species. Since the weed spectra controlled by trifluralin and propachlor are largely complementary, pre-sowing treatment with trifluralin plus a pre-emergence application of propachlor is suggested as an effective combination worth investigating.

The severe crop damage which occurred with C 7019 in cauliflower, cabbage and in one Brussels sprout trial clearly indicates that this herbicide is not selective enough for pre-emergence application in any of these crops. Also the severe damage following post-emergence application in cauliflower even at the 5-leaf stage raises some doubts about the safety of this material for application at earlier stages of growth in other less injury sensitive brassica crops. In these trials C 7019 gave consistently good control of a wide range of weeds but Capsella bursa pastoris, Polygonum spp. and Chenopodium album showed partial resistance in some cases.

The combination of chlorpropham with propachlor gave good weed control and was less damaging than a mixture of this herbicide with nitrofen. However the persistent crop check obtained at Kinsealy on cauliflower (Table 2) and on cabbage at Carlow (Table 5) with this mixture suggests that the addition of chlorpropham at 0.5 lb is too hazardous in drilled brassica crops. This suggestion is supported by the results obtained by Roberts & Wilson (1966) on a light soil with propachlor/chlorpropham mixtures.

Acknowledgments

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HERBICIDES ON TRANSPLANTED CAULIFLOWERS

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Summary A series of eight experiments on transplanted early summer, summer and autumn and winter hardy cauliflowers conducted between the years 1966 and 1968 on silt soils in Holland, Lincolnshire showed that trifluralin at 1 lb/ac a.i. incorporated into the soil before planting, and propachlor at 4 lb/ac a.i. applied after planting were the safest and most satisfactory herbicide treatments. Neither herbicide is ideal, because both have a limited spectrum of weed control and trifluralin has to be rotovated or disced in before planting which may cause difficulties in management.

Simazine at rates of 4 to 12 oz/ac a.i. gave very good weed control, but the higher dosages were harmful to the summer and autumn varieties. Mixtures of nitrofen and chlorpropham checked growth severely when applied to established plants, but crop damage was only slight if the application was made immediately after planting. Desmetryne at 4 and 6 oz/ac a.i. damaged eight of the eleven varieties used in the experiment, the exceptions being Canberra, Mayfare and St. George.

INTRODUCTION

Cauliflowers of all types are grown extensively on the silt lands of Holland and Lindsey, Lincolnshire and adjacent counties, and nearly all of them are raised in seedbeds and planted in the field by machine. In some locations weeds are a serious problem and the object of the series of eight experiments was to compare six different herbicides considered suitable for use on transplanted early summer, summer, autumn and winter hardy cauliflowers with respect to weed control and their effect on crop growth, date of maturity, yield and quality.

Earlier work had suggested that the herbicides selected were suitable for brassica crops including cauliflowers. Simazine was used on transplanted April Glory broccoli (winter hardy cauliflower) by Allott (1966) in Northern Ireland who found that it gave a good weed control and no crop damage at 8 and 16 oz/ac a.i., but in the same experiment desmetryne damaged cauliflower plants at the 3-4 true leaf stage. Propachlor was found safe on the early summer cauliflower No.110 by Roberts & Wilson (1966) who found that it gave good weed control and had no effect on crop yield. It was shown by Tyson & Smith (1966) that brassicae were very tolerant to trifluralin and at 1 lb/ac a.i. had no effect on the yield of cauliflower transplants. The work of Brown (1966) indicated that nitrofen alone was fairly safe to use on cauliflowers but had a poor spectrum of weed control, and that mixtures of nitrofen and chlorpropham caused damage to the crop and loss in yield.

METHOD AND MATERIALS

All the experiments were conducted at Kirton E.H.S. on a moisture retentive alluvial silt soil of very fine sandy loam texture. The plots were split for varieties and laid down in randomized blocks with three replications.

Each sub-plot contained 40 recorded plants in four rows of ten entirely surrounded by guards. Spraying was carried out with a knapsack sprayer at a volume of 100 gal/ac. Weed control was assessed visually on a scale of 1 to 10 where 1 = 10% and 10 = 100% weed cover. At harvest, the dates of maturity were recorded as days after the 31st December, the head diameter was measured in inches, depth recorded as flat, medium or deep, and all heads were classified as Extra, 1, 2 or 3 according to the new statutory grades. Crop phytotoxicity was assessed visually when it occurred by noting height depression and leaf-scorch symptoms and date of maturity, yield and head quality.

All plants were raised under cold glass and drawn for planting when 6-8 weeks old, the exceptions being the early summer cauliflowers which overwintered in cold frames, and the winter hardy cauliflowers which were raised in outdoor seedbeds. The early summer cauliflowers were spaced at 24 x 18 in., summer cauliflowers at 24 x 24 in., and autumn and winter hardy at 27 x 27 in.

Commercially available formulations of the herbicide were employed, and all rates are given in terms of a.i. The treatments were as follows. (treatment key numbers underlined)

1. Control hand-weeded. 2. Control unweeded. 3, 4, 5 and 6. Simazine at 4, 6, 8 and 12 oz/ac respectively applied after planting. 7, 8 and 9. Propachlor at 3, 4 and 6 lb/ac respectively applied 2-4 weeks after planting. 10 and 11. Nitrofen 1 and 2 lb/ac applied within three days of planting. 12. Nitrofen + chlorpropham. 1.0 + 0.5 lb/ac applied 2-4 weeks after planting when the weed seedlings were at the cotyledon stage. 13 and 14. Nitrofen + chlorpropham at 2.0 lb + 0.5 lb/ac and 2.0 lb + 0.25 lb/ac applied within three days of planting. 15. Trifluralin 1 lb/ac incorporated into the soil just before planting. 16, 17 and 18. Desmetryne 4, 6 and 8 oz/ac applied 4-5 weeks after planting.

DISCUSSION

Early summer cauliflowers Table (I) Treatment numbers are in brackets

Simazine at 4, 6 and 8 oz/ac (3, 4 and 5) applied soon after planting gave the best control of weeds, but the higher rates severely checked the varieties Delta and Midsummer No.2 and caused a reduction in crop yield and extension in the length of the cutting period. The 8 oz/ac rate reduced the yields of both varieties in 1967 and in addition lowered head quality and increased buttoning in Delta.

Propachlor at 3 and 6 lb/ac (7 and 9) gave poor weed control in 1966 because the weed seedlings had reached the resistant stage. In 1967 propachlor at 4 lb/ac (8) applied when the weed seedlings were in the cotyledon stage, gave improved weed control, but some species survived, notably Polygonum convolvulus, P. aviculare, P. persicaria, Matricaria spp. and Veronica spp. Propachlor had no adverse effect on crop growth, date of maturity, yield or quality.

Trifluralin (15) gave very poor results in 1966, partly because the plots had a heavy population of the resistant Capsella bursa-pastoris, and partly because the herbicide was incorporated by raking and not rotovation. This confirms the findings of Schwer (1966). The results were much better in 1967 when the chemical was rotovated into the top 3 in of soil. Trifluralin had no adverse effect on the crop in comparison with the control.

Nitrofen + chlorpropham (13) gave a satisfactory control of weeds in both years, but some survived notably Capsella bursa-pastoris, Matricaria spp., Senecio vulgaris, Veronica spp., Lamium purpureum and Fumaria officinalis. This mixture applied immediately after planting checked the growth of all four varieties, but they recovered, and at harvest there was no delay in maturity or reduction in yield and quality in comparison with the control. Nitrofen 1 lb/ac + chlorpropham ½ lb/ac (12) applied to established cauliflowers 4 weeks after planting caused severe crop damage and reduced yield and quality of both Delta and Dominant.

Table 2.

Effect of herbicides on weed cover, and crop performance of two summer cauliflower varieties

Treatment code	% weed cover		Mean cutting date (days after 31 Dec.)				Marketable yield in crates/acre				% "perfect" of nos. marketable		% "extra" and "class 1" grades	
	1966	1967	1966		1967		1966		1967		1966		1967	
	6 weeks after planting	6 weeks after planting	Sesam	‡Lero	Sesam	‡Lero	Sesam	‡Lero	Sesam	‡Lero	Sesam	‡Lero	Sesam	‡Lero
1	0.0	10.0	221.9	221.0	208.2	210.0	501	647	945	957	ǂ63.3	ǂ78.9	78.6	90.5
2	-	83.3	-	-	207.2	209.3	-	-	967	997	-	-	62.2	84.7
3	-	15.8	-	-	207.9	209.5	-	-	924	1049	-	-	75.9	90.0
4	22.0	20.0	223.9	224.6	208.7	210.6	441	603	968	993	66.7	76.7	76.7	90.6
5	33.0	20.0	223.3	222.2	209.3	210.1	471	626	953	1031	72.2	85.3	78.2	88.2
7	32.0	-	221.7	221.5	-	-	569	694	-	-	61.9	77.3	-	-
8	-	31.7	-	-	208.4	208.8	-	-	973	1022	-	-	78.2	92.5
9	25.0	-	221.0	222.2	-	-	545	675	-	-	63.9	90.0	-	-
10	42.0	-	219.6	220.9	-	-	557	689	-	-	67.5	90.0	-	-
11	-	23.3	-	-	208.0	209.6	-	-	958	991	-	-	78.4	86.3
12	-	50.0	-	-	209.8	211.7	-	-	888	862	-	-	73.1	72.7
13	18.0	21.7	223.9	221.8	210.1	211.3	494	643	853	921	58.1	78.6	60.2	77.1
14	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	25.0	25.0	222.2	221.0	207.1	209.6	527	709	1003	1021	55.1	80.9	70.0	92.2
16	17.0	-	228.6	227.4	-	-	158	388	-	-	44.3	62.2	-	-
17	12.0	-	237.4	228.0	-	-	131	299	-	-	60.2	65.8	-	-
ϕ standard error	9.6 (16)	-	1.36(19)		1.24(34)		64.9(19)		48.7(36)		7.43(19)		4.86	
Significance of F. test	-	-	-		NS		-		0.5%		-		NS	

‡ Formerly named "Le Cerf Improved". ϕ standard error on differences, degrees of freedom given in brackets.
ǂ Angular transformations.

Table 3.

Effect of herbicides on weed cover and crop performance of four autumn cauliflower varieties

Treatment code	% weed cover		Mean cutting date (days after 31 Dec.)				Marketable yield (crates/acre)				*% perfect (of Nos. marketable)		*% "extra" and "Class 1" grades	
	1966	1967	1966		1967		1966		1967		1966		1967	
	6 weeks after planting	6 weeks after planting	S. Pacific	Canberra	Coronation	Royal Swan	S. Pacific	Canberra	Coronation	Royal Swan	S. Pacific	Canberra	Coronation	Royal Swan
1	70.0	34.1	281.5	299.0	271.7	331.1	437	366	506	408	76.2	63.9	47.1	49.9
2	-	16.6	-	-	271.9	329.1	-	-	521	328	-	-	45.3	54.1
3	-	10.8	-	-	271.9	328.3	-	-	501	366	-	-	38.8	54.2
4	56.6	26.6	279.9	291.4	271.6	328.9	459	391	504	331	73.8	59.6	44.4	46.8
5	38.0	15.8	284.5	292.0	270.7	331.2	393	390	526	322	71.2	57.6	50.1	50.5
7	48.3	-	277.5	287.9	-	-	490	397	-	-	76.2	56.2	-	-
8	-	12.4	-	-	274.1	327.1	-	-	500	292	-	-	46.9	54.6
9	18.3	-	282.7	304.3	-	-	439	356	-	-	75.6	57.0	-	-
10	74.9	-	278.7	293.5	-	-	482	371	-	-	82.5	58.2	-	-
11	-	25.8	-	-	274.3	323.3	-	-	508	392	-	-	42.1	44.9
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	28.3	19.9	278.3	288.5	271.8	326.8	440	388	525	400	79.4	57.4	45.8	50.1
14	-	14.1	-	-	273.7	325.7	-	-	498	417	-	-	45.4	47.3
15	56.6	5.8	281.3	289.8	270.7	323.7	440	372	542	352	78.6	60.7	49.0	53.7
16	33.3	-	289.8	296.2	-	-	355	379	-	-	66.7	54.6	-	-
17	23.3	-	289.6	288.7	-	-	341	432	-	-	66.9	55.0	-	-
ϕstandard error	-	8.0(18)	4.05(38)		4.37(38)		33.0(38)		47.4(38)		5.34(36)		5.69(38)	
Significance of F. test		10%	0.5%		NS		0.5%		NS		NS		NS	

ϕ Standard errors for differences, degrees of freedom given in brackets. *Angular transformation.

Table 4.

Effect of herbicides on weed cover and crop performance of two winter cauliflower varieties

Treatment code	% weed cover		Mean cutting date (days after 31 Dec.)				Marketable yield (crates/acre)				% "Extra" and "class 1" grades			
	1967	1968	1967		1968		1967		1968		1967		1968	
	8 weeks after planting	8 weeks after planting	May-fare	St. George	May-fare	St. George	May-fare	St. George	May-fare	St. George	May-fare	St. George	*May fare	*St. George
1	-	-	-	-	121.7	121.3	-	-	498	470	-	-	420.0	39.3
2	95	100.0	116.3	119.3	121.3	123.3	549	572	565	462	69.4	59.7	43.7	41.3
3	-	55.8	-	-	122.2	123.7	-	-	499	454	-	-	43.3	37.0
4	14	43.3	115.8	118.2	122.2	122.7	557	534	545	516	70.9	46.0	45.6	34.9
5	8	26.7	116.1	119.1	122.6	123.0	572	534	517	483	67.4	44.1	43.3	37.9
6	4	-	115.6	118.4	-	-	528	553	-	-	65.1	39.9	-	-
7	77	-	115.9	118.3	-	-	558	543	-	-	71.0	54.0	-	-
8	-	19.2	-	-	121.9	123.1	-	-	534	460	-	-	37.1	36.6
9	35	-	116.3	121.1	-	-	542	575	-	-	74.3	50.7	-	-
10	95	-	117.2	119.5	-	-	576	572	-	-	78.7	53,0	-	-
11	-	89.2	-	-	121.1	123.1	-	-	532	490	-	-	44.8	39.3
13	32	69.2	117.1	118.9	122.3	122.1	526	540	544	426	68.4	61.6	43.2	40.4
14	-	84.2	-	-	122.3	122.1	-	-	533	473	-	-	47.7	41.2
15	78	43.3	116.7	118.0	122.1	122.7	548	558	549	499	65.3	58.0	44.2	44.1
17	48	-	119.6	119.8	-	-	564	540	-	-	70.5	37.3	-	-
18	40	-	119.1	120.7	-	-	605	517	-	-	71.5	42.5	-	-
∅standard error	-	10.82(16)	1.50(42)		0.81(27)		29.8(42)		32.6(38)		-		4.68(38)	
Significance of F. test	-	0.1%	0.5%		NS		NS		NS				NS	

∅ standard error for differences, degrees of freedom are given in brackets. *Angular transformation

Summer cauliflowers Table (2)

Simazine at 4, 6 and 8 oz/ac (3, 4 and 5) had no lasting harmful effects on the varieties Lero and Sesam in 1966 and 1967. There was no loss in yield, delay in maturity or loss of crop quality. In 1966 weed control was unsatisfactory because the ground was very dry at the time of application and many common weeds such as Polygonum aviculare, Poa annua, veronica spp., Senecio vulgaris, chenopodium album and Lamium purpureum survived. The simazine treatments gave the best weed control in 1967.

Propachlor (7, 8 and 9) proved very promising, but in 1966 only 6 lb/ac gave satisfactory weed control and even this failed to kill Polygonum persicaria, Polygonum aviculare, P. convolvulus, Matricaria spp. and Capsella bursa-pastoris. In 1967 4 lb/ac (8) gave satisfactory weed control except for the species mentioned. A slight check to crop growth was noticed in both varieties with 6 lb/ac in 1966 but in neither year was there any harmful effect on crop performance. The optimum results were obtained from propachlor at 4 lb/ac.

Trifluralin gave satisfactory weed control in both years and had no harmful effect on the two varieties. Resistant weeds were Capsella bursa-pastoris, Senecio vulgaris and Urtica urens.

Nitrofen at 2 lb/ac + CIPC at ½ lb/ac (13) applied immediately after planting gave good weed control although Matricaria spp., Chenopodium album and Capsella bursa pastoris were present on the plots 6-7 weeks after planting. In 1966 the two varieties received a slight check but this did not lower the final yield and quality or delay maturity; in 1967 the check was more severe and this resulted in reduction in yield and quality for the variety Sesam and the harvesting period of Lero was extended. Nitrofen and chlorpropham (12) applied 2 weeks after planting gave poor weed control and a severe check to the crop growth. This resulted in an extended harvesting period and lowering of yield in both Sesam and Lero. Nitrofen alone at 1 and 2 lb/ac (10 and 11) gave a poor weed control but had no harmful effect on the crop. Resistant weeds included Stellaria media, Matricaria spp., Chenopodium album, Capsella bursa pastoris and Polygonum spp. Desmetryne applied at 4 and 6 oz/ac in 1966 (16 and 17) severely damaged both varieties of cauliflower and greatly reduced yields and crop quality.

In 1967 the control unweeded plots had over 80% weed cover 7 weeks after planting and this remained on the plots until harvesting was completed. This weed competition did not affect yield or date of maturity on either variety and the only adverse effects noted were a slight reduction in curd depth of both cultivars and a slight reduction of quality in Sesam. The variety Sesam grew less vigorously than Lero and was more sensitive to herbicide damage.

Autumn cauliflowers Table (3)

Simazine at 6 and 8 oz/ac (4 and 5) was not very effective on the weeds in 1966 due to the dry soil conditions at the time of planting. Simazine at 8 oz/ac caused a slight check to the growth of Canberra and South Pacific. This lowered the yield and quality of South Pacific, but not of Canberra. The 6 oz/ac rate had no harmful effects on either variety. In 1967 simazine at 4, 6 and 8 oz/ac (3, 4 and 5) gave a satisfactory control of weeds and did not lead to any loss in yield, delay in maturity, or reduction in quality in the varieties Coronation and Royal Swan.

Propachlor at 6 lb/ac (9) gave the best weed control in 1966, and caused no check to growth of either variety, but this treatment tended to lower the yield and curd depth in the variety Canberra. Propachlor at 4 lb/ac (8) gave a satisfactory weed control in the 1967 experiment, but again lowered the yield of the variety Royal Swan (syn. Canberra).

The mixture of nitrofen plus chlorpropham (13) gave a satisfactory control of weeds in 1966 and only a slight check to the growth of the varieties South Pacific and Canberra. There was no final effect on date of maturity, yield or crop quality. In 1967 nitrofen and chlorpropham (13 and 14) gave satisfactory weed control, but treatment 13 caused a check to both Coronation and Royal Swan which resulted in an extension of the cutting period. Nitrofen alone at 2 lb/ac had no harmful effect on either variety.

Trifluralin at 1 lb/ac (15) gave poor control of weeds in 1966 due to inadequate incorporation in very dry soil before planting, but had no harmful effects on the crop. In 1967, this treatment gave the best weed control 6 weeks after planting, because incorporation was thorough, and the herbicide was not affected by the dry soil conditions. In the 1967 experiment only trifluralin gave good weed control, and none of the treatments, including the control unweeded, affected the date of maturity, yield and crop quality of either variety.

Winter Hardy Cauliflowers Table (4)

1966/67 The three simazine treatments 6, 8 and 12 oz/ac (4, 5 and 6) were very successful in controlling weeds and even at 12 oz the check to crop growth was only very slight. This rate gave the best weed control, but was only marginally better than 8 oz/ac.

Propachlor at 3 lb/ac failed to control the annual weeds and was too light a dose to be effective but at 6 lb/ac weed control was much better. Even this failed to control Polygonum aviculare, Polygonum persicaria, Polygonum convolvulus, Poa annua, Chenopodium album, Stellaria media and Urtica urens, specimens of which were present on the plots 8 weeks after application. Neither rate had any harmful effects on the crop plants.

The nitrofen and chlorpropham mixture gave a slight check to the growth of both varieties, but did not affect dates of maturity, crop yield or quality. Capsella bursa-pastoris and Matricaria spp. were resistant. Trifluralin failed to control Capsella bursa-pastoris and Senecio vulgaris, and gave a poor control of Urtica urens, Polygonum persicaria and Veronica spp.

The different herbicides did not affect the head size and marketable yield of either variety, but the desmetryne and simazine treatments lowered the head quality of St. George. The two varieties differed markedly in response to the herbicides. For Mayfare, desmetryne at 8 oz/ac gave the best results and nitrofen plus chlorpropham the worst. For St. George, the control unweeded gave the best results and desmetryne at 6 oz/ac the worst.

1967/68 In this experiment, propachlor 4 lb/ac (8) and simazine 8 oz/ac gave the best weed control. There was no significant differences between treatments in date of maturity, marketable yield and head quality.

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THE USE OF PRE- AND POST-EMERGENCE HERBICIDES ON CAULIFLOWERS AND BRUSSELS SPROUTS ON A SANDY SOIL

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Stockbridge House Experimental Horticulture Station

Cawood, Near Selby, Yorkshire

Summary Simazine, nitrofen + chlorpropham, propachlor, desmetryne and trifluralin were tested on cauliflowers and Brussels sprouts crops on a coarse sandy soil at Stockbridge House E.H.S. in 1966-68. Simazine caused crop damage even when applied at a rate as low as 0.25 lb/ac a.i. at which level weeds were only partially controlled. Chlorpropham also caused damage particularly to the early summer cauliflower crops. Desmetryne was a useful material in Brussels sprouts in the one trial on this crop but Poa annua, which was not present on the site, was resistant to this material in an earlier cauliflower trial. Chlorpropham was dropped from the final experiment on early summer cauliflowers in which nitrofen did not give a very good control of weeds. Propachlor appeared to cause little crop damage at 4.0 lb/ac a.i. and gave a reasonable control of weeds. Trifluralin gave a good control of some weeds, notably Polygonum aviculare, provided it was rotavated in to a depth of 2 in. There was no apparent crop damage.

INTRODUCTION

A range of herbicides of potential value for use in brassica crops was used in a series of experiments carried out at Stockbridge House Experimental Horticulture Station during the period from 1966 to 1968. When the experiments started in spring 1966 some of the materials used had already been shown to be safe on other E.H.S.'s where the soils contained a fairly high proportion of clay. Stockbridge House and part of the area it serves is on a light sandy soil and it was necessary to evaluate the performance of these materials under such conditions before recommendations to local growers could be made. Brussels sprouts and cauliflowers are important crops on the Station and were used in these experiments.

METHODS AND MATERIALS

The experiments were conducted on soils of the Stockbridge series which contains approx. 5% silt, 10% clay and only 1-2% organic matter. The materials used were simazine, nitrofen + chlorpropham, propachlor, desmetryne and trifluralin. In the light of experience gained, application rates were often modified as the work progressed. In 1966 experiments were carried out on early, midsummer and autumn cauliflowers along with Brussels sprouts. In 1967 midsummer cauliflowers and Brussels sprouts were dropped from the trials and in 1968 only early summer cauliflowers were used. Randomized block designs were used with either 3 or 4 replicates. The plot size varied from 39 to 56 yd². Commercial conditions were simulated as far as possible so that the results might be of maximum value to growers. Either a pressurized knapsack sprayer fitted with a boom mounted on wheels or a Dorman Wheelaway sprayer was used for applying the herbicides in 50-100 gal water/ac. The main weed species on the sites of the experiments were:- Stellaria media (chickweed), Senecio vulgaris (groundsel), Tripleurospermum maritimum ssp. inodorum (scentless mayweed), Poa annua (annual meadow grass), Chenopodium album (fat hen), Capsella bursa-pastoris (shepherd's purse), Urtica urens (annual nettle), Polygonum persicaria (redshank), Polygonum aviculare (knotgrass) and Spergula arvenis (spurrey).

Comments later in the report on the efficiency of the herbicides are based mainly on visual assessments made on each species on a 0 - 5 scoring carried out a few weeks after spraying (0 = sp. Not present; 5 = abundance of sp.). Crop damage was usually scored at the same time and wherever possible marketable yield figures were obtained. The herbicides used in each experiment along with the rates in lb/ac a.i. appear in the respective tables of results.

RESULTS

The results for each experiment appear under the year and crop title in chronological order.

1966

Early Summer Cauliflowers

Plants of the varieties Major and Delta were overwintered in pots and planted out on 27th April. All the herbicides were applied 2 days later. Stellaria media and Poa annua were the problem weeds.

Table 1

Effect of post-planting sprays on early summer cauliflowers

Herbicide	lb/ac	Weed assessment		Crop damage
		Poa annua	Stellaria media	1 = None 3 = Severe
Simazine	0.375	2.7	2.7	2.3
"	0.5	3.3	2.0	3.0
Control	-	3.0	4.0	-
Propachlor	3.0	2.7	3.0	1.3
"	6.0	3.0	2.0	1.7
Nitrofen + Chlorpropham	2.4 0.5	2.0	2.7	1.0

Simazine caused severe crop damage, some plants being killed at the 0.5 lb/ac rate, without giving a very good control of weeds. The three remaining treatments gave a similar degree of weed control but caused little crop damage.

Midsummer Cauliflowers

Desmetryne was added to the list of treatments used on the previous experiment and was used on the variety Idol planted on 31st May. Two rates of simazine and nitrofen + chlorpropham were applied to clean plots on 2nd June. Seedling weeds at the 1-2 true leaf stage were present on 17th June when the propachlor treatments were applied. The desmetryne treatments were applied 4 days later.

Table 2

Effect of post-planting sprays on midsummer cauliflowers

Herbicide	lb/ac	Weed assessment			Crop damage	Yield
		Poa annua	Stellaria media	Chenopodium album	1 = None 3 = Severe	in crates/ac
Simazine	0.375	1.3	1.7	2.0	1.7	362
"	0.5	1.3	1.3	1.3	1.3	398
Control	-	2.0	3.7	3.7	-	414
Propachlor	3.0	2.0	2.0	3.0	1.0	401
"	6.0	0.7	1.3	1.3	1.0	487
Nitrofen + Chlorpropham	2.4 0.5	0.7	2.7	2.3	1.0	499
Desmetryne	0.25	1.3	1.3	0.7	2.0	446
"	0.375	2.0	1.3	0.0	2.3	307

S.E. of diff. (14 d.f.) ± 44.7

During the dry June weather simazine damage was less than in the early summer crop but with a better control of weeds, probably due to the fact that there was sufficient moisture in the soil surface following ½ in. of irrigation applied soon after spraying to allow a kill of germinating weeds without the risk of simazine being moved down to the root zone of the crop.

Propachlor at 3 lb/ac gave poor weed control partly due to the advanced stage of weed growth when applied. A better control resulted from using 6 lb/ac and this was reflected in the yield.

Nitrofen + chlorpropham gave a similar effect to propachlor at 6 lb/ac.

Aided by warm weather, desmetryne at 0.375 lb/ac caused severe crop damage and led to a yield significantly lower than most other treatments. The control plots were not weeded and thus gave a reduced yield.

Brussels Sprouts

The variety Rollo was planted on 2nd June and the simazine plots were sprayed the next day. In order to take advantage of the slight contact action of nitrofen, this, in combination with chlorpropham was applied after weed germination on 10th June. The propachlor treatments were applied on 30th June and desmetryne the next day. Unfortunately, a previous horse-radish crop had regenerated by this time and eventually the trial was abandoned.

Table 3 shows the effect of the materials on Senecio vulgaris and Armoracia rusticana (horse-radish). Differences in effect on other weeds were not great. 1 in. of irrigation water was applied during a dry spell in mid June to aid the distribution of the residual materials. This, coupled with heavy rain during early July was probably sufficient to wash simazine down to the roots of the crop and cause the stunting which occurred.

Table 3

Effect of post-planting sprays on Brussels sprouts

Herbicide	lb/ac	Weed assessment		Crop damage
		Senecio vulgaris (0 - 5)	Armoracia rusticana (0 - 3; 0 = No damage, 3=severe damage to weed)	0 = None 3 = Severe
Simazine	0.375	1.0	1.0	2.0
"	0.5	0.7	1.3	2.7
Control	-	4.3	0.0	-
Propachlor	3.0	4.0	0.7	1.3
"	6.0	1.3	0.7	1.7
Nitrofen + Chlorpropham	2.4 0.5	3.7	0.0	2.0
Desmetryne	0.25	0.0	2.3	1.3
"	0.375	0.0	2.3	1.7

Simazine gave a good control of weeds but caused crop damage especially at 0.5 lb/ac. Propachlor at 6 lb/ac gave quite good weed control but at the lower rate gave poor control, as did nitrofen + chlorpropham. Slight crop damage was scored for desmetryne which gave very good control of annual weeds and checked the horse-radish.

Autumn Cauliflowers

The var. Snowcap was planted on 18th July. The simazine and nitrofen + chlorpropham treatments were applied on 22nd July and propachlor on 27th when weed seedlings had emerged. Weeds were at the 3-4 true leaf stage on 8th August when the desmetryne was applied.

The whole experiment was hoed during September. Taking the control as 100, relative hoeing times were recorded and appear in Table 4 along with figures for marketable yield in crates/ac.

Table 4

Effect of post-planting sprays on autumn cauliflowers

Herbicide	lb/ac	Relative hoeing times	Yield in crates/ac
Simazine	0.375	18	187
"	0.5	10	171
Control	-	100	204
Propachlor	3.0	54	234
"	6.0	39	205
Nitrofen + Chlorpropham	2.4 0.5	48	220
Desmetryne	0.25	26	194
"	0.375	16	206

The relative hoeing times indicate the measure of weed control obtained. Crop damage caused by simazine was noted in early August when the other treatments appeared to be having no ill effect. The overall yield figures are low due to plant losses as a result of frost but these indicate any crop damage due to herbicide, which could not be seen during the season.

1967

Reduced rates of application were used for all treatments and desmetryne was dropped.

Early Summer Cauliflowers

The varieties Major and Delta were planted on 7th March and the simazine treatments were applied the next day. Nitrofen + chlorpropham was applied on 21st March and propachlor when seedling weeds were at the cotyledon stage on 28th March. The main weeds to which the weed assessment figures in Table 5 refer were Polygonum persicaria, Stellaria media, Poa annua and Senecio vulgaris.

Table 5

Effect of post-planting sprays on early summer cauliflowers

Herbicide	lb/ac	Weed assessment		Yield in crates/ac	
		Measure of control	% cover	Major	Delta
Simazine	0.125	Fair	27	301	378
"	0.25	F.Good	12	276	298
Control	-	-	87	349	374
Propachlor	4.0	F.Good	13	232	349
Nitrofen + Chlorpropham	2.1 0.25	F.Good	17	319	392
Nitrofen + Chlorpropham	2.1 0.5	Good	8	298	312

Simazine at 0.125 lb/ac did not give an adequate control of weeds but was sufficient to cause a drop in yield. At 0.25 lb/ac it gave a better control of weeds but an even lower yield. Greater crop damage occurred from using the higher rate of chlorpropham (0.5 lb/ac) on plots which received the nitrofen/chlorpropham combination. A high proportion of the curds from these plots were bracted or multi-headed. Although propachlor gave a fairly good control of weeds, the yield figures were disappointing.

Autumn Cauliflowers

Trifluralin (raked in the day before planting) was added to the list of materials used on the early summer crop. The varieties South Pacific and All-the-Year Round were planted on 13th June. Simazine was applied the day after. Due to the dry weather which followed neither material had much effect on the first "flush" of weeds which soon germinated on the whole experiment. It was necessary to hoe all plots before applying propachlor and nitrofen + chlorpropham on 13th July. Heavy rain followed, washing the materials into the root zone of the crop which was damaged by some of them (Table 6).

Table 6

Effect of pre- and post-planting sprays on autumn cauliflowers

Herbicide	lb/ac	Weed assessment			Crop damage	Yield*
		Poa annua	Senecio vulgaris	Spergula arvensis	0 = None 5 = Severe	in crates/ac
Simazine	0.125	2.0	2.0	1.3	0.3	511
"	0.25	1.3	1.3	1.0	1.7	447
Control	-	1.5	1.5	2.3	-	488
Propachlor	4.0	0.7	1.3	0.7	0.0	452
Nitrofen + Chlorpropham	2.1 0.25	1.0	1.3	1.3	0.7	464
Nitrofen + Chlorpropham	2.1 0.5	1.3	1.7	0.7	0.7	399
Trifluralin	1.0	0.7	2.0	1.0	0.0	472
					S.E. of diff.(14 d.f.)	± 48.2

* Mean of 2 vars.

Simazine at 0.125 lb/ac was least effective of any of the treatments on the weeds referred to in Table 6, but at 0.25 lb/ac gave a better weed control but caused crop damage. Propachlor gave a good control of Poa annua and Spergula arvensis with no apparent crop damage. Nitrofen + chlorpropham gave a fair control of weeds but again led to the production of bracted and multiheaded curds. Trifluralin was not very effective probably because raking did not give adequate incorporation. The differences in yield did not quite reach significance (at P=0.05) but, except in the case of propachlor and trifluralin, crop damage during the season was related to a subsequent lower yield than the control.

1968

Early Summer Cauliflowers

Only the materials found to be safe (Table 7) on cauliflowers were used on the varieties Romax and Delta planted on 11th March. Trifluralin was rotavated in to a depth of 2 in. 3 days before planting and the propachlor and nitrofen treatments were applied 17 days after planting when some weed seed had just germinated.

Table 7

Effect of pre- and post-emergence sprays on early summer cauliflowers

Herbicide	lb/ac	Weed assessment				Yield in* crates/ac	
		Polygonum aviculare	Tripleurospermum maritimum ssp inodorum	Stellaria media	Poa annua	Romax	Delta
Propachlor	4.0	2.8	1.3	0.8	0.5	590	629
Nitrofen	2.1	1.8	2.5	3.3	0.5	559	583
Control(Hoed)	-	2.8	2.3	2.5	2.5	614	556
Trifluralin	1.0	1.0	2.0	1.3	1.3	615	595

*S.E. of diff. for use in horizontal comparisons (12 d.f.) ± 33.8
S.E. of diff. for use in other comparisons (20 d.f.) ± 34.5

The effect of the materials varied according to weed species. Propachlor gave the best control of all the main weeds except Polygonum aviculare. Trifluralin gave a good control of this weed. Because of the damage it had previously caused, chlorpropham was not used with the nitrofen, which on its own did not give a very good control of weeds. There was no significant effect on yield from any of the treatments.

DISCUSSION

Simazine, especially where heavy rain followed spraying, was found to cause damage at the lowest rate which would give a satisfactory weed control (0.25 lb/ac). While chlorpropham enhanced the value of nitrofen when the two were combined, it caused too much damage for it to be recommended. A well-time application of desmetryne proved to be a useful material in Brussels sprouts. It did not control Poa annua in the 1966 midsummer cauliflower experiment.

Early summer cauliflowers seemed to be the most sensitive crop used in the experiments and thus gave some useful information on herbicide tolerance. Weed control in early summer cauliflowers is perhaps less important than in the other crops due to the fact that it is not in the field long and weed germination is slow during the first 4-6 weeks after planting. In the final experiment there was no yield increase in the early maturing var. Romax where herbicides had been used but with the later var. Delta, freedom from weed competition following herbicides led to a slightly higher yield.

The need to incorporate trifluralin by rotavation rather than raking was shown when the 1967 autumn cauliflower and 1968 early summer cauliflower trials were compared. In the latter a good weed control occurred within the spectrum covered by the material. A particularly good control of Polygonum aviculare was obtained.

Propachlor caused little crop damage and when spraying was done before the weeds reached the expanded cotyledon stage, as in the 1968 early summer cauliflowers, it gave a good control of two important weeds on the site, Stellaria media and Poa annua.

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HERBICIDES FOR THE CONTROL OF WEEDS IN BRASSICA CROPS

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Summary In two experiments on a sandy loam in 1967, seventeen herbicides were tested for their selective activity on annual weeds in sown brassica crops. CP 50144 (2-chloro-N-2,6-diethylphenyl-N-methoxymethyl acetamide), R 2063 (2-(α-naphthoxy)-N,N-dimethylpropionamide) and planavin were at least as effective as nitrofen, propachlor and trifluralin. In a third experiment in 1968 on a similar soil type 15 lb TCA/ac applied 6 weeks before drilling gave excellent control of A. repens with no damage to rape, kale and swedes. R 2063 and R 7465 applied at the time of drilling were less effective

INTRODUCTION

Nitrofen, propachlor, trifluralin and desmetryne have already shown some promise for the control of annual weeds in seeded brassica crops (Allott, 1966; Cassidy, 1966; Roberts and Wilson, 1966). In two experiments in 1967 their effectiveness was compared with that of a number of other candidate herbicides.

A further experiment in 1968 examined herbicide treatments for the selective control of Agropyron repens in seeded brassica crops.

METHOD AND MATERIALS

All three experiments were at the Weed Research Organization on a sandy loam, relatively low in organic matter. In the 1967 experiments, logarithmically reducing doses of the herbicides were applied from a Fisons Mini Logarithmic Sprayer, at a volume rate of 28 gal/ac (using a matched pair of Teejets No. 6503 and a pressure of 40 lb/in^2). Plots were 22 x 1 yd, the dose being halved every 5.5 yd. The experimental design was a randomised block replicated six times in experiment I and three times in experiment II with a yard discard between each plot. Pre-drilling treatments were mixed with the soil by one pass of a small tined rotary cultivator, mounted on a Ransome MG 40 tractor and working to a depth of 3 - 4 in. The implement always worked up the logarithmic dose from the lighter to the more heavily treated end of the plot.

The herbicides used in these experiments and their formulation are listed below Table 1. All doses quoted in this paper are in terms of active ingredient.

In experiment I the pre-drilling treatments were applied on 7/4/1967. The crops, Brussels sprout (var. Cambridge Special), swede (var. Best of All), rape (var. Rigo), kale (var. Marrow Stem) and cauliflower (var. Novo) were sown along the length of the plots in single rows, at a spacing of 4 in. and a depth of approx. 0.75 in., immediately after the pre-drilling treatments had been mixed in. The pre-emergence treatments were applied on 12/4/1967 and the post-emergence treatment (crops 2-4.5 true leaves) on 17/5/1967.

In experiment II the pre-drilling treatments and the immediately post-drilling treatments were applied on the same day as sowing - 21/8/1967. The pre-emergence and early post-emergence treatments were applied on 25/8/1967 and 8/9/1967 respectively. In this experiment the same crops as in experiment I were sown, but at a spacing of 9 in.

Table 1

The dose of herbicides below which crops were apparently unaffected, type of damage caused by higher doses, and the dose below which weed control was inadequate (Expt. I)

Doses in lb a.i./ac Mean of 6 replicates and range shown by individual replicates

Crop	Brussel sprouts			Swedes			Rape			Kale			Cauliflower			Weed Control
	dose	range	dmge	dose	range	dmge	dose	range	dmge	dose	range	dmge	dose	range	dmge	dose
*R 4574	2.1	1.3-3.5	BD	3.6	3.1-4.0	BD	3.5	3.1-4.0	B	2.8	2.1-4.0	B	2.7	2.1-3.5	B	2.5
*R 2063	1.8	0.8-2.7	CB	2.1	1.0-3.1	B	2.4	1.5-3.1	B	2.2	1.6-3.1	CB	1.6	0.8-2.4	CB	1.0
*R 1910	1.6	1.0-2.4	CB	2.5	1.6-4.0	B	2.5	1.6-3.2	B	2.0	1.3-3.3	CB	1.5	0.8-2.1	CBD	2.0
*planavin	1.8	1.6-2.0	B	1.9	1.7-2.0	B	>2.0	- -	-	1.9	1.8-2.0	B	1.8	1.3-2.0	B	1.3
*benefin	1.2	0.6-2.0	BDF	1.4	1.2-2.0	B	1.6	1.2-2.0	B	1.6	1.4-2.0	B	1.2	0.5-1.8	BF	2.0
*trifluralin	1.8	1.4-2.0	B	>2.0	- -	-	>2.0	- -	-	>2.0	- -	-	1.8	1.2-2.0	B	2.0
C 7019	1.6	1.1-1.9	BD	1.4	0.6-2.1	BD	1.6	1.3-2.4	BD	1.6	0.9-2.4	BD	1.0	0.4-1.3	ABD	1.5
GS 11357	2.1	1.2-3.7	BD	1.4	0.8-2.0	ABD	1.7	1.2-2.3	ABD	2.1	1.4-3.3	ABD	2.0	0.9-3.3	ABD	2.0
R 7465	3.2	1.9-4.0	B	3.8	2.7-4.0	B	3.6	2.1-4.0	B	3.5	1.9-4.0	B	2.8	1.5-4.0	B	1.75
CP 50144	1.7	1.0-3.2	BF	2.4	1.5-3.4	BF	2.7	2.1-2.8	BF	2.7	1.5-3.5	BF	2.2	1.4-3.5	BF	0.75
nitrofen	3.2	2.2-8.0	BF	2.7	2.0-3.8	BF	2.8	2.2-4.2	BF	2.8	1.4-4.8	BF	2.6	1.8-3.3	BF	2.5
OCS 21799	0.4	0.25-0.7	BDF	0.4	0.25-0.7	BDF	0.4	0.3-0.7	BDF	0.4	0.25-0.6	BDF	0.3	0.2-0.4	BDF	0.9
UC 22463	1.2	0.5-1.3	ABD	0.6	0.5-0.9	ABD	1.0	0.8-1.3	ABD	1.0	0.9-1.3	ABD	0.8	0.5-1.0	ABD	0.75

*These herbicides were mixed with the soil pre-drilling

Damage (dmge) code A = chlorosis; B = retarded; C = loss of cuticular wax; D = some mortality; F = deformity

Principal weeds present: Chrysanthemum segetum, Matricaria recutita, Fumaria officinalis, Stellaria media, Raphanus raphanistrum, Poa annua

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Herbicides used and formulation

R 4574	NN-hexamethylene-S-isopropyl-(thiocarbamate)	- 72.3% e.c.
R 2063	N-cyclohexyl-N-ethyl-S-ethyl (thiocarbamate)	- 72.3% e.c.
R 1910	S-ethyl-N,N-diisobutylthiolcarbamate	- 72.3% e.c.
C 7019	2-azido-4-isopropylamino-6-methylthio-1,3,5-triazine	- 50% w.p.
GS 11357	2-methylthio-4-methylamino-6-n-propylamino-1,3,5-triazine	- 25% w.p.
CP 50144	2-chloro-N-2,6-diethylphenyl-N-methoxymethylacetamide	- 48% e.c.
R 7465	2-(α-naphthoxy)-N,N-dimethylpropionamide	- 50% w.p.
OCS 21799	2-(4-chloro-o-tolyloxy)-N-methoxyacetamide	- 80% w.p.
UC 22463	(3,4-dichlorobenzyl-N-methylcarbamate - 75% + 2,3-dichlorobenzyl-N-methylcarbamate - 25%)	- 48% e.c.

planavin - 80% w.p.; benefin - 15% w.p.; trifluralin - 48% e.c.; tri-allate - 40% e.c.; propachlor - 65% w.p.; nitrofen - 24% e.c.; desmetryne - 25% w.p.; phenmedipham - 19.6% e.c.; TCA - 80.7% w.s.p.; dalapon - 74% w.s.p.

Table 2

The dose of herbicide below which crops were apparently unaffected and the dose below which weed control was inadequate (Expt. II)

Herbicide	Time of application	Doses in lb a.i./ac Kale dose	Kale range	Mean of 3 replicates Rape dose	Rape range	Swedes dose	Swedes range	Weed Control dose
R 2063	pre-drilling	0.8	0.5-1.1	1.8	1.3-2.1	1.7	1.5-1.8	1.1
R 7465	pre-drilling	1.9	1.5-2.7	>4.0	-	2.0	1.3-2.4	0.75
trifluralin	pre-drilling	>2.0	-	>2.0	-	>2.0	-	0.75
tri-allate	pre-drilling	7.0	5.0-8.0	7.7	7.0-8.0	6.8	4.2-8.0	>8.0
C 7019	im. post-drill	2.0	1.6-2.4	1.25	1.2-1.3	1.0	0.9-1.1	1.0
"	pre-em.	3.0	2.1-3.5	1.4	1.3-1.6	1.1	0.8-1.6	0.8
"	early post-em.	0.4	0.3-0.4	<0.25	-	<0.25	-	0.5
GS 11357	im. post-drill	1.9	1.5-2.5	1.5	1.0-2.3	0.75	0.6-1.4	1.1
"	pre-em.	3.0	2.0-3.8	1.75	1.4-2.0	1.5	1.2-1.8	1.0
"	early post-em.	<0.5	-	<0.5	-	<0.5	-	<0.5
CP 50144	im. post-drill	3.0	2.6-3.7	3.3	2.8-3.8	2.5	2.0-2.9	1.9
"	pre-em.	3.5	2.9-3.7	3.5	2.9-4.2	2.8	2.7-2.9	1.5
"	early post-em.	3.0	2.6-3.7	3.0	2.0-3.3	2.3	1.2-2.9	>8.0
propachlor	im. post-drill	7.0	6.5-8.0	7.6	6.2-8.0	7.8	7.0-8.0	3.5
"	pre-em.	6.9	5.0-8.0	>8.0	-	7.5	6.2-8.0	1.75
"	early post-em.	2.5	2.3-2.6	3.5	2.6-5.0	2.5	2.3-2.6	>8.0
UC 22463	im. post-drill	1.8	1.5-1.9	1.0	0.9-1.1	0.5	0.5-0.7	1.7
"	pre-em.	1.1	1.0-1.2	0.7	0.6-0.8	0.4	0.3-0.5	1.4
phenmedipham	early post-em.	0.6	0.5-0.7	<0.5	-	<0.5	-	0.75

Principal weeds present - Stellaria media, Poa annua

Table 3

Crop scores and shoot counts of A. repens 6 weeks after treament (Expt. III)

Scores on 0 - 10 scale 0 = complete kill, 10 = as control

Herbicide	lb/ac	Crop scores Rape	Kale	Swede	A. repens shoots/yd^2	A. repens % reduction
R 7465 mixed in	1.0	10	9.7	9.7	39	39
	2.0	8.5	7.7	9.5	39	39
	4.0	7.2	3.8	7.2	20	69
R 7465 surface only	1.0	10	10	10	57	11
	2.0	10	10	10	58	9
	4.0	10	9.7	10	46	28
R 2063 mixed in	0.5	10	9.7	9.7	62	3
	1.0	10	10	10	48	25
	2.0	10	10	10	33	48
dalapon surface	2.0	10	7.2	10	32	50
	4.0	10	10	10	20	69
*TCA surface	15.0	10	9.3	10	3	95
*TCA mixed	15.0	10	9.7	10	3	95
Control mixed	-	10	10	10	62	3
Control	-	10	10	10	64	00
S.E.					± 18	

* These treatments were applied 6 weeks before drilling

In the 1968 experiment the crops (swedes, rape and kale in 14 in., 7 in. and 14 in. rows respectively) were sown in three strips 7.5 ft wide with a fourth strip uncropped, on an area with dense A. repens. An Oxford Precision Sprayer was used to apply finite doses of the herbicides in swaths 2 x 10 yd across the strips, at a volume rate of 21 gal/ac and a pressure of 28 lb/in^2. through Allman 00 fan nozzles. Two treatments with TCA were applied on 5/4/1968, one before and the other after rotary cultivation of the whole experimental area to a depth of 4-5 in. The pre-drilling treatments with R 7465 and R 2063, and the sowing of the crops were not possible due to soil and weather conditions until 16/5/1968. The post-drilling treatments were applied on 17/5/1968.

Assessments

In the first of the 1967 experiments, the numbers of plants were counted in alternate yard lengths of crop row down the plots, six weeks after drilling. At the same time notes were made of any herbicidal effects, and the density and vigour of the weeds were noted at every 2.75 yd down the plots.

In the second experiment, the crops treated before emergence were scored for vigour and density, and effects on the crops and weeds noted every 2.75 yd, three weeks after sowing. One week later the effects due to the post-emergence treatments were similarly noted.

In the 1968 experiment, 6-7 weeks after drilling, the numbers of shoots of A. repens in four 18 x 18 in. quadrats on each individual crop sub-plot were counted and the crops themselves scored for vigour and density. Table 3 gives the crop scores and the A. repens density as a mean of the 4 sub-plots.

RESULTS

In the first experiment - the results of which are summarised in Table 1 - the most promising herbicides were R 2063, planavin, R 7465 and CP 50144.

R 2063 prevented the formation of the cuticular wax bloom on the Brussels sprout, kale and cauliflower in the early stages of growth but the vigour of the plants seemed to be unimpaired. It was particularly effective on Poa annua, Fumaria officinalis, Polygonum convolvulus and Stellaria media which were controlled by doses of 0.5 - 1.0 lb/ac. Raphanus raphanistrum, Chrysanthemum segetum and Matricaria recutita were considerably more resistant and required 1.5 - 2.5 lb/ac.

Of the three aniline compounds tested planavin was the most effective - trifluralin was surprisingly ineffective. However all three prevented the growth of P. annua down to relatively low rates. R 7465 controlled most of the weeds at rates of 1.0 - 1.75 lb/ac, and P. annua was almost absent at the minimum rate of 0.25 lb/ac. The most resistant weeds were R. raphanistrum and C. segetum both of which required over 3 lb/ac. CP 50144 was one of the most selective herbicides in this experiment. C. segetum, M. recutita and Poa annua were very susceptible, being eliminated by 0.25 - 0.5 lb/ac. R. raphanistrum was more resistant requiring 1.5 - 2.0 lb/ac while F. officinalis and S. media were intermediate (1.0 - 1.5 lb/ac). A few plants of P. aviculare were apparent even at 2.0 - 3.0 lb/ac and this species may be particularly resistant.

Nitrofen was moderately effective on many of the weeds at 2 lb/ac with the very striking exception of S. media. R. raphanistrum was also relatively resistant. Both OCS 21799 and UC 22463 showed inadequate selectivity while C 7019 was also disappointing. Desmetryne applied post-emergence scorched all the crops severely.

The second experiment was relatively late in the year and the weed population was confined largely to S. media and P. annua. The results are summarised in Table 2.

R 2063 again showed selectivity although the crops appeared to be somewhat more susceptible.

R 7465 which was mixed with the soil pre-drilling in this experiment had no apparent effect on rape at the peak dose of 4 lb/ac although swedes and kale were more susceptible. The weeds however were controlled by 0.75 lb/ac.

The crops again tolerated relatively high doses of CP 50144 (2.5 - 3.5 lb/ac) and pre-emergence 1.5 - 2.0 lb/ac gave good weed control but in contrast 8.0 lb/ac post-emergence was inadequate. The related compound propachlor appeared to be considerably less toxic to the crops but was also less consistently effective on the weeds.

Trifluralin and C 7019 were both considerably more effective on the weeds in this experiment although post-emergence C 7019 scorched the crops at relatively low doses. Phenmedipham applied post-emergence also scorched the crops severely and showed insufficient selectivity.

In the 1968 experiment (Table 2) the TCA treatments gave very effective control of the A. repens.

All the other treatments were disappointing and R 7465 when mixed with the soil was unexpectedly toxic to all three crops. The only broadleaved weed present in any quantity on the experimental area was R. raphanistrum and not unexpectedly none of the treatments controlled this very effectively.

DISCUSSION

These experiments were assessed relatively soon after treatment and most of the toxic effects on the crops were at their maximum but from the results it is apparent that in addition to nitrofen, propachlor and trifluralin a number of other herbicides merit attention.

CP 50144 was one of the most promising herbicides. In the first expt. it was particularly effective on the Compositae and in the second, it was more active than its close relative propachlor. However it may suffer some of the weaknesses of propachlor also, as indicated by its low level of effect on P. aviculare and R. raphanistrum.

R 7465 and R 2063 also deserve further testing, particularly as both suppress A. repens to some extent in addition to their control of annual weeds. However both have some drawbacks - R 2063 being volatile needs to be mixed with the soil and R 7465 is more active when mixed in. The temporary de-waxing caused by R 2063 may also be unacceptable.

TCA applied before drilling was very effective on A. repens but would need to be followed by a treatment for broadleaved weed control.

Acknowledgments

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PRELIMINARY EXPERIMENTS ON WEED CONTROL WITH HYDROXYBENZONITRILE FORMULATIONS IN SALAD AND BULB ONIONS

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Summary Post-emergence treatments of ioxynil octanoate, bromoxynil octanoate and a mixture containing equal parts of the two compounds were applied to various growth stages of salad and bulb onions at 8, 12 and 16 oz/ac a.i. All gave commercially acceptable control of weeds up to harvest.

All treatments applied before the two erect leaf stage caused phytotoxicity and death of the crop. Applied at or after this stage, 8 and 12 oz a.i. of ioxynil octanoate and 8 oz a.i. of the mixture of ioxynil and bromoxynil did not cause phytotoxic symptoms. Transient phytotoxicity was caused by all other treatments but the effect was not discernible at harvest.

Crop yields from a number of sites indicated that 8 oz/ac of ioxynil alone, the same rate of the ioxynil/bromoxynil mixture and 12 oz/ac of ioxynil alone had a beneficial effect on yield consistent with effective herbicidal activity, and that these treatments could be used as a basis for further work leading to recommendations for commercial use in the future.

INTRODUCTION

Initial trials work with hydroxybenzonitrile herbicides was concentrated on cereal weeds, where various formulations successfully controlled a wide spectrum of species including those which were resistant to phenoxyalkanoic treatments, (Carpenter et al, 1964; Folland et al, 1966).

More recently other crop/weed associations have been found, among which the post-emergence tolerance of onions to ester formulations of ioxynil and to a lesser extent bromoxynil has been reported from Australia. There, the use of pre-emergence residual herbicides controlled weeds for approximately one third of the life of the crop but their residual activity was insufficient and of rather too narrow a spectrum to control weeds up to crop harvest. Post-emergence herbicides were obviously required and of those tested by the South Australian Department of Agriculture the best weed control consistent with crop tolerance was provided by ioxynil. (Rogers and Gilbertson 1968).

The increased acreage envisaged for the U.K. crop prompted similar trials in this country to determine the following factors:-

(a) Crop tolerance of salad and bulb onions at various growth stages to ioxynil and bromoxynil octanoate.

(b) The efficacy of post-emergence treatments of these herbicides when used with or without standard pre-emergence treatments.

(c) The maximum and minimum effective dose for (a) and (b).

(d) Evidence of commercially acceptable weed control in these crops.

METHOD AND MATERIALS

In all the experiments a randomised block design with three replicates per treatment was used with a plot size of approximately 18 yd^2. Applications were made with a power-driven single-wheeled sprayer. Assessments were taken immediately prior to the post-emergence applications by recording the number of weeds present in 2 x ½ yd^2 quadrats in two control plots per replicate and prior to harvest in 1 x ½ yd^2 quadrat per treated plot. Yields were recorded when the crop matured.

Treatments

(a) Emulsifiable concentrate formulation containing 25% bromoxynil as the octanoyl ester applied at 8, 12 and 16 oz/ac a.i.

(b) Emulsifiable concentrate formulation containing 25% ioxynil as the octanoyl ester applied at 8, 12 and 16 oz/ac a.i.

(c) Emulsifiable concentrate formulation containing 20% ioxynil and 20% bromoxynil as the octanoyl esters applied at 4 4, 6 6 and 8 8 oz/ac a.i.

Propachlor at 3.9 lb/ac a.i. was applied pre-emergence, as soon as possible after drilling, to all the crop tolerance plots and half the weed control plots at each site.

RESULTS

To assess crop tolerance to the three dose rates of each herbicide the treatments were applied at different growth stages to both salad and bulb onions grown on the same site. The onions, varieties White Lisbon, Bedfordshire Champion and Rijnsburger were drilled on the same date and herbicidal treatments throughout the trial were applied on the same day.

Table 1

Mean % weed control by hydroxybenzonitrile formulations prior to harvest

Figures derived from the numbers of weeds per $\frac{1}{2}$ yd^2 quadrat/plot x 3 replicates/site

Weed spp.	Site	Growth Stage	Mean No. of weeds in control plots	Propachlor + hydroxybenzonitrile treatment oz/ac/a.i.									Propachlor alone
				Bromoxynil			Ioxynil			Iox + Brom			3.9 lb ac/a.i.
				8	12	16	8	12	16	8	12	16	
Fumaria officinalis	B	1-4 in. tall	32	69	100	100	82	13	82	75	100	100	44
Polygonum convolvulus	E	6 lvs	39	88	92	93	77	77	88	92	75	86	17
Rumex obtusifolius	B	10 lvs	9	78	67	45	12	67	67	56	78	78	- 11
Stellaria media	A	1-4 in. diam.	59	97	85	87	100	100	100	100	100	100	46
	B		62	60	47	88	91	94	91	92	88	83	39
	C		13	100	60	60	80	100	100	100	100	100	40
	E		16	93	85	100	97	85	100	97	93	97	64
Urtica urens	A	2-4 in. tall	39	59	70	67	88	100	98	90	98	95	21
	C		20	65	90	50	70	75	85	85	95	100	55
Total weeds/site	A		149	83	84	84	94	97	94	92	98	94	40
	B		200	75	74	85	83	81	90	94	86	86	28
	C		62	86	86	76	86	84	89	88	84	100	65
	D		79	93	92	97	82	93	69	93	97	64	64
	E		92	94	96	98	89	85	95	95	89	91	55

Table 1 shows the mean control of weed species which were present at a density of one or more per square foot on the various sites at maturity. Other weeds were present and these figures are included in the totals at the appropriate site.

Table 2

Mean yield of onions in lb per 1/3 plot x 3 replicates

Treatment	oz/ac a.i.	Salad onions		Bulb onions			
		Crop tolerance site (2nd growth stage)	Site A	Site B	Site C	Site D	Site E
Bromoxynil	8	152	84	54	163	136	89
"	12	136	54	31	193	106	89
"	16	129	32	6++	164	72	73
Ioxynil	8	213	160	106	224	160	95*
"	12	194	136	52*	184	74*	103
"	16	176	97	88	188	94	88
Bromoxynil+ Ioxynil	4+4	185	125	77	189	151	105
"	6+6	161	96	70	204	149	114
"	8+8	132	90	59	181	98	74
Propachlor alone	-	142 ø	103	26	192	+++	+++
Untreated control	-	111 ø	8	7	82	+++	+++
Farmer's crop	-	-	-	-	-	-	72

* 2 plots only ø hand weeded

++ 1 plot only +++ plots weeded by grower

DISCUSSION

Weed Control

Both salad and bulb onions require from 1½ to 2 months after drilling to reach the two erect leaf stage. This allows ample time for the emergence of weed species which, due to the lack of crop competition, can consolidate their position. The trials have shown that if pre-emergence herbicides are not used the majority of the weeds have emerged and passed the growth stage when the hydroxybenzonitriles can be expected to provide a commercial acceptable control by the time the onions have two erect leaves. Although some considerable scorch of weeds is obtained this is not sufficient to allow the crop to mature. As propachlor is widely used as a pre-emergence treatment the use of post-emergence herbicides which are particularly effective against the weeds which are not controlled by propachlor as well as being generally effective, is highly desirable.

Weed counts taken immediately before application of the hydroxybenzonitrile treatments showed that although pre-emergence treatments of propachlor had reduced the number of weeds when compared with the untreated control plots, a large number of weeds had germinated due to either the lack of persistence or the inability of the treatment to control these species. Notably, lack of control was evident on the following species: Stellaria media, Urtica urens, Chenopodium album and Polygonum spp., and a reduction in yield was measured from the plots on which this single treatment was used. The complementary effect of the hydroxybenzonitriles to propachlor was noted in that all the post-emergence treatments, in particular those containing ioxynil, gave a commercially acceptable control of all broad-leaved annual weeds including those mentioned above, which occurred on the various sites.

Generally, the performance of the post-emergence treatments followed the known pattern of activity of these herbicides. Stellaria media was better controlled by ioxynil and a higher degree of activity was recorded in the control of Polygonum spp. by bromoxynil. Variable control of Cirsium spp. was expected and obtained with all treatments. The only anomalous result was the better control of Fumaria officinalis by bromoxynil when compared with ioxynil; the converse would be expected.

Although the hydroxybenzonitrile herbicides are not noted for their control of perennial weeds it is evident that some control of Rumex spp. was obtained at the cotyledon to 2-leaf growth stage. Docks treated at a later stage than this suffer considerable scorch and damage but recover sufficiently well to outgrow the crop.

Weed assessments taken at harvest (Table 1) show the commercially acceptable control obtained by the use of propachlor, pre-emergence, with application of hydroxybenzonitrile treatments after the 2 erect leaf stage of the onions, which enabled the crop to mature and be harvested without weed interference.

Ioxynil octanoate alone and as a mixture with bromoxynil octanoate afforded the best weed control as bromoxynil alone does not control Stellaria media which actively competes with the crop in the early stages of bulb onion growth, and for a longer period with salad onions.

Crop Tolerance

At a site reserved for crop tolerance experiments only the first set of post-emergence hydroxybenzonitrile treatments were applied on 2nd May when the crops had reached the loop and crook stage. Virtually a complete kill of both bulb onion varieties resulted from all treatments and a similar effect was apparent with the heavier dose rates of all treatments on the salad onions.

The same treatments were applied on 31st May to a second set of plots sown on 28th March and treated with propachlor on 4th April. The salad onions were somewhat more advanced in growth than the bulb onions but the majority of plants had reached the 2 erect leaf stage. Crop tolerance at this growth stage had significantly increased and at the lowest doses of ioxynil alone and of the mixture no phytotoxicity was apparent.

Phytotoxicity in the form of tip scorch increased with increasing dose rate but this effect in all cases was transient and was not observed at harvest although the highest doses of bromoxynil and of the mixture caused a decrease in the height of mature salad onions which was discernible at harvest. This effect was evident in the reduced yield from these plots.

On application of the post-emergence treatments on 24/6/68 when the crop had 3 erect leaves all plots contained a large number of mature and flowering weeds. Although the treatments killed most of the weed top growth, secondary growth occurred and no commercially acceptable crop was obtained. No phytotoxicity was recorded on the onions because they were protected by the weeds and it is doubtful whether sufficient spray reached the crop to produce symptoms. Crop weights were not taken.

The weed control experiments were conducted concurrently with the crop tolerance trial, the first applications of post-emergence treatments being made when the crop had reached the 2 erect leaf stage.

The lowest dose of ioxynil octanoate was always best tolerated and this effect was confirmed by the enhanced yields from the plots so treated. For salad onions the yields from these plots were markedly superior to those from the other treatments but this effect was less noticeable on the bulb onion plots, possibly because of the somewhat longer time required for this crop to attain maturity.

Compared with the plots treated with propachlor alone and subsequently hand weeded, the hydroxybenzonitrile plots were markedly greener and this typical hydroxybenzonitrile effect was noted by growers on the sites with which they were involved.

Current trials where lower dose rates of ioxynil alone and the mixture have been applied to leeks drilled to a stand have confirmed the tolerance of this crop also and the dose rate of ioxynil has been reduced to 4 oz/ac a.i. without affecting the degree of weed control. No phytotoxicity was observed on any of these plots and mature flowering weeds of the family Polygonaceae were killed.

Further trials on the three alliaceous crops will be conducted next year.

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CHEMICAL WEED CONTROL IN ONION NURSERIES

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Summary In a nursery at Shandaweel Experimental Station, Upper Egypt, where the soil is loamy clay of pH 7.5 and where Phytolacca spp., Melilotus indica, Portulaca oleracea, Chenopodium spp., Cyperus spp., Cynodon dactylon are the more predominant weeds, nitrofen, prometryne, ioxynil octanoate, linuron, diphenamid, and chlorbufam with pyrazon were applied pre-planting, just pre-emergence, and post-emergence on onions. Data concerning weights of weeds and numbers of onion seedlings were recorded and analysed statistically.

The most promising treatment for weed control and for safety towards the onion seedlings was nitrofen applied pre- or post-emergence at rates 6-8 lb/feddan (14-19 lb/ha). It is proposed that such treatments with nitrofen be employed in combination with EPTC incorporated into the soil 3 weeks prior to sowing onion seeds.

INTRODUCTION

In onion nurseries in United Arab Republic weeds present a serious problem. They are generally removed by hand but, because of difficulties in hand weeding and scarcity of labour, there is a pressing need for another reliable way.

Zahran et al (1967) described the advantageous use of EPTC and chlorpropham on onions sown on ridges. Three weeks before sowing, EPTC was incorporated into the loamy soil at rates 6-8 lb/feddan (1 feddan = 4200 m^2); then, one week after sowing and thereafter at intervals of two weeks, chlorpropham was applied on four occasions at a rate 4-5 lb/feddan. Such treatments provided acceptable weed control and a good stand of onion seedlings.

It was desired to find another herbicide of which one application would be as effective as the four separate applications of chlorpropham. The purpose of this paper is to describe the effects of Alicep (chlorbufam with pyrazon), diphenamid, linuron, ioxynil octanoate, prometryne, and nitrofen when substituted respectively for chlorpropham.

METHOD AND MATERIALS

The trial sites were located at Shandaweel Experimental Station, Upper Egypt, where the soil is loamy clay of pH 7.5. Onion seeds (Giza 6 improved) were here sown on 23rd August at about 1 in. depth on both sides of four ridges in plots of area 6 m^2. The treatments were randomized blocks replicated four times.

The six herbicides were each tested at several rates both pre-planting (though sprayed on the day of sowing) and pre-emergence (sprayed four days after sowing). In further experiments each herbicide was applied at three rates post-emergence when the onions were at the loop stage. In every trial the herbicides were applied by knapsack sprayer at a dilution of 400 l./feddan.

In order of their dominance in untreated parts of the field, the weeds included Phytolacca spp., Melilotus indica, Portulaca oleracea, Chenopodium spp. amongst the annuals, with Cyperus spp. and Cynodon dactylon as perennials.

Table 1

Comparative effects on weeds and onion seedlings of herbicides applied pre-planting and pre-emergence

Herbicide	Rate lb/feddan	Weeds g/plot		Onion seedlings/plot	
		pre-planting	pre-emergence	pre-planting	pre-emergence
Chlorbufam with pyrazon	Hand-weeded	730	730	1510	1510
	0	3423	3423	64	64
	2.0	1516	1078	450	625
	2.5	1464	1025	511	617
	3.0	1333	973	581	672
	3.5	1241	933	559	746
	4.0	1086	739	554	863
	LSD (P=0.05)	522		153	
Diphenamid	Hand-weeded	691	691	1247	1247
	0	4157	4157	43	43
	0.75	1502	1209	395	590
	1.00	1374	1166	485	628
	1.25	1260	1064	495	604
	1.50	1416	1016	570	661
	1.75	1252	861	648	832
	LSD (P=0.05)	486		122	
Linuron	Hand-weeded	488	488	1185	1185
	0	3562	3562	43	43
	0.2	1703	984	408	501
	0.4	1444	803	432	517
	0.6	1251	788	440	600
	0.8	1018	718	479	810
	LSD (P=0.05)	357		127	
Ioxynil octanoate	Hand-weeded	724	724	1193	1193
	0	2461	2461	56	56
	0.3	1123	861	399	583
	0.4	1012	830	428	671
	0.5	984	824	465	749
	0.6	916	613	546	824
	LSD (P=0.05)	630		68	
Prometryne	Hand-weeded	517	517	1211	1211
	0	1613	1613	45	45
	0.2	1316	905	353	449
	0.4	1231	799	393	506
	0.6	1075	755	403	569
	0.8	1010	773	450	741
	LSD (P=0.05)	365		70	
Nitrofen	Hand-weeded	656	656	1129	1129
	0	4600	4600	60	60
	2.0	1227	1107	482	825
	4.0	1238	1072	502	938
	6.0	1202	942	618	1035
	8.0	1221	674	676	1179
	LSD (P=0.05)	516		150	

Table 2

Comparative effects on weeds and onion seedlings of herbicides applied post-emergence

Herbicide	Rate lb/feddan	Weeds g/plot	Onion seedlings per plot
Chlorbufam with pyrazon	2.0	1596	550
	3.0	1430	615
	4.0	1410	725
Diphenamid	0.75	1818	436
	1.25	1583	477
	1.75	1496	597
Linuron	0.4	1779	345
	0.6	1581	386
	0.8	1494	410
Ioxynil octanoate	0.4	1570	534
	0.5	1327	586
	0.6	1071	744
Prometryne	0.4	1736	395
	0.6	1404	469
	0.8	1285	500
Nitrofen	4.0	1328	622
	6.0	1152	888
	8.0	889	1170
Hand-weededd	-	1049	1138
Untreated control	-	4489	73
LSD (P=0.05)		515	103

Weights of fresh weeds and numbers of onion seedlings of more than 0.4 cm diameter were recorded 12 weeks after sowing at harvest time. Data were analysed statistically.

RESULTS

Weeds

Perennial weeds, comprising mainly Cynodon dactylon and Cyperus spp., on the trial site were not visibly affected by any of the herbicides. The effects on annual weeds were recorded for the spectrum of annuals as a whole, and data of Tables 1 and 2 present the average weights of fresh weeds per plot.

Generally, for weed control pre-emergence and post-emergence applications of herbicides were superior to pre-planting applications. Herbicides applied pre- or post-emergence became more effective against annual weeds as rates were raised; at the higher rates there was no significant difference as between the effects of many of the herbicides and the results of hand weeding. The hand-weeded plots were cared for in accordance with good, present day commercial practice. The most effective herbicide was nitrofen, both in pre-emergence applications and in post-emergence applications at the loop stage, at the rate 8.0 lb/feddan. Upon the untreated

control plots there were many more weeds than upon plots of other kinds.

Crop

The average numbers of onion seedlings of the required size are also shown in Tables 1 and 2. The onion seedlings on untreated control plots suffered drastic reduction in numbers as compared with the excellent stand of seedlings of proper size on hand-weeded plots.

On plots treated with five of the herbicides the numbers of onion seedlings was significantly smaller than on hand-weeded plots; whereas the application of nitrofen at 8 lb/feddan, either pre- or post-emergence, yielded numbers of onion seedlings not significantly different from the numbers in hand-weeded plots.

DISCUSSION

From standpoints of both weed control and numbers of properly sized onion seedlings, nitrofen was superior to the other herbicides tested in this investigation.

A communication from Trinidad (1964) referred to the tolerance of direct sown onions towards pre-emergence applications of nitrofen. Also, Rogers (1967) found that of several herbicides tested only nitrofen was without harm to the crop.

In our own investigation unsatisfactory results from Alicep (chlorbufam with pyrazon), from diphenamid, linuron, ioxynil octanoate, and prometryne are attributed not only to competition of annual weeds against onion seedlings but partly also to chemical injury. In this connection, in a communication from Stichting Nederlandse Uien-Federatie (1964) Alicep was stated to be injurious on light soils after one week. Furthermore, a report from the National Vegetable Research Station (1965) pointed out that Alicep would cause slight injury to the onions if applied either before crop emergence or at the loop stage, also ioxynil might cause slight crop injury. Roberts & Wilson (1964) reported that prometryne and linuron tend to be injurious if applied before the first leaf stage. Rogers also noted damage from linuron applied too early.

In experiments by Stichting Nederlandse Uien-Federatie (1965) with Alicep and by National Vegetable Research Station (1965) with prometryne, chemical damage was the more severe when heavy rain had followed spraying. Similarly, in our investigation frequent irrigation might have aggravated damage to onion seedlings by residual herbicides other than nitrofen.

A technique for using EPTC and nitrofen in separate applications must next be considered. Our suggestion is to incorporate EPTC into the soil 3 weeks prior to sowing and to apply nitrofen either pre-emergence of onion seedlings or post-emergence at the loop stage.

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EXPERIMENTS WITH POST-EMERGENCE TREATMENTS IN DRILLED ONIONS

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Summary In 1967 - '68, a number of herbicides, with mainly contact action, were examined for post-emergence application in drilled onions. Of the herbicides tested at the crook - 1 leaf stage under wet conditions, desmetryne 0.25 lb caused the least crop damage. This herbicide was highly selective at doses up to 0.375 lb when applied at the 2 leaf and 3 - 4 leaf stages when dry weather preceded and followed spraying. Experiments with 2-azido-4-isopropylamino-6-methylthio-1, 3, 5-triazine (C 7019) suggest that onions are very tolerant to applications of this material at the crook and later stages of growth. At the more sensitive loop stage, crop check occurred at a dose of 2.0 lb per acre. Results with chlorflurazole, cypromid, prometryne and phenmedipham are also included.

INTRODUCTION

The position regarding weed control in drilled onions has improved considerably in recent years with the introduction of propachlor and the mixed formulation of pyrazon plus chlorbufam. Repeated applications of these residual herbicides can, in the absence of resistant weed species, reduce hand-weeding and cultivation to a minimum (Cassidy & Doherty 1966 - 1968). However, for success with these materials careful timing of application in relation to weed growth is essential since neither pyrazon/chlorbufam or propachlor are effective on most weeds that have outgrown the cotyledon stage. Adequate soil moisture is also necessary for satisfactory results. In the absence of irrigation this can often be a problem under Irish conditions particularly during the months of May and June. There is therefore a need for a good contact herbicide preferably with some residual activity which could be applied post-emergence from the loop - crook stage onwards. The application of this herbicide would be a follow up to the now accepted practice of using paraquat alone or in combination with propachlor or pyrazon/chlorbufam prior to crop emergence.

Although sulphuric acid and sodium monochloroacetate have been used post-emergence in onions for some considerable time and are still the only contact herbicides recommended for this purpose (Weed Control Handbook 1968), they have many disadvantages. Both have definite limitations as regards application, crop selectivity and weed control.

In this paper results are described of trials carried out in 1967 -'68 in which a number of mainly contact herbicides were tested.

METHOD AND MATERIALS

Trials were sited at Kinsealy on a medium loam soil containing 23.5% clay and 7.0% organic matter. A randomized block design was used with four replicates and plot size was 10 - 20 yd^2. Sprays were applied at a volume of 40 gal/ac using an Oxford Precision Sprayer or a pressure-retaining knapsack. All doses are given as lb/ac a.i. In all experiments at least two visual assessments of treatment effect on crop and weeds were made. Plant or bulb counts were recorded and these are presented in tables as percentages of the control or standard treatment value. Statistically significant depressions at $p < 0.05$ are indicated by asterisks. Crop yields are also given. In 1968 trials weed kill was assessed by counting survivors in a number of random quadrats on each plot.

RESULTS

In 1967 four herbicides were examined in two experiments principally to evaluate crop tolerance. In the first experiment the crop (var. Primodoro) was sprayed at the late crook - 1 leaf stage, 23 days after emergence, when approximately 75% of the plants were showing the first true leaf. Results are given in Table 1.

Table 1

Effect of post-emergence treatments on stand and yield of onions 1967

Var. Primodoro

Treatment	Dose lb/ac	Experiment 1 Applied crook - 1 leaf stage		Experiment 2 Applied 3 - 4 leaf stage	
		Yield tons/ac	Onion stand as % of control (6 plants/ft^2)	Yield tons/ac	Onion stand as % of control (5 plants/ft^2)
Desmetryne	0.25	14.8	78*	17.3	112
"	0.375	12.2	50*	17.4	114
Prometryne	0.5	13.9	62*	17.2	110
"	0.75	11.2	44*	16.6	115
Cypromid	1.0	13.6	68*	12.8	99
"	1.5	12.4	44*	12.8	106
Chlorflurazole	1.5	9.7	34*	16.8	105
"	2.0	7.8	24*	17.5	102
Hand-weeding		15.0	100	14.6	100
S.E. of treatment mean (df=27)		±0.9		±1.4	

In the week prior to application almost 2 in. of rainfall was recorded and in the week following spraying over 1 in. fell. All treatments, even the lowest doses applied, caused crop injury, the least-developed onion plants being more severely affected. Desmetryne at 0.25 lb was the least injurious; although a significant reduction in plant numbers occurred, total yield was not reduced compared with hand-weeded control plots. At the higher dose of 0.375 lb plant stand was reduced by 50%. However, plants which survived recovered well and the final yield was not greatly reduced because of the larger bulb size which resulted from the lower plant density. Severe leaf injury also occurred with prometryne at both doses. Plant kill was greater at the higher dose of 0.75 lb. Again, as with desmetryne, surviving plants showed no permanent check to growth and produced bulbs of marketable size and quality. Similar results were obtained with cypromid. Foliar scorch and reduction in plant stand were most severe in plots treated with chlorflurazole.

When the treatments were applied the weed population was low since the entire trial area had already been sprayed with a mixture of pyrazon/chlorbufam 1.8 lb + paraquat 0.5 lb 4 days prior to crop emergence. The few surviving weeds from this treatment were mainly Fumaria officinalis, Veronica persica, Chenopodium album, Senecio vulgaris, Lamium purpureum and Poa annua. Most species were at the 2 - 4 true leaf stage when post-emergence treatments were applied. Good control was obtained except for Poa annua which proved resistant to all treatments except cypromid.

In the second trial the same treatments were applied when the crop had reached the 3 - 4 true leaf stage, 7 weeks after emergence. Results are given in Table 1. A period of dry weather preceded and followed spraying and the crop was growing vigorously at this stage. Very slight socrch of the leaf tips on occasional plants was evident where desmetryne, prometryne and chlorflurazole was applied and even with the highest dose of these herbicides no depression of yield or stand occurred. Cypromid at 1.0 and 1.5 lb caused severe leaf injury and the crop, although it subsequently recovered, received a serious setback. This is reflected in the lower yields obtained from cypromid-treated plots compared with control or other treatments (Table 1).

Very few weeds were present in this trial when treatments were applied; the area having received pre-emergence application of pyrazon/chlorbufam 1.8 lb + paraquat 0.5 lb with propachlor 3.9 lb + chlorpropham 1.0 lb at the 1 true leaf stage. Only a few plants of Fumaria officinalis, Senecio vulgaris, Lamium purpureum and Chenopodium album had survived. These were mainly at the 2 - 6 leaf stage at the time of spraying and all treatments gave generally satisfactory control. A few large plants of Senecio vulgaris were not completely killed by these herbicides and large (6 in.) Chenopodium album also survived treatment with prometryne.

In three experiments carried out in 1968, 2-azido-4-isopropylamino-6-methylthio-1, 3, 5-triazine (C 7019) was examined at the loop, crook, 2-leaf and 2 - 3 leaf stages. This herbicide had shown promising selectivity in preliminary trials elsewhere in 1967 (Smith, J. M. Personal communication). Experiments in other crops in 1967 had also indicated that C 7019 had very useful contact and residual properties (Cassidy & Doherty 1968).

In the first experiment C 7019 was applied at the loop and crook stages of growth. Propachlor at 3.9 lb was included as a standard treatment. Results of previous trials showed that propachlor was highly selective at these early post-emergence stages (Cassidy 1966-1968). In addition a mixture containing propachlor 3.9 + chlorpropham 1.0 lb was also tested. Applications at the loop stage were made 12 days after the crop emerged and those at the crook stage 11 days later. Four days before emergence all plots in the trial area were sprayed with paraquat 0.5 lb per acre. During the week prior to application of treatments at the loop stage less than $\frac{1}{2}$ in. rain fell, while a similar amount was recorded during the 7 days after spraying. Rainfall was insignificant during the period prior to and following application of treatments at the crook stage. Results of this trial are given in Table 2.

Table 2

Effect of post-emergence treatments applied at loop and crook stage on onion stand and weeds, var. Wijbo. 1968

Treatment	Dose lb/ac	Stage applied	Yield tons/ac	% onion stand[1]	% weed kill A	B	C	D	E	F
Propachlor	3.9	Loop	21.4	100	59	82	68	50	66	0
Propachlor + chlorpropham	3.9 1.0	"	27.5	102	82	97	100	97	83	75
C 7019	2.0	"	22.7	76	83	80	98	100	96	94
Propachlor	3.9	Crook	19.5	91	25	73	60	41	67	0
Propachlor + chlorpropham	3.9 1.0	"	30.0	100	37	77	73	79	13	6
C 7019	2.0	"	26.7	93	45	73	100	93	88	82
"	4.0	"	28.8	103	69	84	100	100	79	100
S.E. of treatment mean (df=26)			1.05							

[1] Compared to propachlor 3.9 lb at loop stage.

A Poa annua B Veronica spp. C Stellaria media D Papaver rhoeas
E Lamium purpureum F Fumaria officinalis

Note. The comparatively lower yields obtained with propachlor 3.9 lb can be attributed to weed competition which occurred before the plots were hand-weeded.

At the loop stage, C 7019 2 lb caused severe crop check and plant stand was reduced compared with other treatments. When applied 11 days later at the crook stage the crop was considerably more tolerant to C 7019. Even at 4 lb per acre only slight temporary check occurred with no depression in plant stand. Propachlor 3.9 lb and the mixture of propachlor 3.9 lb + chlorpropham 1.0 lb proved highly selective at both stages of application.

In the trial area there was a dense weed infestation of 33 plants/ft^2. Poa

annua was the predominant species. Other main weeds in order of prevalence were Veronica spp., Stellaria media, Papaver rhoeas, Lamium purpureum and Fumaria officinalis. Weeds were mainly at the cotyledon stage when treatments at the loop stage were applied. Rapid weed growth occurred between this date and the application of treatments at the crook stage and most species had 4 true leaves at time of spraying. Weed cover was estimated at 60%.

C 7019 2 lb at the earlier stage gave excellent weed control with only a few plants of Poa annua and Veronica spp. surviving. Plots receiving this treatment were still almost weed-free 7 weeks after spraying. At the later application, weed control was also satisfactory with this herbicide, particularly at 4.0 lb/ac. At the lower dose of 2.0 lb only moderate to poor control of Poa annua was obtained and large plants of Veronica spp. survived.

Less effective control was obtained with propachlor 3.9 lb. Fumaria officinalis was resistant at both stages of application and control of other species except Veronica spp. was not as good as with C 7019 2.0 lb applied at either stage. The addition of chlorpropham 1.0 lb gave much improved control at the earlier application particularly of Fumaria officinalis, Stellaria media, Poa annua and Papaver rhoeas. This treatment proved as effective as C 7019 2.0 lb applied at the same stage. With application at the crook stage when weed growth was advanced, control was not as satisfactory with this mixture and clearly indicated the importance of applying these residual herbicides before or at weed emergence for successful results.

In a second experiment, C 7019, desmetryne and phenmedipham at two doses were compared for application at the 2 - 3 leaf stage. A mixture containing propachlor 3.9 lb + chlorpropham 2.0 lb was also included. The trial area was treated pre-emergence with propachlor 3.9 lb + chlorpropham 0.5 lb + paraquat 0.5 lb. When post-emergence treatments were applied 7 weeks later Poa annua was the predominant species present. There were also occasional plants of Fumaria officinalis, Stellaria media and Lamium purpureum. These were advanced in growth, Fumaria officinalis being up to 6 in. and Lamium purpureum about 4 in. high at time of spraying. Treatments were applied during a period of dry weather. No rainfall was recorded in the 3 days prior to application or for 9 days afterwards. Results are given in Table 3.

Table 3

Effect of post-emergence treatments applied 2 - 3 leaf stage on onion stand and weeds, var. Wijbo. 1968

Treatment	Dose lb/ac	Yield tons/ac	Onion stand as % of control	% weed kill			
				Poa annua	Fumaria officinalis	Stellaria media	Lamium purpureum
Desmetryne	0.25	25.2	100	20	93	74	48
"	0.375	25.1	104	20	97	87	60
C 7019	2.0	26.1	100	61	52	83	32
"	4.0	27.4	112	71	83	96	68
Phenmedipham	1.6	24.6	108	0	90	74	80
"	3.2	23.0	104	29	100	100	92
Propachlor + chlorpropham	3.9 2.0	24.5	104	32	38	57	20
Control (Hand-weeded)		20.4	100				
S.E. of treatment mean (df=27)		1.29					

Assessments taken 11 days after spraying showed that C 7019 at 2.0 lb was very selective with a few onion plants only showing slight tip scorch. At the higher dose of 4.0 lb there was a slight increase in foliar scorch. This injury however was short-lived and the crop quickly recovered. Desmetryne 0.25 lb was also highly selective but with a dose of 0.375 lb more scorch and crop check occurred than in plots treated with C 7019 4.0 lb. Severe foliar injury was obtained with phenmedipham

1.6 lb and 3.2 lb. Onion plants also showed slight epinastic twisting in plots treated with this herbicide. Although the crop received a serious initial set-back it subsequently recovered and symptoms of damage were not detectable a month after spraying. No crop damage was evident where the mixture of propachlor 3.9 + chlorpropham 2.0 lb was applied. Plant counts taken 3 weeks after application of treatments showed that none of the herbicides caused any depression in plant stand compared with hand-weeded control plots. Except with phenmedipham 3.2 lb, yields were also significantly higher than with the control treatment (Table 3).

Of the treatments used only C 7019 had any appreciable effect on Poa annua. Severe check and over 60% kill of this weed was obtained at a dose of 2.0 lb/ac. This dose, however, failed to control large plants of Fumaria officinalis and Lamium purpureum. Although these species were severely scorched initially they subsequently recovered. Much improved control was obtained at the higher dose.

Control of weeds other than Poa annua was generally satisfactory with desmetryne at 0.25 and 0.375 lb/ac although large plants of Lamium purpureum and the odd Stellaria media survived. Considering the advanced stage of weed growth phenmedipham gave good control of most species except Poa annua which was completely resistant at a dose of 1.6 lb. The combination of advanced weed growth and dry soil conditions was undoubtedly responsible for the relatively poor weed control obtained with the propachlor/chlorpropham mixture.

In a further experiment the effect of desmetryne 0.25 lb, C 7019 2.0 lb, phenmedipham 1.0 lb and metoxuron 3.2 lb was examined on 4 late sown onion varieties. These were Primodoro, Pukehohe, Bola and Dura. Treatments were applied at the 2-leaf stage when the first true leaf was about 5 in. high. As in the second experiment dry weather preceded and followed application. Weed population was low and consisted mainly of Fumaria officinalis, Lamium purpureum, Stellaria media, Veronica spp., Senecio vulgaris, Poa annua and Capsella bursa-pastoris. These were principally at the 4 - 6 true leaf stage when treatments were applied.

Excellent weed control was obtained with desmetryne 0.25 lb. Only a few Fumaria officinalis, Poa annua and Lamium purpureum survived. Some tip scorch and slight reduction of vigour occurred, particularly in the variety Dura. C 7019 2.0 lb proved even more selective than desmetryne and weed control, particularly of Poa annua was slightly better.

Considerable foliar scorch occurred immediately after spraying where phenmedipham 1.0 lb was applied. Pukehohe appeared more susceptible to injury. All varieties recovered quickly from this check and after a month very little trace of damage was evident. Except for Poa annua and large plants of Lamium purpureum, Senecio vulgaris and Fumaria officinalis this herbicide gave very effective control.

No crop damage was apparent in plots treated with metoxuron 3.2 lb for a period of 2 weeks after application during which the weather remained dry. However, following heavy rain (over 1 in. in 3 days) serious crop check occurred. The main symptoms were severe tip scorch and loss of turgidity. Crop damage was particularly severe in the varieties Pukehohe and Dura.

DISCUSSION

In 1967, none of the herbicides tested for post-emergence contact activity showed sufficient selectivity when applied at the crook - 1 leaf stage. Although least injury occurred with desmetryne 0.25 lb per acre, this treatment caused a significant reduction in plant stand compared with handweeded control plots (Table 1). Most damage was observed on the less forward plants on which the first true leaf had not developed. It must be noted that treatments were applied following a period of heavy rain when increased herbicidal injury could result from leaf uptake. Under dry conditions and with all plants having a well-developed first true leaf much less damage could be expected with desmetryne. In 1967 when applied at the 3 - 4 leaf stage and in 1968 at the 2 leaf and 2 - 3 leaf stages no crop injury occurred with desmetryne at doses up to 0.375 lb/ac (Tables 1 and 3). Applications in all cases were made during a spell of dry weather.

Prometryne up to 0.75 lb and chlorflurazole 2.0 lb were also highly selective at the 3 - 4 leaf stage. Cypromid even at 1.0 lb severely checked the crop at this stage and yields were reduced (Table 1).

In the 1968 experiments, C 7019 was included for the first time. Results suggest that this herbicide is a promising post-emergence treatment for onions. The crop was highly tolerant to doses up to 4.0 lb applied at the crook and post-crook stages (Tables 2 and 3). Dry weather conditions coincided with its application at these stages and information is therefore lacking on the selectivity of this material under moist conditions. Damage might probably occur under these conditions through leaf and root uptake even at the crook or later stages of growth. Roberts and Wilson 1964 have reported serious crop damage through root uptake on a light soil with post-emergence applications of prometryne and other herbicides having contact and residual properties when heavy rain followed spraying. At the earlier more sensitive loop stage when moderate amounts of rain fell severe crop check and some reduction in plant stand resulted with C 7019 2.0 lb.

C 7019 was found effective on many important weeds of onion crops. Only Poa annua and Veronica spp. showed some resistance in these trials. Even weeds advanced in growth were well controlled. Satisfactory control was obtained for period of over 7 weeks which indicates that this herbicide has good residual properties in addition to its contact activity. Although phenmedipham 1.6 lb caused severe foliar scorch following application, the high yield obtained with this treatment shows that no permanent reduction in vigour occurred (Table 3).

On the basis of these trials it is suggested that desmetryne is a suitable alternative to the presently recommended post-emergence contact treatments for onions, once the crop has reached the 1 true leaf stage and provided that application is made under dry weather conditions. C 7019 is also worthy of more intensive investigation particularly on lighter soils and under different weather conditions to establish its apparent potential as an early and late post-emergence treatment for this crop.

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EVALUATION OF 2-AZIDO-4-ISOPROPYLAMINO-6-METHYLTHIO-S-TRIAZINE (C 7019) FOR WEED CONTROL IN VEGETABLE CROPS

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Summary In field tests on a sandy loam, turnip, cauliflower, red beet, lettuce, spinach, carrot, parsnip, parsley and dwarf bean were injured by pre- and post-emergence applications of C 7019 sufficient to give good weed control. Peas showed tolerance to 2 lb/ac a.i. both pre- and post-emergence and broad beans were not affected pre-emergence. Cabbage and radish were only slightly injured by 2 lb/ac pre-emergence; cabbage and Brussels sprouts withstood treatment after the 2-leaf stage and after transplanting. Onions and leeks also showed some tolerance to pre-emergence sprays and to post-emergence treatment after the 2-leaf stage. C 7019 at 2 lb/ac gave effective control of a number of common annual weeds of vegetable crops, whether applied before emergence or to plants at the seedling stage.

INTRODUCTION

The herbicidal properties of 2-azido-4-isopropylamino-6-methylthio-s-triazine (C 7019) were first described by Green, Ebner & Schuler (1967). It was shown that this chemical could act both through the soil and as a foliar spray and that selective control of annual weeds could be obtained in several cruciferous crops and also in peas.

Preliminary field experiments to determine possible uses of this herbicide for weed control in vegetable crops were made at Wellesbourne in 1967 (Roberts & Hewson, 1968), and were continued in 1968. The results obtained are summarized in the present report.

METHODS AND MATERIALS

The experiments were all on a sandy loam of the Newport series, relatively low in organic matter. Except for those involving a range of crops, the experiments were of randomized block design with small plots of 5 - 10 yd^2 and three replicates. The sprays were applied in a volume of 100 gal/ac and a 50% wettable powder formulation was used. Doses are given as lb/ac a.i. throughout. Weed kill was assessed by counting survivors in a number of random quadrats on each plot and visual estimates of weed kill were also made. In some experiments, all plots were then weeded in order to assess the effect of the herbicide on the crop in the absence of any appreciable weed competition. In others, the sprayed plots were not weeded but were compared with both unweeded and hand-weeded controls. Crop injury was assessed visually, using a scale of 0 (no effect) to 10 (complete kill), and records of crop fresh weight or marketable yield were also taken. In the Tables, crop stands and weights are expressed as percentages of the control values and those significantly less ($P = 0.05$) are indicated by asterisks.

RESULTS

Weed control

Applications of 1 to 4 lb/ac prior to the emergence of mixed stands of annual

weeds were made on more than twenty-five occasions during two seasons. With 1 lb/ac there was a range of 28 - 97% kill and a median of 77%; with 2 lb/ac, the range was 73 - 99% kill and the median 93%. All the applications of 4 lb/ac gave more than 94% kill. Species that were consistently killed either completely or almost completely by 2 lb/ac included Stellaria media, Chenopodium album, Poa annua, Senecio vulgaris, Solanum migrum, Viola arvensis, Urtica urens, Capsella bursa-pastoris, Matricaria matricarioides, M. recutita, Tripleurospermum maritimum ssp. inodorum and Fumaria officinalis. Certain other species, including Polygonum aviculare, were rather more tolerant and were not always killed by 2 lb/ac, while the most tolerant species of those encountered were Raphanus raphanistrum, Sinapis arvensis, Veronica hederifolia and Thlaspi arvense.

Most of the weed species susceptible to pre-emergence applications were also killed in the seedling stage by post-emergence sprays of C 7019. Certain of them, notably Stellaria media, Senecio vulgaris and Fumaria officinalis were killed by 2 lb/ac even when quite large. Others, however, such as Poa annua, Capsella bursa-pastoris, Matricaria matricarioides, M. recutita and Tripleurospermum maritimum ssp. inodorum soon acquired tolerance once they had passed the early seedling stage.

Crop tolerance

Four tests were made, under different rainfall conditions, in which C 7019 at doses of 1, 2 and 4 lb/ac was applied immediately after drilling across single rows of fourteen different vegetable crops. The responses were assessed visually and the results are summarized in Table 1.

Table 1.

Response of vegetable crops to pre- and post-emergence applications of C 7019

Crop	Range of injury observed (0 = no effect; 10 = complete kill)				
	Pre-emergence (four tests)			Post-emergence (two tests)	
	1 lb/ac	2 lb/ac	4 lb/ac	1 lb/ac	2 lb/ac
Radish	0	0 - 3	3 - 5	4 - 5	5 - 9
Cabbage	0 - 1	0 - 4	4 - 7	0	0
Turnip	4 - 8	7 - 10	8 - 10	5 - 10	7 - 10
Lettuce	3 - 9	7 - 10	8 - 10	7 - 8	8 - 10
Carrot	0 - 6	3 - 8	6 - 10	2 - 5	3 - 7
Parsley	0 - 5	0 - 9	5 - 10	-	-
Parsnip	0 - 4	2 - 7	5 - 8	0 - 3	0 - 4
Spinach	0 - 3	0 - 4	5 - 6	4	7 - 9
Red beet	0 - 6	5 - 9	8 - 10	8	9 - 10
Onion	0 - 4	0 - 5	4 - 5	2 - 5	2 - 5
Leek	0	0 - 3	4 - 5	0 - 1	0 - 1
Pea	0	0 - 2	0 - 3	0	0
Dwarf bean	0	2	5 - 6	5 - 6	7 - 8
Broad bean	0	0	0 - 4	3 - 4	4
Weeds	6 - 8	7 - 10	8 - 10	5 - 7	7 - 9

Turnip, lettuce and red beet were very susceptible to C 7019 applied before emergence. The results with carrot, parsley, parsnip and spinach were more variable, but these also appeared to be relatively susceptible. With the remaining crops, radish, cabbage, onion, leek, pea, dwarf bean and broad bean, there appeared to be greater tolerance and at 2 lb/ac the crop injury was comparatively slight. Dwarf bean (two tests only) was more severely injured by 4 lb/ac than were pea or broad bean.

Glasshouse tests were made in which various vegetable crops were grown in nutrient sand cultures to which different concentrations of C 7019 had been added, and the concentrations required to produce a standard response were determined. The results were generally in accord with those obtained in the pre-emergence field tests. Among the cruciferous crops, radish, savoy and Brussels sprout showed the same level of tolerance as cabbage. Turnip was much more susceptible, while cauliflower, broccoli, two varieties of oil seed rape (one Brassica napus, the other B. campestris) and swede were also more susceptible than cabbage. The most susceptible of the crops examined was cress. Dwarf bean proved more susceptible than runner bean, broad bean or pea.

Two field tests were also made in which C 7019 was applied to vegetable crops as post-emergence sprays. In one of these, no rain fell between application and assessment, so that the effects observed could be attributed to action via the foliage. Crops which were susceptible to pre-emergence application were also susceptible post-emergence (Table 1), and radish, broad bean and dwarf bean were injured by 1 lb/ac, a dose which had caused no injury pre-emergence. Cabbage (1 - 2 true leaves) and pea (4 leaves) were not affected by 2 lb/ac, while leek (1 true leaf) was only slightly affected and was more tolerant than onion at the same stage.

C 7019 was included in replicated field tests with several vegetable crops, and the results are summarized below.

Peas. In 1967 with only light rainfall, doses of 1, 2 and 4 lb/ac gave good weed control when applied pre-emergence, with no crop injury or adverse effect on crop weight. In a second trial heavy rain fell after application, and even under these conditions there was no crop injury with 1 lb/ac and only slight effects with 2 and 4 lb/ac. The relative tolerance of peas was confirmed in 1968 when in two trials 2 lb/ac was without adverse effect and 4 lb/ac caused only slight injury. Post-emergence applications at the 2 - 5 leaf stages of 2 lb/ac did not harm the crop, although in one trial there was an indication of some injury when applied shortly after emergence.

Dwarf beans. Pre-emergence applications of C 7019 were examined in three trials, two in 1967 and one in 1968. In the first, with only light rainfall, 1 lb/ac caused slight chlorosis and leaf necrosis, while with 2 lb/ac these effects were more severe. Both doses reduced crop weight by 12%, which was just statistically significant ($P = 0.05$). In the second trial, heavy rain fell shortly after application and both doses produced pronounced leaf necrosis; with 2 lb/ac crop weight was reduced by more than 50%. A similar result with the same variety (Tendergreen) was obtained in 1968, although injury was less pronounced with the variety Processor.

Runner beans. In a single trial, pre-emergence application of 1 and 2 lb/ac gave very good weed control with no adverse effects other than slight leaf necrosis on a few plants with 2 lb/ac.

Broad beans. Pre-emergence application of 2 lb/ac in 1967 to the variety Triple White gave weed control similar to that given by the standard treatment of 0.75 lb/ac simazine with no effect on growth or crop weight. The same result was obtained in 1968.

Cabbage. Pre-emergence application of C 7019 to drilled cabbage was examined in several trials, and the results from two of them are shown in Table 2.

With 1 and 2 lb/ac, there was only slight early crop injurty and no significant reduction in crop stand or fresh weight measured 7 - 8 weeks after application. In both trials, however, 4 lb/ac significantly reduced fresh weight and in one the crop stand was also reduced. In a further trial on drilled spring cabbage, 2 lb/ac

gave rather better weed control than the standard propachlor and nitrofen treatments and crop weight was not reduced compared with that from the weeded control.

Table 2.

Effect of pre-emergence applications of C 7019 on drilled Winningstadt cabbage

lb/ac	1967			1968		
	% weed kill	crop injury 0 - 10	wt as % of control	% weed kill	crop injury 0 - 10	wt as % of control
1	85	1	90	90	1	118
2	93	1	120	98	3	91
4	99	4	75*	100	6	54*

Post-emergence applications at different growth stages were also made in several trials (Table 3). Even with 1 lb/ac the cotyledons were killed and at the early 1-leaf stage there was a check to growth; in another trial, treatment with 2 lb/ac at the late cotyledon stage killed more than 75% of the crop. In general, application from the 2-leaf stage onwards was not injurious. It is possible, however, that growing conditions may affect the result; in one trial on drilled spring cabbage, 2 lb/ac applied at the 4-leaf stage caused stunting and a reduction in yield.

Table 3.

Effect of post-emergence applications of C 7019 on drilled cabbage

	Fresh wt as % of control				
	1967, Durham Early			1968, Winningstadt	
Stage	1 lb/ac	2 lb/ac	Stage	1 lb/ac	2 lb/ac
Early 1-leaf	84	-	Early 2-leaf	110	102
2-leaf	92	-	3-leaf	99	91
4-leaf	99	85	4-leaf	89	89

Transplanted cabbage appeared to have a high degree of tolerance to C 7019. Doses of 2 and 4 lb/ac applied to summer cabbage and spring cabbage shortly after transplanting gave excellent weed control with no injury or reduction of yield.

Brussels sprouts. Limited tests indicated with this crop resembled cabbage in tolerance to C 7019. Good results were obtained also on transplanted Brussels sprouts.

Cauliflowers. This crop was found to be appreciably more susceptible than cabbage to C 7019. Pre-emergence application of 1 lb/ac to drilled autumn cauliflowers reduced stand and yield by more than 50%, and post-emergence applications were also damaging. Three varieties of transplanted early summer cauliflower were injured by 1 lb/ac applied after planting, while 2 lb/ac reduced yield appreciably.

Onions. This crop appeared to have some tolerance to C 7019 in the preliminary tests and a trial was made in 1968 in which 1 and 2 lb/ac were applied either after drilling in March or shortly before crop emergence. In addition, 1 lb/ac was applied at both times. All the plots were subsequently weeded and the results are shown in Table 4.

Table 4.

Effect of pre-emergence applications of C 7019 on drilled onions and leeks

Treatment	Onions % weed kill	Onions crop injury 0-10	Onions % of control stand	Onions % of control yield	Leeks % weed kill	Leeks crop injury 0-10	Leeks stand as % of control
1 lb/ac post-drilling	73	0	100	85*	59	0	91
2 lb/ac post-drilling	77	2	98	83*	82	0	102
1 lb/ac late pre-em.	87	1	111	98	97	0	95
2 lb/ac late pre-em.	90	2	90	96	97	1	82*
1 lb/ac + 1 lb/ac	93	4	91	86*	99	0	95

Weed control was better late pre-emergence than when the sprays were applied shortly after drilling, and the split application also gave good results. There was some early crop injury but no significant reduction in stand. The post-drilling treatments resulted in yield reductions which were just significant, probably because some competition took place prior to weeding. The split application caused greatest visible injury and also reduced the yield.

Table 5.

The effect of post-emergence applications of C 7019 on White Lisbon salad onions

Stage of growth	Crop injury, 0 - 10 1 lb/ac	Crop injury, 0 - 10 2 lb/ac	Yield as % of control 1 lb/ac	Yield as % of control 2 lb/ac
Early 1-leaf	1	3	97	92
1-2 leaf	0	1	106	91
2-3 leaf	0	0	100	103

Post-emergence applications of C 7019 were made in several trials. In one, all the plots were treated pre-emergence with propachlor and subsequently kept clean. There was slight injury at the early 1-leaf stage, but none of the treatments adversely affected stand or yield (Table 5). In another trial on salad onions sown for overwintering, 2 lb/ac at the 1-leaf stage reduced stand by 50% whereas application at the 3-leaf stage did not affect it. The stand of bulb onions was also drastically reduced by 1 and 2 lb/ac at the early 1-leaf stage, while later applications had no effect. In a further trial on a clean crop of bulb onions, 2 lb/ac at the 3-4 leaf stage did not reduce the yield.

Leeks. Pre-emergence applications were made on leeks drilled in March (Table 4). As with onions sown at about the same time, weed control was better when the treatments were applied shortly before crop emergence, and only 2 lb/ac applied then had any adverse effect on the crop. From other tests, it appeared that leeks tolerated post-emergence applications better than onions, and in a single trial on transplanted leeks 2 and 4 lb/ac caused no injury or yield reduction when applied after planting out.

DISCUSSION

The tests described were exploratory in nature, to determine those crops for

which C 7019 might have possibilities as a selective herbicide. It is clear from Table 1 that turnip, red beet and lettuce were very susceptible to both pre- and post-emergence application, while carrot, parsley, parsnip and spinach, though more variable in response, were also relatively susceptible.

Peas were one of the most tolerant crops, and the results suggest that C 7019 may prove to be useful in this crop both as a pre- and a post-emergence treatment. Good results were also obtained with pre-emergence applications on broad beans, although this crop was injured by sprays applied after emergence. Dwarf beans were severely injured by post-emergence applications (Table 1), and in subsequent tests when heavy rainfall occurred there was also damage from pre-emergence treatments. Further examination on runner beans may be merited, since the single test suggested that this crop may be more tolerant than dwarf beans.

There were considerable variations in the susceptibility of different cruciferous crops to C 7019. Turnip was severely damaged in all the tests (Table 1), while radish, though damaged by post-emergence treatment, appeared relatively tolerant to applications made immediately after drilling. Cauliflower was comparatively susceptible, and pre-emergence, post-emergence and post-planting applications of 1 lb/ac all caused an unacceptable degree of injury.

One of the main potential uses of C 7019 appeared to be for selective weed control in cabbage. With doses of up to 2 lb/ac pre-emergence, there was only slight injury from which the crop recovered. On the light Wellesbourne soil, however, the safety margin may not be very great; with 4 lb/ac there was always crop injury, sometimes severe (Table 2). Cabbage was also relatively tolerant to post-emergence applications. On some occasions, though not always (Table 3), a proportion of plants at the 1-leaf stage was killed by 1 and 2 lb/ac but treatment once the plants had passed the 2-leaf stage appeared fairly safe. Transplanted cabbage, and also Brussels sprouts, were tolerant.

The results suggest that C 7019 merits further examination on onions and leeks. Both crops showed some tolerance to pre-emergence applications of 1 and 2 lb/ac (Table 4) and good weed control was obtained. There was also appreciable tolerance to post-emergence applications, when the crop had passed the 2-leaf stage. If these indications are confirmed, C 7019 might prove useful as a follow-up treatment in these crops.

Many of the important annual weeds of vegetable crops were killed by 2 lb/ac either before emergence or when the weeds were in the seedling stage. The minimum kill of mixed populations of weed species, assessed about one month after application, was 73% and in half the tests it exceeded 93%. Frequently the weed control was of long duration and plots were satisfactorily clean at harvest. Even with 1 lb/ac the results were often good, and it is probable that on this light soil a dose of rather less than 2 lb/ac would suffice to give consistent weed control.

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