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PICLORAM - EFFECT ON WINTER TURNIP RAPE AND WINTER RAPE AFTER SPRING TREATMENT

G. S. Ebbersten
Department of Plant Husbandry, Agricultural College of Sweden, Uppsala 7, Sweden

Summary Spring treatment at six developmental stages with 50 g picloram, (4-amino-3,5,6-trichloropicolinic acid) per hectare in autumn-sown Brassica crops resulted in crop damage, crop losses and increased 1000-seed weight. Winter turnip rape was more sensitive after spring treatment than winter rape. Spring application of picloram in Brassica crops cannot be generally recommended.

INTRODUCTION

The problems encountered in the supply of vegetable fats in Europe during World War II led to a rapid increase in oil-seed cultivation in North-western Europe. In Sweden it was soon found that, as regards productivity, the autumn-sown biennal types of rape and turnip rape were superior to other oil crops. About 45,000 hectares of winter rape and about 15,000 hectares of winter turnip rape are sown every year in Sweden.

The Brassica crops are sown in rows with 45-50 cm spacing to allow tractor hoeing. In spite of tractor hoeing many weeds germinate and grow in the rows. *Tripleurospermum maritimum* ssp. *inodorum* is one of the troublesome weeds in autumn-sown Brassica crops, and leads to technical difficulties at harvest. Thus, the demand from the farmers for a selective herbicide for use in Brassica crops is considerable.

Several authors (e.g. Vernie *et al*., 1966) report good effects against *Matricaria* spp. with picloram. Brassica weeds are said to be considrably less susceptible to picloram (Lawson, 1964; Ritty, 1964). Selective use of picloram in Brassica crops appeared promising. However, some authors (Nölle, 1965) report that Brassica crops show slight injury after treatment with 50 g/ha picloram.

Picloram seemed promising for selective use in Brassica crops when it became available in the Swedish market on a large scale in 1967. The manufacturer recommended spring treatment with 50 g/ha when the crop is 15-20 cm high. However, picloram caused injuries to the crop and a reduction of the seed yield.

For this reason two field trials were performed in 1968 to study the effect of picloram on winter-sown Brassica crops. This paper summarizes the results obtained.

METHOD AND MATERIALS

On two adjoining fields (300 m apart) with identical soil properties (a sandy clay soil) two field trials with picloram were carried out, one trial in winter turnip rape (*Brassica campestris* L. ssp. *oleifera*), the other one in winter rape (*Brassica napus* L. ssp. *oleifera*). The fields were located in the south-western part of Sweden with a relatively humid climate.

The trials were of randomized block design with four replicates in weed-free stands. Each treatment plot (6 × 2 m) consisted of four rows of the crop, and the plots were separated by two guard rows and cross paths. Two unsprayed plots per replicate were included. The herbicide (formulated as the potassium salt) was applied by a 6-litre hand sprayer. The spray volume was 625 litres/ha. There were six dates of application with intervals of 4 days. Spraying dates and details about the crops are given in Table 1.

Table 1.

Date of spraying	Developmental stage of crop at spraying, (height of main shoot)	
	Winter turnip rape (cv. Duro)	Winter rape (cv. Victor)
April 14th	0-4 cm	0-2 cm
April 18th	4-6 cm	3-5 cm
April 22th	8-12 cm	8-10 cm
April 26th	15-20 cm	15-20 cm
April 30th	35-40 cm	25-35 cm
May 4th	40-50 cm	35-45 cm

The plots were harvested by a combine and the yield of the whole plot was weighed. Crop damage due to the chemical was assessed by counting the number of plants with different types of injuries in each replicate 4 weeks before harvest. Two doses of picloram were used in the trials, 50 and 100 g/ha. However, this paper will only discuss results for the 50 g dose.

RESULTS

Crop damage due to the chemical is presented diagrammatically as the percentage number of injured plants of the stand in Figures 1-3.

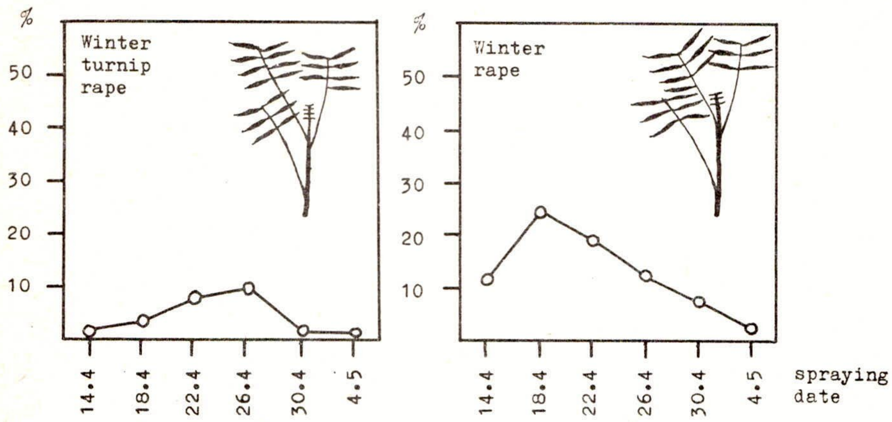
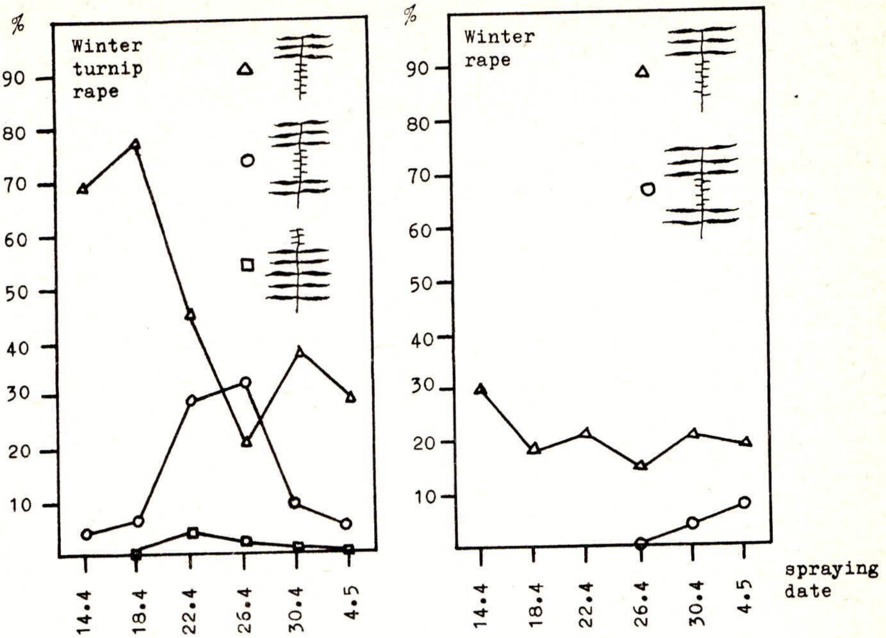
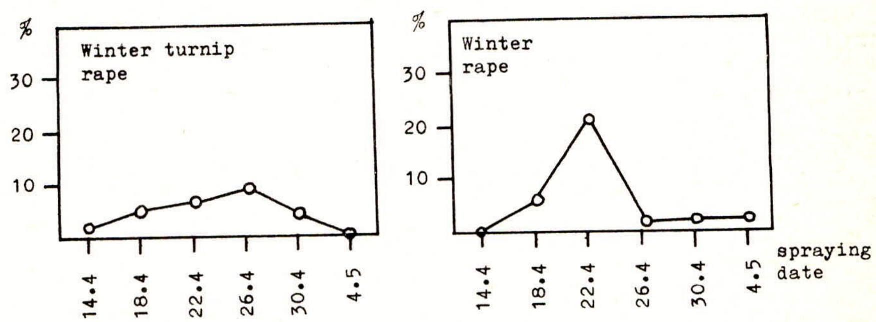


Fig. 1. Percentage number of plants in the stand with dead main shoot. The plants recovered from this injury with the lower branches.



<u>Fig. 2.</u> Percentage number of plants in the stand with pod reduction at the base △ ,the middle ○ ,and the top □ of the pod-raceme.

This injuries on the pod-raceme are the most important reason for the yield decrease. Some of the winter turnip rape plants (about 10 % of the stand) compensated for these injuries later with a new pod-raceme on the top of the old one.



<u>Fig. 3.</u> Percentage number of plants in the stand with prolonged flowering.

Damaged plants compensated for injuries by new flowers. Most of the pods produced by those late flowers did not ripen before harvest.

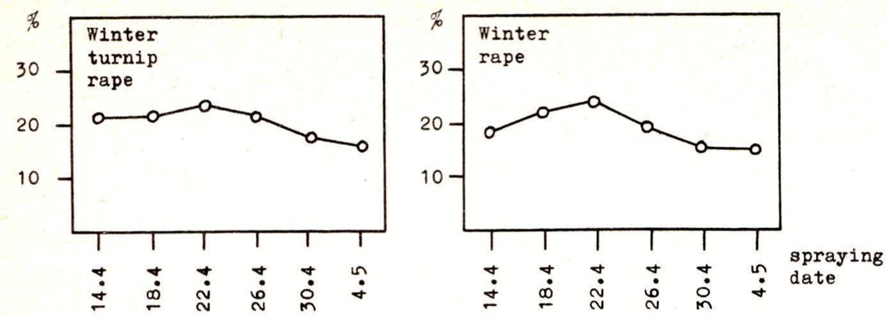


Fig. 4. Percentage water in seed yield. Untreated plot: winter turnip rape 14.4% ; winter rape 16.0 %.

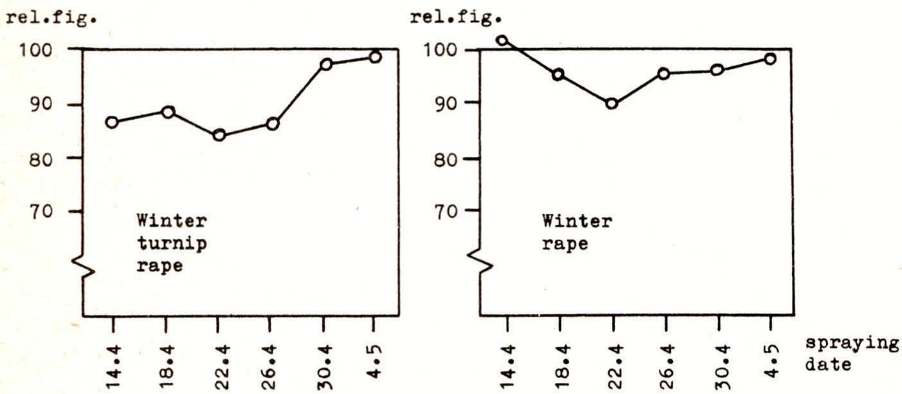


Fig.5. Seed yield adjusted to dry matter (relative figures). Untreated plot = 100; winter turnip rape 3200 kg/ha; winter rape 4200 kg/ha.

The yields have not yet been analysed for oil content and chlorophyll content, but will be later. In Table 2 some figures are given for trials from 1967.

Table 2.

Oil content and chlorophyll content of the seed.

	Oil content in seed, %	chlorophyll content in seed, ppm
Winter turnip rape		
untreated	46.2	6
50 g picloram/ha	44.7	7
Winter rape		
untreated	48.0	8
50 g picloram/ha	46.3	12

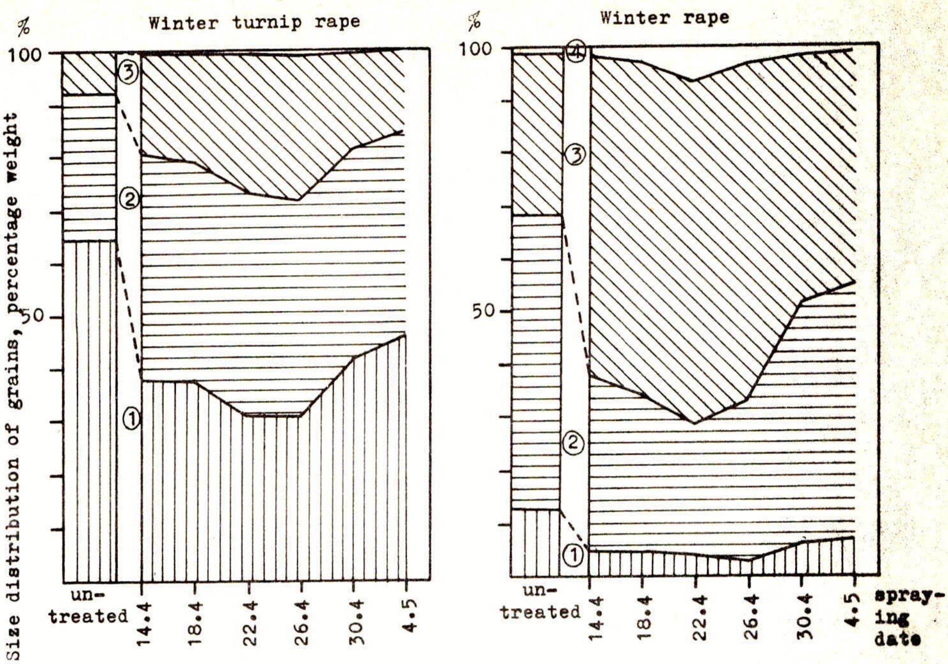


Fig. 6. Effect of picloram on the size distribution of grains.
4, grains 2.50 mm
3, grains 2.00-2.50 mm
2, grains 1.75-2.00 mm
1, grains 1.75 mm

DISCUSSION

The results presented provide evidence that spring treatment with 50 g/ha picloram in winter-sown Brassica crops resulted in injuries and crop losses. The effect of 100 g picloram follows that of 50 g but caused greater crop damage and crop losses.

The growth stage of the Brassica crops is the most important factor governing the effect of picloram. However, it is difficult to define the growth stage exactly because of the great variation in height between single plants of the stand. The height of the stand is not exact enough a character to describe the developmental stage. That is why the results given in the Figures are plotted against the spraying dates instead of the developmental stages.

The general pattern of damage on winter turnip rape caused by picloram is that treatments earlier than the 50 cm stage resulted in severe crop losses. Treatments later than the 25 cm stage are of less interest in practice.

The pattern of injuries to winter rape is somewhat different from that of winter turnip rape. The yield results described in Figure 5 do not show the whole truth about the effect of picloram on winter rape. The tendency for no yield decrease at early stages must not lead to the conclusion that the crop is unaffected by picloram at this stage. Both the water content of seed yield (Fig. 4) and the grain size distribution (Fig. 6) show that the crop is affected by picloram, and the oil content is probably also lowered.

A change in the 1000-seed weight is a good indication of a picloram effect on the Brassica crop. The 1000-seed weight increased after spring treatment (mean values about 15-20 %). However, the 1000-seed weight involves mean values, and it is better to look at the grain size distribution, which reveals the effect of picloram on grain size more accurately.

The prolonged flowering is a dynamic character and depends on the severity of the plant damage, on the environmental conditions, especially soil humidity, and on the time when the counts have been done. Winter turnip rape seems to be more sensitive to picloram than winter rape.

The last year's trials with 50 g/ha picloram (15-20 cm stage) both in winter turnip rape and winter rape caused a slight reduction in germinative ability of the seed.

Preliminary results from autumn treatments with 50 g/ha picloram on winter turnip rape (rosette stage) last year indicate a considerable weakening of the winter hardiness. This result is supported by findings of Raatikainen (1966).

Picloram is more persistent in the soil than most other herbicides. The risk involved in using picloram in areas with mixed crop rotations is thus obvious. Young seedlings of winter turnip rape, sown in the autumn on fields where winter turnip rape was treated with 50 g/ha picloram in the spring of the same year, showed leaf injuries. This happened when the soil was rotary cultivated, but when the surface soil with the herbicide residues was ploughed down, no injuries were visible on the seedlings.

Experiments (bio-assay) to check the effects of picloram residues in straw and seed of treated Brassica crops show that enough picloram is present to give effects on susceptible plants (peas and red clover).

Acknowledgments

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INVESTIGATIONS INTO THE CHEMICAL CONTROL OF SOME ANNUAL WEEDS AND PERENNIAL GRASSES IN OIL SEED RAPE

D.H. Bartlett and R.A. Jones
The Murphy Chemical Company Limited, Wheathampstead

H.A. Castle
Twyford Seeds Limited, Banbury, Oxford.

Summary. A trial in 1967 was carried out on oil seed rape to compare pre-emergence applications of nitrofen 3lb/ac a.i. and propachlor 3.9lb/ac a.i.; results indicated that nitrofen gave the best weed control. A further trial in 1968 with these two materials demonstrated their superiority in annual weed control over the other treatments tested. A second trial was laid down in 1968 to compare a number of treatments for the control of couch grasses and annual weeds in oil seed rape. EPTC 4lb/ac a.i. gave the best control of couch and annual weeds; other promising treatments for this crop were trifluralin 1lb/ac a.i. and TCA 30lb/ac product. Dalapon was the only treatment to significantly reduce crop yield.

INTRODUCTION

The increase of continuous cereal growing and the decrease in the use of cultivations in break and root crops, has led to a serious increase in perennial weed grasses such as *Agropyron repens* and *Agrostis gigantea*.

Oil seed rape is usually regarded as a cereal break and cleaning crop. A well sown and heavily fertilised crop, germinating and growing under good conditions will sometimes smother annual weeds and so act as a cleaning crop. Perennial grass weeds are much more difficult to smother and their presence will often interfere with crop growth and reduce final yield.

At the present time, nitrofen is the only herbicide that has a label recommendation for the control of certain weeds in oil seed rape. There is no label recommendation for any herbicide for the control of perennial grasses.

Trials were laid down, in conjunction with Twyford Seeds Limited, to compare nitrofen with other commercially available brassica herbicides for the control of annual weeds, and also to evaluate several commercially available chemicals for the control of perennial grasses in oil seed rape.

METHODS AND MATERIALS

All three trials in 1967 and 1968 were carried out on the same field in Oxfordshire which had a sandy loam soil. All treatments were applied with a Van der Weij sprayer modified to give finite rates. All pre-planting treatments were incorporated into the soil by rotavation, the EPTC to a depth of 3-4 in., the trifluralin and TCA to a depth of 2-3 in. and the di-allate and tri-allate to 1-2 in. Drilling of the oil seed rape var. Rigo took place on the same day. Post-emergence applications of the nitrofen at Trial II took place when the rape was at the 2-3 true leaf stage, and of the dalapon at Trial I at 6-8 true leaf stage. Tractor hoeing of the untreated hoed, dalapon, di-allate and tri-allate plots was carried out when the crop was tillering. The other treatments were not hoed. Plot size was 25 x 2 yd (200 yd^2 per treatment). All trials were laid out in randomised blocks with four replicates.

Assessments of weed control, weed vigour, crop stand and crop vigour were made for Trial I on 23.4.68 and for Trial II on 14.5.68 by taking 5 quadrats of 200 in^2 per plot. Vigour was assessed visually on a 1-10 grading where 10 equals untreated. Yield data were obtained by first windrowing and later combining each plot. Materials and application details are shown in Table 1.

Table 1

Details of treatments and dates of application

TRIAL I		TRIAL II	
a) Pre-planting applications 21.3.68		a) Pre-emergence applications 24.3.68	
1. EPTC	4lb/ac a.i.	11. nitrofen	3lb/ac a.i.
2. trifluralin	1lb/ac a.i.	12. propachlor	3.9lb/ac a.i.
3. TCA-Na	15lb/ac product	13. sulfallate/ chlorpropham	1.75lb/ac a.i./ 0.25lb/ac a.i.
4. TCA-Na	30lb/ac product	b) Post-emergence applications 23.4.68	
5. di-allate	1.1lb/ac a.i.	14. nitrofen	1lb/ac a.i.
6. tri-allate	1.1lb/ac a.i.	15. nitrofen + wetter	1lb/ac a.i. + Spreadite 4 fl.oz/ac
b) Post-emergence applications 14.5.68			
7. dalapon-Na + wetter	7½lb/ac product	16. untreated hoed	6.6.68
8. dalapon-Na + wetter	15lb/ac product	17. untreated unhoed	
9. untreated hoed	6.6.68		
10. untreated unhoed			

RESULTS

Table 2

Trial I giving crop stand as % of the unhoed and weed control as a % reduction of the unhoed

Treatment	Rape No.as % unhoed	Rape Vigour 1-10	% control of annual weeds: Chenop. album	Polyg. avic.	Polyg. lapath.	Stell. media	Poa annua	Total annual weed control	Agropyron/Agrostis % shoot control	Agropyron/Agrostis Vigour
1.EPTC	106.4	5.8	95.6	79.6	69.5	99.5	100.0	93.2	98.8	3.0
2.triflur-alin	110.9	10.0	84.5	89.6	30.3	75.3	85.0	84.1	71.1	6.6
3.TCA 15lb	95.5	8.6	82.4	0.1	30.3	64.4	97.9	66.9	63.6	7.4
4.TCA 30lb	96.8	7.6	73.4	12.1	100.0	58.0	99.6	68.1	84.6	7.0
5.di-allate	105.5	10.0	60.2	51.9	39.4	46.6	31.6	45.8	44.6	9.0
6.tri-allate	95.8	10.0	-	-	-	-	-	-	-	-
10.unhoed weeds/ft^2	702	10.0	25.6	30.7	1.2	7.9	81.5	146.9	13.3	
L.S.D. at 5%								36.0	37.9	

Di-allate and tri-allate were included to determine their effect on the oil seed rape. Both treatments proved to be safe on the rape but only di-allate is included in Tables 2 and 4 because tri-allate did not give any weed control as *Avena fatua* was not present.

Table 3

Trials I and II crop vigour at time of flowering (vigour grading 1-10 where 10 = untreated)

Treatment	Vigour	Treatment	Vigour	Treatment	Vigour
1. EPTC	9.8	7. dalapon 7½lb	8.0	13. sulfallate/ chlorpropham	9.9
2. trifluralin	10.0	8. dalapon 15lb	6.8	14. nitrofen 1lb	9.9
3. TCA 15lb	9.9	9. hoed	10.0	15. nitrofen 1lb + wetter	9.9
4. TCA 30lb	9.7	10. unhoed	9.7	16. hoed	10.0
5. di-allate	9.9	11. nitrofen 3lb	10.0	17. unhoed	9.9
6. tri-allate	9.3	12. propachlor	9.8		

The application of dalapon caused severe scorch and check to the rape, particularly at the 30lb/ac rate. Another later application on nearby plots, under more damp conditions resulted in very little scorch. The dalapon gave very little control of annual weeds as was expected, and no assessment was made of *Agropyron/Agrostis* because the plots, along with the di-allate and tri-allate plots, were tractor hoed so that weed growth would not interfere with crop yield, but the final assessment after harvest indicated very good control of *Agropyron/Agrostis*.

The crop check caused by the dalapon was still evident at time of crop flowering and finally resulted in a significant yield reduction by both rates of use. No treatment gave significant yield increases as can be seen in Table 4.

EPTC gave the best control of annual weeds (93%) and of Agropyron/Agrostis (99%). No reduction in crop yield was found even though a severe crop check resulted from drilling the rape the same day as application. The rape suffered delayed emergence and had a shiny dark green appearance, but these symptoms were soon outgrown. The EPTC plots were almost completely clean when assessed after harvest.

Trifluralin was extremely safe on the rape and gave 84% control of annual weeds. The 71% control of Agropyron/Agrostis proved to be only temporary as it had re-appeared in the after harvest assessment.

TCA 30lb/ac gave good control of Agropyron/Agrostis (85%) and Poa annua but control of Polygonum aviculare was very poor. An initial crop check did not result in any significant yield depression. TCA 15lb/ac was safer on the rape than the 30lb/ac rate, but gave reduced control of Agropyron/Agrostis (64%), control of annual weeds was almost identical by both rates.

Table 4

Trial I Yield results as % of hoed and unhoed (corrected to 10% moisture) and post-harvest assessment of ground weed cover

Treatment	Yield as cwt/ac	Yield as % hoed	Yield as % unhoed	% ground cover after harvest	Dominant surviving weeds
1. EPTC 4lb	16.0	100.0	104.2	4.5	Stellaria
2. trifluralin 1lb	16.6	103.6	105.8	61.7	Agropyron/Agrostis Stellaria, Poa
3. TCA 15lb	17.3	108.3	111.3	26.7	Stellaria, Poa
4. TCA 30lb	15.4	96.3	98.5	13.3	Poa, Stellaria
5. di-allate 3 pt. + hoeing	16.6	103.8	105.9	71.7	Agropyron/Agrostis Stellaria
7. dalapon 7½lb + hoeing	13.4	83.6	85.5	13.0	Stellaria Myosotis
8. dalapon 15lb + hoeing	13.1	81.9	84.6	14.2	Stellaria Myosotis
9. hoed	16.0	100.0	107.6	90.8	Agropyron/Agrostis Stellaria, Poa, Myosotis
10. unhoed	15.7	98.0	100.0	100.0	As hoed
L.S.D. at 5%	2.0	10.2	11.7		

A trial carried out in 1967 showed that nitrofen 3lb/ac gave 94% control of Poa annua and Polygonum aviculare while propachlor 3.9lb/ac gave 58% control. Neither treatment reduced crop stand or vigour. In fact both treatments resulted in the rape being 10-12 inches higher than the unhoed crop at harvest. An increase in yield would probably have resulted, but unfortunately plot size was insufficient for harvesting by combine.

Table 5

Trial II giving rape vigour and % weed control compared with the unhoed

Treatment	Rape Vigour 1 - 10	Chenop. album	Polyg. avic.	Polyg. lapath.	Stell. media	Poa annua	Total annual weed control
11. nitrofen 3lb	9.8	40.1	69.8	90.5	61.9	75.7	74.3
12. propachlor	9.8	23.3	34.6	76.2	66.6	82.2	73.5
13. sulfallate/ chlorpropham	9.8	45.5	16.7	100.0	83.3	46.2	44.8
14. nitrofen 1lb	8.6	63.6	56.3	81.0	50.0	33.8	38.8
15. nitrofen 1lb + wetter	8.6	81.8	65.9	100.0	59.5	37.0	43.1
17. unhoed weeds/ ft^2	10.0	0.8	4.5	0.8	1.5	37.9	45.5
L.S.D. at 5%							23.1

Table 6

Trial II Yield results as % of hoed and unhoed (corrected to 10% moisture)

Treatment	Yield as cwt/ac	Yield as % hoed	Yield as % unhoed
11. nitrofen 3lb	17.4	97.6	108.3
12. propachlor	19.5	109.5	121.4
13. sulfallate/ chlorpropham	19.2	106.9	118.6
14. nitrofen 1lb	17.6	98.6	109.2
15. nitrofen 1lb + wetter	18.4	102.9	113.8
16. hoed	18.0	100.0	111.2
17. unhoed	16.1	90.9	100.0
L.S.D. at 5%	N.S.	N.S.	N.S.

In 1968 the effects of annual weed competition in Trial II was to some extent masked by the presence of moderate amounts of Agropyron repens and Agrostis gigantea. Annual weed control by chemical treatment was also slightly inferior to that achieved in 1967. These factors resulted in no significant yield increases by any treatment, even though all treatments gave significant weed control. Pre-emergence applications of nitrofen and propachlor gave significantly higher weed control over sulfallate/chlorpropham applied pre-emergence and nitrofen applied post-emergence. Although no yield increase was significant there was a definite trend that all chemical and hoeing treatments increased yield over the unhoed.

DISCUSSION

The probable reason for the poorer weed control in 1968 by the nitrofen applied pre-emergence (74% compared with 94% in 1967) was that almost no rain fell in the two weeks following application. Propachlor did not appear to be affected by this lack of rainfall as it gave better results (74%) than in 1967 (58%). Sulfallate/chlorpropham gave only 45% total weed control; Poa annua and Polygonum aviculare were both poorly controlled.

The application of nitrofen and nitrofen plus wetter was made rather too late when the rape was at the 2-3 true leaf stage and when the weeds were becoming established. The rape suffered a slight temporary growth check and weed control was less than normally expected, but if P. annua is excluded from the total weed number the figures for annual broad leaved weed control are increased to 58.3% for the nitrofen and 69.7% for the nitrofen plus wetter. The addition of the wetter (Spreadite-allyl polyoxyethylene glycol) to nitrofen, definitely improved the weed control but the improvement was not significant.

The results from Trial I indicate that EPTC 4lb/ac a.i. and TCA 30lb/ac product show promise for the control of A. repens and A. gigantea in oil seed rape. EPTC also gave good control of annual weeds as did trifluralin. Dalapon at 7½lb and 15lb/ac product both reduced crop yield but gave good control of Agropyron/Agrostis. Di-allate and tri-allate proved to be safe on the crop.

The results from Trial II indicate that both nitrofen and propachlor applied pre-emergence gave satisfactory weed control, the nitrofen gave superior control of C. album, P. aviculare and P. lapathifolium. Nitrofen 1lb/ac a.i. applied post-emergence gave the best control of C. album and the addition of wetter gave a slight increase in control of all weeds present.

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A DALAPON FORMULATION FOR GRASS CONTROL IN OIL SEED RAPE

D. J. Clare
Dow Chemical Company (UK) Limited, Kings Lynn

H. A. Castle
Twyfords Seeds Limited, Adderbury, Banbury

Summary. Dalapon, formulated as Dowpon* was used at 4 and 8 lb/ac on Victor and Giant varieties of winter rape without any apparent adverse effect on yield. 4 lb/ac applied at the 4-6 true leaf stage appeared to have no undesirable effect on the varieties of spring rape on which it was used.

November or early autumn treatment of winter rape gave the best weed control of volunteer barley, *Avena ludoviciana*, *A. strigosa*, and *Poa annua*. Treatment after November was usually successful, but some variation in susceptibility of weed species with spraying date was apparent. Split applications of 2, 4 or 8 lb/ac in November, followed by the same level again in March, gave good grass weed control, but tended to cause slight phytotoxicity. This did not result in yield depression.

For satisfactory control of *Alopecurus myosuroides* 8 lb/ac dalapon is required. This can give some height reduction of the rape crop and slight leaf cupping but does not appear to reduce yield. Dalapon at 4 lb/ac gave good control of grass weeds in spring rape.

INTRODUCTION

After a period of continuous cereal growing, many farmers and agricultural advisory workers have become interested in finding profitable break crops.

For a break crop to be successful in a long cereal rotation, good control of grass weeds and volunteer cereal plants is essential. It is on these "weeds" that many of the cereal fungal pathogens persist to subsequently infect the following grain crops.

Many farmers have successfully been using Dowpon for a number of seasons as a post-emergence herbicide for grass weed control in the oil seed rape crop. Because of the increasing interest in this crop as a break from cereals the need for definitive data on rates and times of application become obvious.

In this work the dalapon was used as Dowpon (85% wt/wt dalapon sodium salt) formulated by Dow Chemical Company (UK) Limited. All dose rates quoted in the paper refer to weights of the Dowpon formulation used, and not to active ingredient.

* Trademark of The Dow Chemical Company

WINTER RAPE

Methods

Non-randomised treatments of 0, 2, 4 and 8 lb/ac dalapon were applied at several growth stages to winter rape at four sites. The details of the sites, growth stages and conditions at the time of application are given in Table 1. The plot size was 5 x 24 yd, and the sprays were applied at 30 gal/ac with a Dorman sprayer attached to a Land Rover.

Table 1.

Trial details summary.

Site	Location	Rape Variety	Spraying Dates	Blocks	Stage of growth
1	North Aston	Victor	8 Nov 1967	I & II	2-4 lvs 6 in.tall
			5 Dec 1967	III	2-4 lvs 6 in.tall
			25 Jan 1968	IV	4-6 lvs 3-4 in.tall
			12 Mar 1968	V & I	Just beginning to grow again.
2	Kings Sutton	Giant	14 Nov 1967	I & II	6 lvs 6 in.tall
			5 Dec 1967	III	6 lvs
			25 Jan 1968	IV	6-8 lvs up to 6 in.tall
			11 Mar 1968	V & I	Just beginning to grow again.
3	Adder-bury	Victor	14 Nov 1967	I & II	6 lvs 6 in.tall
			5 Dec 1967	III	6 lvs 6 in. tall
			25 Jan 1968	IV	6 lvs 3-4 in. tall
			12 Mar 1968	V & I	Just beginning to grow again.
4	Twyford	Victor	21 Nov 1967	I & II	5-6 lvs 6 in. tall
			20 Feb 1968	III	5-6 lvs 6 in. tall
			11 Mar 1968	IV & I	Just beginning to grow again.
5	Kings Sutton	Rigo	9 May 1968	All	4-6 lvs 4-6 in. tall
6	Cottis-ford	Nilla	9 May 1968	All	4-6 lvs 4-6 in. tall

Prior to spraying the initial weed infestation per plot was determined by counting the various weeds in 2 x 1 yd^2 quadrats. At intervals after treatment each trial was assessed for weed control and phytotoxicity to the rape. Where convenient yield data were also recorded. Stubble assessments were made where possible to ascertain the degree of grass weed control obtained.

Results

Phytotxicity to rape. 2 lb/ac dalapon caused no phytotoxicity except on those plots which were treated twice with this rate. 4 lb/ac dalapon caused no phytotoxicity when applied in November (sites 1, 2, 3, 4) and February (site 4). December, January and March applications caused slight reduction in height compared with control plots. Two applications of 4 lb/ac, one in November and a second in March, caused a slightly more marked reduction in height.

8 lb/ac dalapon caused some phytotoxicity at all times of application.

Susceptibility of volunteer barley. This "weed" was found on sites 1 and 2. All levels of dalapon gave satisfactory control at all spraying dates except for 2 lb/ac applied in January.

Susceptibility of wild oats. 2 lb/ac dalapon gave useful control on both sites. The degree of control was found to vary with date of spraying. Two applications of 2 lb/ac, one in November and one in March, gave excellent control. 4 lb/ac dalapon gave good control of *Avena ludoviciana* and *A. strigosa* except for March application. A similar pattern to this emerged for 8 lb/ac dalapon. The poor control by January treatment is difficult to account for.

Susceptibility of Blackgrass (*Alopecurus myosuroides*). This weed was not really well controlled by 2 or 4 lb/ac dalapon at any spraying date. 8 lb/ac gave good control on all spraying dates as did all treatments which were applied in November and again in March.

Susceptibility of Poa annua. Control of this weed was good at all rates of dalapon and all spraying dates except with 2 and 4 lb/ac dalapon applied in December.

Percentage grass weed control relative to control plots. Grass weed control improved slightly with increasing rates of dalapon. 4 and 8 lb/ac dalapon were not markedly superior to 2 lb/ac. All spraying dates gave good grass weed control except for the December application which was not too satisfactory. All assessments were made on the stubble after harvest.

Yield data. Three sites were taken to yield. The plots were swathed at the appropriate stage and combined off the swathe.

From the data in Table 2 it would appear that despite the slight foliar phytotoxicity, up to 8 lb/ac dalapon can be used on winter rape varieties Victor and Giant without depressing yield. On site 1 all dalapon treatments showed an increase in yield over the untreated controls. This was most probably due to the control of wild oats given by dalapon.

On site 2 there was an increase in yield as the spraying date was delayed. This trend is also apparent in the controls. As the treatments were not randomised it is probably due to a variation in soil fertility along the trial length.

Table 2.

Summary of yield data in lb/plot corrected to 10% moisture

Site	Treatment lb/ac	Block I 8-14 Nov '67 11-12 Mar '68	Block II 8-14 Nov '67	Block III 5 Dec '67	Block IV 25 Jan '68	Block V 11-12 Mar '68
1	Control	41.8	36.4	36.4	27.6	17.8
	2	60.4	48.0	44.4	44.4	24.9
	4	56.9	53.3	66.7	43.6	37.3
	8	39.1	56.9	53.3	62.2	47.1
2	Control	31.9	41.0	36.4	42.2	49.4
	2	38.2	46.4	38.2	40.8	51.1
	4	33.6	35.6	48.6	49.3	44.4
	8	34.6	41.6	33.8	41.8	46.2
3	Control	64.7	64.7	54.7	62.0	52.8
	2	49.2	59.2	61.0	45.6	49.2
	4	45.6	59.2	61.0	45.6	49.2
	8	46.5	63.8	55.6	48.3	38.3

SPRING RAPE

Methods

The treatments used on two sites (5 and 6) were 0, 4, 8 and 15 lb/ac dalapon. Both sites were randomised and replicated four times. The details of the sites, growth stage and condition at time of application are given in Table 1. Plot size was 5 yds x 24 yds and the sprays were applied at 30 gal/ac with a Dorman sprayer attached to a Land Rover.

Site 5 was a uniform stand of rape. It was swathed and yields taken. Site 6 was an even stand of rape, but owing to extremely severe infestation by grass species prior to treatment with dalapon, the crop was thin and unsuitable for taking yield. Various visual assessments of both sites were taken during the season.

On site 7 rates of 4 and 8 lb/ac dalapon were sprayed in 2 yd strips across the end of various spring rape varieties. These treatments were replicated 3 times. Observations were made at intervals during the season to check for specific varietal susceptibilities.

Results.

Site 5. Rates in excess of 4 lb/ac caused a definite delay in flowering as compared with control plots. Treatments of 8 lb and 15 lb/ac also caused slight phytotoxicity (reduction in height and slight leaf cupping).

The yields (lbs/plot, 10% moisture) were - control 35.5; 4 lb/ac 32.0;

8 lb/ac 33.8; 15 lb/ac 32.0. The differences are not statistically significant.

Site 6. This site was selected because it had a high infestation of *Agrostis* sp. Unfortunately it was sprayed a little too late and the *Agrostis* by this time had reduced the stand of rape so much that there was no point in taking yield measurements. The dalapon treatments gave good control of *Agrostis* sp. The degree of control increased with increasing levels of dalapon.

Site 7.

Visual assessment on 2nd July 1968 and 21st August 1968 showed no obvious varietal susceptibilities to dalapon. 8 lb/ac dalapon delayed flowering compared with the untreated control on all varieties. 4 lb/ac may have delayed flowering slightly compared with controls. 8 lb/ac dalapon caused more small and distorted pods to be set than did untreated control. There appeared to be no more small or distorted pods with 4 lb/ac than there were on untreated controls.

Varieties under test were :

Ringot	H. G. 7210	Nilla
R. 66. 1	Rigo	Nilla Elite
R. 67. 1	Sr. 63/80	Nugget
R. 67. 6	Sr. 63/90	Zollerngold
R. 68. 1	Cresus	Target
R. 68. 3		

All these varieties appeared to be quite tolerant to 4 lb/ac dalapon.

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CONTROL OF WILD OAT (AVENA FATUA) AND BLACKGRASS (ALOPECURUS MYOSUROIDES) IN FIELD BEANS AND SEED RAPE AND IN OTHER ARABLE AND VEGETABLE CROPS USING DI-ALLATE AND TRI-ALLATE

G. B. Lush, A. J. Mayes and B. L. Rea

Boots Pure Drug Company Ltd., Lenton Research Station, Nottingham

Summary An account is given of work carried out with di-allate and tri-allate for the control of wild oats and blackgrass, mainly the former in field beans, oil seed rape, turnips, swedes, kale, cabbage, broccoli, cauliflower and a number of crops for processing viz. broad, runner and dwarf beans, carrots and brussels sprouts. A high standard of control of wild oats and blackgrass occurred combined with a very satisfactory safety margin in all crops except in the case of tri-allate in oil seed rape where some adverse crop effect occurred.

INTRODUCTION

The excellent wild oat control properties of di-allate and tri-allate have been well known since their introduction by The Monsanto Chemical Company (Hannah, et al, 1960). In the United Kingdom, di-allate was first developed for cereal crops where it was later replaced by the more cereal-selective tri-allate, which was found to be equally active against wild oats (Lush and Mayes 1964). With the intensification of cereal growing, the continuity of which is broken by broad-leaved arable crops, the need has arisen to control wild oats in a wide range of such crops which, growing on the same land as cereals have inherited a similar wild oat problem.

Work leading to recommendations in sugar beet and peas was carried out earlier. In this paper is described the work carried out in field beans, oil seed rape, turnips, swedes, cabbage, carrots and a number of crops grown for processing i.e. broad, runner, dwarf beans, brussels sprouts, broccoli and cauliflower.

METHOD AND MATERIALS

Standard 40% w/v emulsifiable concentrate formulations of di-allate and tri-allate were used throughout, usually at normal and twice normal rate.

Standard experimental procedures were followed. Detailed trials involving replicated treatments were carried out to investigate aspects of rate and timing in relation to control of graminaceous weeds and crop safety.

The details of incorporation in relation to weed control and crop safety had already been thoroughly investigated for cereals and were applicable in the case of all crops being considered. Thus, two differentially directional passes of a set of suitable harrows immediately after spraying, the depth of tine penetration usually 3-4 in. being such as to incorporate the majority of the chemical into the upper inch or so of soil, became the standard recommendation in the trials.

Much greater emphasis was placed on crop safety. At least four assessments of the crops were made to study responses and in most crops, varietal susceptibility was studied. Yield data were obtained wherever possible. User trials were arranged in a number of crops as a reliability check.

In all crops, residue studies were carried out in order to comply with the requirements of the Ministry of Agriculture, Fisheries & Food Pesticides Safety Precautions Scheme. In the case of processed crops, taint studies were arranged in collaboration with processing companies and with the Fruit & Vegetable Preservation Research Association but results of these and of residue determinations in a number of crops are not yet available.

RESULTS

Results tend to be divisible under the two main considerations of weed control and crop safety. In view of the well known efficacy of di-allate and tri-allate against both wild oats and blackgrass, it is unnecessary to deal in detail with this aspect of the work. Of the two weeds, wild oat occurred in the majority of the trials. This is because a) most trials were in spring-sown crops, blackgrass still being predominantly a weed of winter crops and b) wild oats are still more widely distributed and predominant than blackgrass. In all cases, control of wild oats, and, where present blackgrass also, was of a high order, certainly as good as and occasionally, in user trials, better than normally experienced in cereal crops. The reason for this superiority of weed control in the user trials is that because of the greater resistance of these crops application was almost invariably made before drilling and incorporation was often carried out more thoroughly than is sometimes the case in cereal crops. Since incorporation into the soil is so necessary with both compounds, it is fortunate that in none of the crops concerned did husbandry requirements mitigate against the use of the well-established technique of incorporation already developed for use with di-allate and tri-allate. Typical results of wild oat control in field beans are shown in Table 3 and in oil seed rape in Table 4.

In all trials carried out in the crops concerned, no adverse effects have occurred in any variety following the use of either di-allate or tri-allate. Results are summarised in Table 1 where reference to crop effect is made and representative yield data is given in Table 2.

In the case of field beans the results of detailed and user trials appear in Table 1. In no trials, including the detailed trials where twice normal rate was used, were adverse effects observed. Data showing yield appear in Table 2.

The results of detailed trials in dwarf, runner and broad beans shown in Table 1 are very satisfactory and again indicate a very adequate safety margin at twice normal rate. Yield data are presented. For swedes and turnips, the data are more limited but of a similar pattern. Data from a range of brassica crops is presented in Table 1 and representative yield figures are given in Table 2. In the case of carrots, yield data is not yet available but careful assessment revealed no crop effect at any stage of growth and lifted roots appeared equal to those in the control plots. In the trials on crops for processing, wild oats were usually absent so that no advantage in crop yield due to removal of competition could be expected.

In the case of oil seed rape, data for 25 trials including one variety trial are given. Representative yield data are presented. In no instance was any adverse effect observed with either di-allate or tri-allate at up to twice normal rate but in a trial carried out by Twyford Seeds Ltd. in 1967, a depression in crop yield following the use of tri-allate was reported. Di-allate in the same trial did not adversely effect yield.

Table 1.

Trial Data and Crop Assessment

Crop*	Location	Soil type	Spray date	Treatment lb/ac di-allate		Treatment lb/ac tri-allate		Visual assessment effect on crop
Swedes	Lenton, Notts.	medium loam	29.5.68.	1.5	3.0	1.5	3.0	nil
Turnip	Lenton, Notts.	medium loam	29.5.68.	1.5	3.0	1.5	3.0	nil
Turnip	Johnshaven, Kincardine	medium loam	20.4.68.	1.5	3.0	1.5	3.0	nil
Kale	Lenton, Notts.	medium loam	29.5.68.	1.5	3.0	1.5	3.0	nil
Kale	Docking, Norfolk	sand	30.4.68.	1.5	3.0	1.5	3.0	nil
Kale	Johnshaven, Kincardine	medium loam	20.4.68.	1.5	3.0	1.5	3.0	nil
Kale	Whinburgh, Norfolk	sand	4.68.	1.5	3.0	1.5	3.0	nil
Kale	Whitstable, Kent	medium loam	4.68.	1.5	3.0	1.5	3.0	nil
Cabbage	Syston, Leics.	sandy loam	8.5.68.	1.25	3.0	1.25	3.0	nil
Cabbage 2	Syston, Leics.	sandy loam	2.5.68.	1.5	3.0	1.5	3.0	nil
Cabbage 2	Docking, Norfolk	sand	30.4.68.	1.5	3.0	1.5	3.0	nil
Cabbage 2	Redhill, Notts.	clay loam	19.6.68.	1.5	3.0	1.5	3.0	nil
Cabbage	Lenton, Notts.	medium loam	29.5.68.	1.5	3.0	1.5	3.0	nil
Cauli-flower	Syston, Leics.	sandy loam	8.5.67.	1.25	2.5	1.25	2.5	nil
" 2	Syston, Leics.	sandy loam	2.5.68.	1.5	3.0	1.5	3.0	nil
" 4	Docking, Norfolk.	sand	30.4.68.	1.5	3.0	1.5	3.0	nil
"	Lenton, Notts.	medium loam	29.5.68.	1.5	3.0	1.5	3.0	nil
Sprouts	Market Rasen, Lincs.	clay loam	29.4.68.	1.5	3.0	1.5	3.0	nil
Sprouts 7	Docking, Norfolk	sand	30.4.68.	1.5	3.0	1.5	3.0	nil
Sprouts	Lenton, Notts.	medium loam	29.5.68.	1.5	3.0	1.5	3.0	nil
Carrots	Ely, Cambs.	fen	12.7.67.	1.5	3.0	1.5	3.0	nil
Carrots	Fakenham, Norfolk	sand	20.5.68.	-	-	1.5	3.0	nil
Carrots	Lenton, Notts.	medium loam	29.8.68.	1.5	3.0	1.5	3.0	nil
Broad beans 15	Ormskirk, Lancs.	sandy loam	66.	-	-	1.5	3.0	nil
" 15	Ormskirk, Lancs.	sandy loam	67.	-	-	1.5	3.0	nil
"	Lenton, Notts.	medium loam	29.5.68.	1.5	3.0	1.5	3.0	nil
" 8	Boston, Lincs.	medium loam	14.3.68.	-	-	1.5	3.0	nil
"	Syston, Leics.	sandy loam	2.5.68.	1.5	3.0	1.5	3.0	nil
" 4	Syston, Leics.	sandy loam	8.5.67.	1.25	2.5	1.25	2.5	nil
Dwarf beans 4	Syston, Leics.	sandy loam	8.5.67.	1.25	2.5	1.25	2.5	nil
"	Syston, Leics.	sandy loam	2.5.68.	1.5	3.0	1.5	3.0	nil
"	Lenton, Notts.	medium loam	29.5.68.	1.5	3.0	1.5	3.0	nil
"	Wainfleet, Lincs.	clay loam	28.5.68.	1.5	3.0	1.5	3.0	nil
"	Deeping, Lincs.	medium loam	21.5.68.	1.5	3.0	1.5	3.0	nil
"	Stowbridge, Lincs.	clay loam	18.6.68.	1.5	3.0	1.5	3.0	nil
Runner beans	Knapton, Norfolk	medium loam	14.5.68.	1.5	3.0	1.5	3.0	nil
"	Lowestoft, Suffolk	medium loam	5.68.	1.5	3.0	1.5	3.0	nil
"	Lenton, Notts.	medium loam	29.5.68.	1.5	3.0	1.5	3.0	nil
Field beans	Swarkestone, Leics.	clay	4.4.66.	-	-	1.5	3.0	nil
"	Market Rasen, Lincs.	clay loam	27.3.66.	-	-	1.5	3.0	nil
"	Muskham, Notts.	clay loam	6.3.68.	1.5	3.0	1.5	3.0	nil
"	Sibthorpe, Notts.	medium loam	7.3.68.	1.5	3.0	1.5	3.0	nil
"	Bottesford, Leics.	clay	13.3.68.	1.5	3.0	1.5	3.0	nil
"	Hull, Yorks.	-	4.66.	-	-	1.5	3.0	nil

Table 1 contd/

Crop*	Location	Soil Type	Spray date	Treatment lb/ac di-allate			tri-allate			Visual assessment effect on crop
Field beans	Dunham, Norfolk	-	14.5.66.	-		-		1.5	3.0	nil
Oil seed rape	Barnby, Notts.	clay loam	21.3.67.	1.25	1.87	2.5	1.25	1.87	2.5	nil
"	Cotham, Notts.	clay loam	25.3.67.	1.25	1.87	2.5	1.25	1.87	2.5	nil
"	Thorpe, Notts.	medium loam	20.3.67.	1.25	1.87	2.5	1.25	1.87	2.5	nil
"	Brampton, Hunts.	medium loam	5.4.67.	1.25	1.87	2.5	1.25	1.87	2.5	nil
"	Marnham, Notts.	clay loam	23.3.67.	1.25	1.87	2.5	1.25	1.87	2.5	nil
"	Barnby, Notts.	clay loam	3.67.		1.25			1.25		nil
"	Cotham, Notts.	clay loam	25.3.67.		1.25			1.25		nil
"	Alconbury, Hunts.	medium loam	3.4.67.		1.25			1.25		nil
"	Upton, Hunts.	clay loam	1.4.67.		1.25			1.25		nil
"	Offord, Hunts.	medium loam	7.4.67.		1.25			1.25		nil
"	Buckworth, Hunts.	clay	20.4.67.		1.25			1.25		nil
"	Saffron Walden, Essex	clay loam	20.4.67.		1.25			1.25		nil
"	Heacham Norfolk	sandy loam	12.4.67.		1.25			1.25		nil
"	Bonhunt, Essex	clay loam	20.4.67.		1.25			1.25		nil
"	Winchester, Hants.	-	14.4.67.		1.25			1.25		nil
"	Kingsclere, Hants.	-	17.4.67.		1.25			1.25		nil
"	Saltburn, Co. Durham	clay loam	28.3.67.		1.25			1.25		nil
"	Partrington, Yorks.	-	3.2.67.		1.25			1.25		nil
"	Dorchester, Dorset	clay loam	25.4.67.		1.25			1.25		nil
"	Clevelade, Worcs.	-	67.		1.25			1.25		nil
"	Crux Easton, Berks.	-	16.4.67.		1.25			1.25		nil
"[15]	Heacham, Norfolk	sandy loam	12.4.67.		1.25			1.25		nil
"	Normanton, Leics.	clay loam	27.3.68.	1.25	1.85	2.5	1.25	1.85	2.5	nil
"	Rempstone, Leics.	clay loam	27.3.68.	1.25	1.85	2.5	1.25	1.85	2.5	nil

* Figure after crop denotes the number of different varieties in the trial.

Table 2.

Examples of Yield Data

Crop	Location	Spray date	Yield as percentage of unsprayed: di-allate 1.5 lb	di-allate 3.0 lb	tri-allate 1.5 lb	tri-allate 3.0 lb	Un-treated yield cwt/ac
Swede	Lenton, Notts.	30.5.68.	85.7	108.6	98.9	100.6	189.1
Turnip	Lenton, Notts.	30.5.68.	109.9	103.1	100.0	-	352.1
Broad beans	Lenton, Notts.	30.5.68.	130.8	130.1	140.4	130.0	75.0
French beans	Wainfleet, Lincs.	28.5.68.	88.2	101.0	91.2	96.1	88.2
Runner beans	Lenton, Notts.	30.5.68.	126.4	101.9	122.6	122.6	76.0
Field beans	Bottesford, Leics.	13.3.68.	104.1	101.4	101.4	102.3	21.2
Kale	Lenton, Notts.	30.5.68.	104.6	92.7	104.6	97.6	88.5

Crop	Location	Spray date	di-allate 1.25	di-allate 1.87	di-allate 2.5	tri-allate 1.25	tri-allate 1.87	tri-allate 2.5 lbs	Un-treated yield cwt/ac
Oil seed rape	Marnham, Notts.	23.3.67.	99.6	100.7	101.8	100.7	99.3	99.1	26.9

Table 3.

Control of wild oats in field beans 1963-1966 with tri-allate

Wild Oats	Site 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Approximate population/sq yd	1000	100	50	40	20	60	70	50	70	110	170	40	30	60	70
% Control to nearest 5%	95	90	80	85	90	85	75	90	90	95	95	80	75	80	85

Table 4.

Control of wild oats in oil seed rape 1967 with di-allate and tri-allate

Wild Oats	1	2	3	4	5	6	7
Approximate population/sq yd	14	16	12	26	17	270	257
% Control to nearest 5%) di-allate	90	90	90	90	95	90	95
% Control to nearest 5%) tri-allate	90	95	90	95	90	90	95

DISCUSSION

The work reported shows the usual high standard of wild oat control associated with the use of di-allate and tri-allate. This is to be expected since the procedures developed for use of tri-allate in cereals were followed and differences in the competitive properties of crops have always been shown to be unimportant with di-allate and tri-allate. Because of this it can safely be assumed that control of other graminaceous annual weeds susceptible to di-allate and tri-allate, e.g. blackgrass, will also be as well controlled as in cereal crops.

In all crops reported here, no differences in crop safety occurred in any trials except in one trial of Twyford Seeds Ltd. where di-allate proved to be the safer compound. Fortunately, di-allate was already preferred for other reasons and this result has not proved to be an embarrassment.

In all other crops no difference in crop safety has been seen between di-allate and tri-allate so that provided no differences between the two compounds are discovered in terms of residue in any crop or of taint in those for processing, choice of compound for commercial use is not affected by technical considerations. With field beans it was decided to recommend tri-allate. Provided residue and taint studies are favourable, this compound will be recommended in all other bean crops and carrots. In the case of oil seed rape, di-allate is already recommended and provided residue and taint studies are satisfactory this compound will also be recommended in all other brassica crops.

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STUDIES OF HERBICIDAL AND RESIDUAL PROPERTIES OF ATRAZINE AND LINURON IN MAIZE CROPS

J. W. Ludwig

A.R.C. Unit of Experimental Agronomy,
Department of Agriculture, University of Oxford

Summary. Atrazine, linuron and mixtures of these herbicides were applied pre-emergence on maize and uncropped plots. At 1 lb/ac a.i. atrazine and the mixture (0.5 + 0.5 lb/ac a.i.) virtually killed all weeds (422/yd^2 recorded on untreated controls). With 1 lb/ac a.i. linuron, about 5% of weeds survived. The surviving weeds, mostly *Polygonum aviculare* and *Veronica* spp. significantly reduced the yield of maize shoots. Bioassays 5 months after application showed that the amount of herbicide residue in the soil was directly related to the dose applied. The results indicated that greater amounts of linuron than atrazine had persisted in the field, although linuron was shown to be less harmful than atrazine to turnip, used as a test plant in the bioassays. The amount of atrazine residue in uncropped (bare) soil was found to be lower than in soil on which maize had been grown.

INTRODUCTION

The risk of atrazine residue injuring crops which succeed maize may be reduced by limiting the dose to the minimum necessary for effective weed control. However, even when the weed situation is known and the dose adjusted accordingly, indifferent control of weeds may result if a dry period follows pre-emergence application. Thus, Splittstoesser & Derscheid (1962) found that atrazine controlled *Setaria* spp. only if 0.5-1 in. of rain fell within 15-20 days after pre-emergence application. Irrigation would activate atrazine when rain is delayed, but where this is not feasible, a partial replacement of atrazine by other herbicides could provide an additional assurance of satisfactory weed control. Mixtures of atrazine with other herbicides for use in maize are therefore receiving considerable attention (Behrens & Lee, 1966). In particular, mixtures of linuron and atrazine have been suggested. Accounts have been given of successful tests of atrazine - linuron mixtures in Wisconsin and Minnesota, and of the excellent results obtained by maize growers in the mid-western States of America in 1965 (Anon., 1966). The objectives of the present studies of weed control in maize at the University Field Station, Wytham near Oxford were, first to compare the herbicidal properties of pre-emergence applications of atrazine and linuron either alone or as mixtures, and secondly, to ascertain the rate of disappearance of these residual herbicides from the soil.

METHOD AND MATERIALS

A split-plot, randomised block experiment was conducted in 1967, on freely drained clay soil, overlying Thames gravel. Maize (var. Inra 200) was sown on May 1. Six herbicide treatments and two unsprayed controls formed the eight main plots of each of the three replications (Table 1). The main plots, twelve rows 12 ft long, 28 in. apart, were split into three 4-row sub-plots. In the first of these, surviving weeds were removed by hand to exclude weed competition and enable assessments of any possible effects of herbicides on maize. In the second sub-plot, weeds were allowed to grow and compete with the maize crop, while the third sub-plot remained uncropped and weeds were removed by hand. From the sub-plot data the rate of disappearance of residual herbicides from cropped and uncropped land could be ascertained. Herbicides were applied to the soil surface with the Oxford Precision Sprayer, at 30 lb/in^2 and 20 gal/ac on May 6, before crop emergence. Weed counts were made early in June from nine 1 ft^2 quadrats/plot, and the maize was then thinned to a final density of 5 plants/yd^2. The maize was harvested in October. The ear, including husks, and stover (stem + leaf) were harvested separately. Yields were obtained of ear, stover and total shoot dry material, and the percentage contribution of ear to total shoot dry matter was calculated. The data were analysed statistically.

Shortly before harvesting the maize, turnip and winter barley were sown on the uncropped plots to give a field assessment of herbicide residues in the soil. Immediately before these test plots were sown, soil samples were collected from the plots for greenhouse bioassays.

For the bioassays twelve cores of soil 2.25 in. in diameter and 4 in. deep, were taken at random from each sub-plot which had received herbicide treatment in May, and from each sub-plot of the untreated control. Additional soil from each untreated sub-plot was collected from the same depth (0-4 in.) to be used for the preparation of standard laboratory spray treatments, and also for dilution of treated soil to give a dilution series as described by Holly & Roberts (1963). Samples within sub-plots were bulked, the soil was partially dried in the greenhouse, thoroughly mixed, passed through a 0.25 in. sieve and used as follows :

1) 100% field-treated soil
2) 50% field-treated soil (diluted with the same amount of untreated soil collected from the same depth from the appropriate control sub-plots)
3) 25% field-treated soil
4) 0% field-treated soil (random sample from untreated control sub-plots).

For the laboratory standards, field untreated soil from the appropriate sub-plots was sprayed with atrazine or linuron to give the following doses of active ingredient : 0.01, 0.02, 0.04, 0.08 and 0.16 lb/ac/in. The soil was sprayed in tins, then the content of each tin was mixed thoroughly, before being placed in pots.

Plastic pots, 2.25 in. in diameter, were filled loosely to the top with soil, and the soil was uniformly consolidated and sown with turnip (var. Green Globe). Twelve seeds were sown per pot and covered with fine sand. Pots were randomised within blocks in the greenhouse. After emergence plants received supplementary lighting from 8 a.m. to 6 p.m. Seedlings were thinned to 8 per pot, and a complete compound fertiliser was applied to all pots. Test plants were sown on October 10 and harvested on October 27 when untreated control plants had 2 true leaves.

The bioassay involved a total of 468 pots. There were 324 pots of field-treated soil (4 main plots X 3 sub-plots X 3 field replications X 3 soil dilutions X 3 greenhouse replications), 54 pots of untreated soil (2 main plots X 3 sub-plots X 3 field replications X 3 greenhouse replications), and 90 pots of standard spray treatments (5 doses X 3 sub-plots X 2 chemicals X 3 greenhouse replications).

RESULTS

Herbicidal efficiency of treatments

Assisted by 1.33 in. of rain during the fortnight following application, treatments were very effective, and the weed population was reduced by more than 95% on all plots apart from those treated with linuron at the lowest dose (1 lb/ac).

The performance of atrazine and linuron mixtures was excellent and comparable to that of atrazine on its own (see Table 1).

Table 1

Herbicidal efficiency of atrazine, linuron and atrazine + linuron mixtures applied pre-emergence

Herbicide treatment		Surviving weeds as % of number on control					
Chemical	Dose lb/ac a.i.	(1)	(2)	(3)	(4)	(5)	Total weeds
Atrazine	1	0.1	0	0	0.0	0.0	0.03
Atrazine	2	0.0	0	0	0.0	0.0	0.00
Linuron	1	7.2	0	0	1.1	16.1	5.08
Linuron	2	1.2	0	0	0.0	1.5	0.75
Atrazine + Linuron	0.5 + 0.5	0.2	0	0	0.0	0.0	0.01
Atrazine + Linuron	1 + 1	0.0	0	0	0.0	0.0	0.00
Control; weeds/yd^2		241	62	62	37	20	422

Weeds: (1) Polygonum aviculare (2) Stellaria media (3) Papaver rhoeas (4) Senecio vulgaris (5) Veronica spp.

The yields of maize (Table 2) reflect the effect of treatments on weed control. On control plots infested with 241 P. aviculare plants and a similar number of other weeds/yd^2, there was an almost total suppression of crop growth.

Table 2

Effects of pre-emergence application of atrazine, linuron and atrazine + linuron mixtures on the yield and ear development of maize (var. Inra 200)

Herbicide treatment		Yield of dry material in total shoot tons/ac		% contribution of ear to dry material of total shoot	
Chemical	Dose lb/ac a.i.	Not weeded	Hand-weeded	Not weeded	Hand-weeded
Atrazine	1	4.81	5.11	57.4	57.6
Atrazine	2	5.09	4.80	57.1	55.3
Linuron	1	3.15	4.70	61.1	58.5
Linuron	2	4.09	4.90	59.2	59.4
Atrazine + Linuron	0.5 + 0.5	4.50	4.66	57.6	58.3
Atrazine + Linuron	1 + 1	4.53	4.98	57.7	59.7
Untreated control		0.11	4.80	18.0	59.4

On the hand-weeded sub-plots, similar yields of maize were obtained from all treatments, including the control, indicating that the herbicides, at the levels used, had no direct effect on crop development. The interaction between the presence or absence of hand cleaning and the different chemicals was significant statistically - a consequence of the relatively low yields from plots treated with linuron and subsequently not cleaned by hand. This interaction, however, did not significantly affect the percentage contribution of ear to total shoot dry material, because on 1 lb/ac linuron plots, the moderate weed infestation (21/yd^2), depressed the yield of stover relatively more than the yield of ears, the reduction being 38 and 29.5% respectively. In contrast, the heavy infestation on untreated control plots (422 weeds/yd^2), led to a relatively greater reduction in yield of ears than of stover, 99.2 and 95.6% respectively.

Bioassays

(a) Field bioassay. The reduction in yield of turnip as a result of applications 5 months earlier of 2 lb/ac atrazine was very significant. The atrazine/linuron mixtures had no depressing effect on growth of turnip and the reduction in yield of barley was not significant statistically for any treatment. The fresh weights of turnip and barley are presented in Table 3.

Table 3

Effects of herbicides applied in May on fresh wt of turnip (var. Green Globe) and barley (var. Maris Otter) grown on uncropped sub-plots during the following October

Herbicide treatment Chemical	Dose lb/ac a.i.	Turnip Fresh wt of shoot as % of control	Barley Fresh wt of shoot as % of control
Atrazine	1	119	84
Atrazine	2	61	75
Linuron	1	80	90
Linuron	2	84	97
Atrazine + Linuron	0.5 + 0.5	122	93
Atrazine + Linuron	1 + 1	93	73

(b) Greenhouse bioassay. Soon after emergence of the test plants it became apparent that turnip is much more susceptible to atrazine than it is to linuron. This difference was especially emphasized when the concentration of these chemicals in the soil was low, and is clearly demonstrated by the data from the freshly prepared laboratory standards (see Table 4).

Table 4

Effects of herbicides on the growth of turnip plants in laboratory standards

Laboratory treatment of field untreated soil		Origin of field untreated soil used in standards		
		No crop	Maize only	Maize + weeds
Chemical	Dose lb/ac/in. a.i.	Fresh wt turnip as % of control		
Atrazine	0.01	83.0	71.3**	62.9***
Atrazine	0.02	41.1***	41.8***	42.5***
Atrazine	0.04	15.4***	20.9***	16.8***
Atrazine	0.08	7.4***	6.7***	6.9***
Atrazine	0.16	4.4***	3.9***	3.6***
Linuron	0.01	93.2	100.8	84.1
Linuron	0.02	90.1	98.1	85.7
Linuron	0.04	63.2*	100.5	104.1
Linuron	0.08	85.7	78.1	81.6
Linuron	0.16	10.4***	10.8***	12.9***

Significantly different from control: *at P=0.05 **at P=0.01 ***at P=0.001

Residual effects of herbicides applied in May showed that treatment, dose and cropping differences were all significant (Table 5).

Table 5

Residual effects of herbicides measured by the growth of turnip plants, in the greenhouse bioassay, conducted 5 months after field application

Field herbicide treatment		Origin of field-treated bioassay soil								
		Uncropped			Maize only			Maize + weeds		
		% of field treated soil in bioassay pots								
Chemical	Dose lb/ac a.i.	100	50	25	100	50	25	100	50	25
		Fresh wt turnip as % of control								
Atrazine	1	32***	57***	89	25***	52***	82	22***	57***	75**
Atrazine	2	12***	37***	65**	11***	22***	51***	10***	20***	46***
Linuron	1	87	85	88	106	84	96	84	90	91
Linuron	2	67*	80	87	50**	81	87	65*	86	86

Significantly different from control: *at P=0.05 **at P=0.01 ***at P=0.001

In the case of atrazine, test plants grown in soil from uncropped, bare plots gave higher weight than those grown in soil collected from plots cropped with maize.

The levels of herbicide residues present in the soil 5 months after application were determined in oz/ac and as a percentage of the original dose. When expressed in oz/ac, the amount of residue on plots treated with 2 lb/ac a.i. was approximately double the amount found on plots treated with 1 lb/ac a.i. Analysis of variance of the residual amount of atrazine and linuron, expressed as % of original dose, showed marked differences between the compounds, with the % linuron residue in the soil significantly greater than that of atrazine (see Table 6).

Table 6

Bioassay determination of herbicide residues present in the soil 5 months after treatment

Original field treatment		Origin of field-treated bioassay soil		
Chemical	Dose lb/ac a.i.	Uncropped	Maize only	Maize + weeds
		Active ingredient in top 4 in. of soil, oz/ac		
Atrazine	1	1.75	2.35	2.33
Atrazine	2	3.67	4.15	4.29
Linuron	1	4.06	2.15	3.60
Linuron	2	6.38	7.25	6.36
		Active ingredient as % of original dose		
Atrazine	1	10.9	14.7	14.5
Atrazine	2	11.5	13.0	13.6
Linuron	1	25.3	13.5	22.5
Linuron	2	19.9	22.7	19.9

The effect of different cropping regimes was not significant, but the interaction cropping X treatment was significant at P = 0.05, with less atrazine residues detected on uncropped than on cropped plots. In the case of linuron no effect of cropping was observed on residual amounts following application of 2 lb/ac but, following a dose of 1 lb/ac, a very low residual value was recorded on plots cropped with maize. This latter result may be anomalous and occasioned by the low susceptibility of turnip to linuron (see Tables 4 & 5).

DISCUSSION

Results showed that although linuron is a less effective herbicide than atrazine, mixtures of linuron and atrazine applied before crop emergence were very successful in controlling weeds in maize, producing crop yields similar to those obtained following treatments with comparable doses of atrazine alone. The data suggest that partial replacement of atrazine by linuron would not affect the efficiency of the treatment.

The bioassay results indicate that the amount of herbicide residue in the soil is directly related to the dose applied. Whenever the weed situation makes it possible, therefore, a reduction in the amount of atrazine applied in May is advisable to reduce the amount of atrazine residue in the soil the following autumn.

Linuron is described by Soyez (1961) as being deactivated in the soil more rapidly than other residual herbicides and the Du Pont Agricultural News Letter (Anon., 1966) suggests that linuron ("Lorox") is known for its favourable rate of disappearance from the soil. These claims have not been substantiated by the results of this experiment. The bioassay data showed that linuron persists in the soil longer than atrazine. If this is so, then the use of atrazine/linuron mixtures would be justified only if linuron residues could be shown to be less toxic to crops following maize than atrazine residues. Evidence to support such possibilities has been found in the field bioassay in which the weight of turnip was significantly reduced only on plots treated with 2 lb/ac atrazine 5 months earlier. Also the greenhouse bioassay results showed very clearly that linuron is much less harmful than atrazine to turnip. The differences between the compounds were especially marked at low concentrations. To obtain further information, several crops were sown after usual winter cultivation including 7-8 in. deep ploughing, on all plots of the described experiment on March 28, nearly 11 months after herbicide application, and harvested on May 14. Fresh weight of shoot showed no effect of residues on wheat, barley and oats, only slight effect on sunflower, oil seed rape and turnip, but the weight of oil seed poppy plants was reduced by 40% on 2 lb/ac a.i. atrazine treated plots and only by 8% on plots treated with a similar dose of linuron.

Results of the greenhouse bioassay also disclosed that the amount of atrazine residue in the soil, 5 months after application, was higher on maize plots than on uncropped plots. The most probable explanation for this finding is in terms of differences in the microclimate. On bare, unshaded plots, soil temperature during the day would be higher than on cropped,shaded plots. Moreover, soil moisture on bare plots would be higher than on cropped plots and microbial activity in the uncropped plots probably intensified, to lead to a more rapid breakdown of atrazine. It is also possible, that sunlight could enhance the disappearance of atrazine from unshaded, uncropped plots as this factor is thought by Eplee & Klingman (1968) to be responsible for the photo-chemical dissipation of surface applications of simazine, a related compound. The differences in microclimate leading to more rapid breakdown of atrazine must have been sufficient to outweigh significantly any metabolising effect of maize on atrazine, which would have increased the rate of disappearance of atrazine from the cropped land.

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CHEMICAL CONTROL OF POLYGONUM AVICULARE IN MAIZE, WITH ESPECIAL REFERENCE TO MIXTURES OF ATRAZINE AND 2,4-D AMINE APPLIED POST-EMERGENCE

J. W. Ludwig

A.R.C. Unit of Experimental Agronomy,
Department of Agriculture, University of Oxford

Summary. Several herbicides were tested in maize in pre- or post-emergence treatments, under conditions of heavy weed infestation, especially with *Polygonum aviculare* (knotgrass). At doses of 0.5 and 1 lb/ac atrazine applied pre-emergence controlled virtually all weeds, but it was significantly less effective in post-emergence applications at doses up to 2 lb/ac. In pre-emergence treatments linuron was inferior to atrazine. Cypromid, tested post-emergence, gave good control of *P. aviculare* only when applied at 2 lb/ac and at this dose apparently affected growth of the maize crop. 2,4-D applied pre- or post-emergence, pyriclor, propachlor and paraquat pre-emergence and monalide post-emergence were ineffective. The most promising results in post-emergence, overall treatments were obtained from mixtures of atrazine and 2,4-D amine. The herbicidal efficiency of these mixtures was appreciably greater than that of either of the components applied alone, especially in the control of *P. aviculare*.

INTRODUCTION

Atrazine, applied before crop emergence, has become extremely important for weed control in maize, because maize is remarkably tolerant to the chemical whereas most germinating weeds are susceptible even at low doses of application. The undesirable feature of atrazine is the risk that the toxicity may outlast the seasonal requirements and affect succeeding crops. Hence, the use of mixtures of atrazine with other herbicides is being investigated and the search for new herbicides continues (Behrens & Lee, 1966).

In the present experiments, the performance of the following herbicides was compared with atrazine : (1) Linuron (2) 2,4-D (3) Paraquat (4) Propachlor (5) Cypromid (6) Pyriclor (7) Monalide.

As there is a need for an effective post-emergence treatment in maize, especially in regions of low rainfall, where pre-emergence application may often be unreliable, the possibility of mixtures of atrazine and 2,4-D as an overall spray was also examined. 2,4-D amine was chosen in preference to 2,4-D ester as the component of the mixture for the following reasons :

1) Maize is known to be less susceptible to injury from 2,4-D amine than from 2,4-D ester.

2) 2,4-D amine, as an aqueous solution, can be expected to remain more stable than an emulsifiable oil solution of 2,4-D ester, when used in mixture with a wettable powder such as atrazine.

3) The hasard of drift from amine is far less serious than from ester. Canadian farmers, for example, are strongly advised to use 2,4-D amine, not ester formulations, for spraying maize crops in areas where oil seed rape is grown (Anon., 1968).

METHOD AND MATERIALS

Conducted at the University Field Station, Wytham, in 1967, on freely drained Oxford clay soil, the experiments occupied adjoining areas of land with a similar cropping history (1964 ryegrass/clover ley, 1965 wheat, 1966 barley) and a comparable weed situation. Maize (var. Inra 200) was sown on May 1 in plots of four rows, 12 ft long, 28 in. apart. There were 33 treatments in Expt 1, involving the eight herbicides mentioned in the introduction, applied pre- or post-emergence at varying doses, while in Expt 2 the eight treatments consisted of mixtures of 2,4-D with varying levels of atrazine applied post-emergence. All treatments were twice replicated.

In Expt 1, pre-emergence/residual surface applications were made on May 9 (Table 1, treatments 1-8); pre-emergence/contact paraquat was applied on four occasions namely May 12, 13, 16 and 17 (Table 1, treatments 9, 10, 11 and 12 respectively) and pre-emergence contact/residual on May 12 (Table 1, treatments 13-16).

Post-emergence, overall treatments in Expt 1 (Table 1, treatments 17-30) and in Expt 2 (Table 3, treatments 1-7) were applied on June 5, when the maize was 8-10 cm high and had 2-3 true leaves, whilst some of the weeds were still in the cotyledon stage, but the majority had commenced formation of true leaves.

Herbicides were applied with the Oxford Precision Sprayer at a pressure of 30 lb/in^2 and a volume of 20 gal/ac. Weed counts were made in June from nine 1 ft^2 quadrats per plot and the maize was then thinned to a final density of 5 $plants/yd^2$. The maize was harvested in October; the ear (including husks) and stover (stem + leaf) were harvested separately.

RESULTS

Experiment 1 - Test of herbicides

The data presented in Table 1 show that atrazine applied pre-emergence was very effective and even at 0.5 lb/ac gave almost complete control of Polygonum aviculare and totally controlled all other weeds. It is true that atrazine as well as linuron were applied in mixtures with paraquat (Table 1, treatments 13-16), but it seems doubtful whether the contact effect of the latter contributed much to the performance of these treatments. When applied alone on four occasions, paraquat was relatively ineffective, largely because even the latest application was made prior to rapid weed emergence, which coincided with the emergence of maize. Linuron at 0.5 lb/ac + paraquat killed all Papaver rhoeas and with 1 lb/ac dose of linuron in the mixture also controlled completely Stellaria media and 92% of P. aviculare. At 0.5 lb/ac linuron, however, 33% of P. aviculare plants survived. Propachlor, 2,4-D and pyriclor all applied pre-emergence failed to control P. aviculare effectively, but S. media and P. rhoeas were all killed by pyriclor at 0.5 lb/ac and substantially reduced by propachlor at 8 lb/ac. P. rhoeas was also well controlled by 2,4-D, especially by the ester formulation applied pre-emergence at a dose of 2 lb/ac.

Post-emergence treatments were generally disappointing. Only cypromid, at 2 lb/ac controlled all main weeds, though at 1 lb/ac dose 14% of P. aviculare plants survived. Pyriclor, somewhat resisted by P. aviculare, controlled other species well. There was a remarkable effect of time of application on control of P. aviculare by atrazine. At 0.5 lb/ac atrazine, only 3 P. aviculare $plants/yd^2$ survived pre-emergence treatment, though the entire population of this species, 184 $plants/yd^2$, survived a similar dose in the foliar treatment. At 2 lb/ac atrazine applied post-emergence, still 28 P. aviculare $plants/yd^2$ survived. S. media also showed some resistance to 0.5 and 1 lb/ac atrazine applied post-emergence, but it was totally controlled by pre-emergence application at these levels. Neither P. aviculare, nor other main weeds were satisfactorily controlled by 2,4-D or monalide applied post-emergence.

Data on yields of maize show that pre-emergence applications of atrazine + paraquat gave far superior results to those obtained from other treatments. In contrast,

Table 1

Summary of performance of herbicides (Expt 1)

Herbicide treatment No.	Chemical	Dose lb/ac a.i.	Surviving weeds as % of control (1)	(2)	(3)	(4)	Total	Dry wt of maize shoot g/plant	% ear in dry shoot
Pre-emergence/residual									
1)	Propachlor	2.0	112	127	45	61	94.2	8.4	24
2)	Propachlor	4.0	67	60	22	52	54.3*	8.6	16
3)	Propachlor	8.0	44	12	4	23	25.1**	16.8	29
4)	2,4-D amine	2.0	23	52	14	12	28.0**	21.2	32
5)	2,4-D ester	2.0	42	31	1	24	29.1**	28.6	39
6)	Pyriclor	0.125	34	46	23	62	36.4**	18.6	40
7)	Pyriclor	0.25	28	10	9	50	22.0**	11.9	25
8)	Pyriclor	0.5	37	0	0	19	18.1***	7.2	18
Pre-emergence/contact									
9)	Paraquat	0.5	38	83	53	32	52.1*	13.2	29
10)	Paraquat	0.5	38	50	81	78	50.0*	14.0	23
11)	Paraquat	0.5	62	70	73	54	64.1	30.0	44
12)	Paraquat	0.5	34	80	47	21	47.3*	19.6	34
Pre-emergence contact/residual									
13)	Linuron +Paraquat	0.5+0.5	33	2	0	43	16.9***	53.1	41
14)	Linuron +Paraquat	1.0+0.5	8	0	0	15	5.2***	80.1	61
15)	Atrazine+Paraquat	0.5+0.5	2	0	0	0	1.0***	151.4	60
16)	Atrazine+Paraquat	1.0+0.5	1	0	0	2	0.2***	150.2	64
Post-emergence, overall									
17)	Cypromid	0.5	67	28	43	43	47.2*	37.8	52
18)	Cypromid	1.0	14	1	1	34	8.8***	86.6	61
19)	Cypromid	2.0	2	0	2	27	4.1***	116.6	59
20)	Monalide	0.5	42	103	73	104	65.0	11.0	20
21)	Monalide	1.0	60	84	93	39	70.5	10.9	24
22)	Monalide	2.0	83	51	63	61	66.5	17.2	30
23)	2,4-D amine	0.5	68	54	45	19	54.5*	22.0	46
24)	2,4-D amine	1.0	55	71	19	12	48.2*	36.8	57
25)	Pyriclor	0.125	38	0	26	10	22.5**	19.6	32
26)	Pyriclor	0.25	55	0	2	11	24.9**	24.0	31
27)	Pyriclor	0.5	14	0	0	1	5.9***	82.6	59
28)	Atrazine	0.5	111	32	5	12	58.5	6.0	12
29)	Atrazine	1.0	36	20	1	21	23.0**	44.0	56
30)	Atrazine	2.0	17	0	0	14	8.9***	101.5	69
31-33)	Control; weeds/yd^2		166	105	74	42	387	8.4	18

*Total weeds sign. diff. from control at P = 0.05
**Total weeds sign. diff. from control at P = 0.01
***Total weeds sign. diff. from control at P = 0.001

Weeds: (1) Polygonum aviculare (3) Papaver rhoeas
(2) Stellaria media (4) Other weeds

post-emergence applications of atrazine at similar doses (0.5 and 1 lb/ac) resulted in yields being significantly lower, and the reduction should be attributed mainly to unsatisfactory control of P. aviculare (see Table 1). Even 2 lb/ac dose of atrazine applied post-emergence failed to control this species effectively and 28 plants/yd^2 survived. Under those conditions of moderate weed infestation the vegetative growth of the maize plants was affected relatively more than the ear development, and consequently the yield of stover (stem + leaf) was reduced by 47% and the yield of ear only by 23% below the level recorded on atrazine pre-emergence treated plots. Hence, although the yield of total shoot was reduced by 33%, the contribution of the ear to the total shoot dry material was, at 69% , appreciably higher than on other treatments.

Yield following cypromid 2 lb/ac post-emergence application was affected by the presence of 14 surviving weeds/yd^2, mostly Aethusa cynapium, and it was much below the level recorded on plots treated with atrazine pre-emergence. A. cynapium was remarkably tolerant to cypromid and plants of this species after the foliar treatment, noticeably gained in vigour, under conditions of significantly reduced density of the main weeds. It is however possible, that the direct effect of cypromid on maize might have contributed to the reduction in yield. Symptoms of toxicity, brown stains on maize leaves, showed after treatment, and the growth seemed to be less vigorous. Similar leaf stains appeared also on maize after monalide foliar application, whilst on pyriclor 0.5 lb/ac pre-emergence treated plots, maize after emergence was often pale or even bleached. These symptoms were less frequent after the foliar treatment, but then, the lethal effects of pyriclor on weeds, and especially on Stellaria media were demonstrated by almost a total destruction of chlorophyll. Moderate yields were obtained following linuron + paraquat (1.0 + 0.5 lb/ac) pre-emergence, and cypromid (1 lb/ac) or pyriclor (0.5 lb/ac) post-emergence applications. The remaining treatments were ineffective, and yields of maize were reduced to levels associated with untreated controls (Table 1).

The results suggest that the effects of competition from P. aviculare were relatively greater than those from other weeds. In Table 2 details of the effects observed on different untreated control plots are presented. It will be seen that on plot I 31, where the number of P. aviculare plants/yd^2 was exceptionally low and the main weeds were S. media and P. rhoeas, the maize grew much better than on plot II 32, infested mostly with P. aviculare. The total number of weeds/yd^2 on these two plots was similar. The effects of severe weed competition on the development of the ear were emphasized especially on plots showing a predominance of P. aviculare.

Table 2

Effects of variations in weed population (especially of P. aviculare) on the growth and ear development of maize on untreated control plots

Plot No.	Weeds/yd^2 P. avic.	S. media	P. rhoeas	Other weeds	Total weeds	Dry wt/plant (g) Ear	Stover	Total shoot	% ear contribution in total shoot
I 31	30	108	72	27	237	16.7	14.9	31.6	52.8
II 31	204	114	135	60	513	0.2	1.8	2.0	8.0
I 32	156	72	60	21	309	0.1	1.6	1.7	6.4
II 32	117	48	33	48	246	1.2	6.9	8.1	14.7
I 33	171	123	84	45	423	0.3	2.6	2.9	11.6
II 33	321	167	57	18	563	0.5	3.6	4.1	11.5

Experiment 2 - Atrazine + 2,4-D amine mixtures applied post-emergence

The effects of treatments on weed survival, on yield of maize and on percentage contribution of ear to total shoot dry material were significant at P = 0.01 and are presented in Table 3. While 2,4-D amine applied post-emergence at a dose of 0.5 lb/ac gave poor control of weeds, especially of P. aviculare, S. media and Veronica spp., it was appreciably more effective when applied in the mixture with varying doses of atrazine. Comparison of the effects of foliar treatments applied on the same day in these two experiments, occupying adjoining areas of land shows that the mixture was more effective than either component on its own, in controlling P. aviculare, which was a predominant weed species in both experiments :

0.5 lb/ac atrazine (Table 1, treatment 28) had no effect on P. aviculare and 0.5 lb/ac 2,4-D (Table 1, treatment 23 and Table 3, treatment 1) allowed approximately

60% survival, but when these two doses were combined in the mixture (0.5 + 0.5 lb/ac, Table 3, treatment 3), only 12% of P. aviculare plants survived. A more relevant comparison, namely, between the effects of a comparable dose of active ingredient shows the following survival of P. aviculare and the inversely related yield of maize :

1 lb/ac in mixture (0.5 + 0.5 lb/ac)	survival	12% ;	dry wt shoot/plant	112 g
1 lb/ac atrazine	"	36% ;	" " "	44 g
1 lb/ac 2,4-D	"	55% ;	" " "	37 g

Again, in the control of S. media :

1 lb/ac in mixture (0.5 + 0.5 lb/ac)	survival	7%
1 lb/ac atrazine	"	20%
1 lb/ac 2,4-D	"	71%

Table 3

Effects of overall post-emergence application of atrazine + 2,4-D mixtures (Expt 2)

Herbicide treatment No.	Chemical	Dose lb/ac a.i.	Surviving weeds as % of control (1)	(2)	(3)	(4)	Total	Dry wt of maize shoot g/plant	% ear in dry shoot
1)	Atrazine + 2,4-D	0.00 + 0.5	57	85	22	33	52.2	18.3	36
2)	Atrazine + 2,4-D	0.25 + 0.5	21	35	3	25	20.0	67.8	65
3)	Atrazine + 2,4-D	0.50 + 0.5	12	7	0	13	8.3	112.2	69
4)	Atrazine + 2,4-D	0.75 + 0.5	15	3	0	6	8.3	84.4	62
5)	Atrazine + 2,4-D	1.00 + 0.5	13	1	0	13	6.8	105.2	62
6)	Atrazine + 2,4-D	1.25 + 0.5	3	0	0	10	1.8	141.5	61
7)	Atrazine + 2,4-D	1.50 + 0.5	3	0	0	8	1.7	119.7	64
8)	Control; weeds/yd^2		256	102	87	63	510	1.6	6

Weeds : (1) Polygonum aviculare (3) Papaver rhoeas
(2) Stellaria media (4) Other weeds

DISCUSSION

Adequate rainfall, 1.6 in. during the fortnight following pre-emergence application, provided optimal conditions for atrazine activity and even at 0.5 lb/ac there was almost total kill of P. aviculare and other weeds. This is of practical significance, as a low dose reduces the cost of the treatment and it may minimise the dangers of residues on any subsequent cropping programme. However, under dry conditions, atrazine may be much less effective. Splittstoesser & Derscheid (1962) found that atrazine controlled Setaria spp. only if 0.5 - 1 in. of rain fell within 15 - 20 days after pre-emergence application. No comparable influence of soil moisture or rainfall applies to foliar applications. Thus, for regions where dry conditions early in the season are expected, there is a need for a reliable, safe and preferably inexpensive post-emergence treatment.

Atrazine can be used also post-emergence in maize, although 1.5 lb/ac a.i. recommended by the manufacturers may create the residual hazard. This dose could be reduced if atrazine were used in mixture with other herbicide. At Wytham 2,4-D was chosen for study in mixtures with atrazine. Foliar application of 2,4-D is the most widely used herbicide treatment in maize in U.S.A. (Behrens & Lee, 1966). 2,4-D is low in toxicity to animals and humans and creates no residue problem, because it disappears rapidly from plants and soil (Klingman, 1961). The possibility of 2,4-D injury to maize, in the form of stalk brittleness, onion leafing, stalk elbowing, or abnormal prop root formation, as described by Klingman (1961), should be expected to be even slighter if low dose, applicable to atrazine + 2,4-D mixtures were used. Maize is known to be less susceptible to injury from 2,4-D amine than from 2,4-D ester. For this reason and those detailed in the introduction (mixing property and drift hazard), 2,4-D amine was used in the mixtures with atrazine in the present studies, and excellent results were obtained.

The advantages of the mixture over its components used on their own can be summarised as follows :

1) For equivalent performance the dose of atrazine in the mixture can be reduced much below the level recommended for atrazine on its own. This would diminish the danger of residue and also lower the cost of treatment as 2,4-D is appreciably less expensive than atrazine.

2) Similarly, the dose of 2,4-D in the mixture lower than required when used on its own involves less risk of 2,4-D damage to maize.

3) Entry of atrazine through the leaves and its subsequent translocation seems to be quicker and more efficient in the presence of 2,4-D.

4) The lethal effect of the mixture is more rapid than is found with 2,4-D due probably to the toxic action of atrazine. There is no prolonged period of slow suppression of weed growth, as is found with 2,4-D alone, and thus a far shorter period of time during which weeds are competing with the crop.

5) Because of the presence of atrazine the mixture may be more effective in controlling grass weeds than is 2,4-D.

6) More rapid kill and better control of weeds treated with the mixture determined its superiority in the present experiments over atrazine and 2,4-D used on their own at comparable doses of active ingredient.

Having regard to these results it is believed that more extensive consideration of atrazine + 2,4-D amine mixtures for weed control in maize is warranted.

Test of new herbicides for weed control in maize gave disappointing results in the present studies. Propachlor and monalide failed to have any satisfactory effect on weeds and monalide caused temporary discoloration and some scorching of maize. Cypromid at 2 lb/ac gave a good control of all weeds except *Aethusa cynapium*, but shortly after treatment the maize showed some symptoms of toxicity and it is intended to study further the direct effect of this herbicide on the maize plant. A similar provision applies to pyriclor, although at the highest concentration tested (0.5 lb/ac) it was somewhat less effective than cypromid (at 2 lb/ac) in controlling *P. aviculare*.

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TRIALS WITH 2-AZIDO-4-ISOPROPYLAMINO-6-METHYLTHIO-S-TRIAZINE, C7019, AS A HERBICIDE IN BRASSICA CROPS

J. M. Smith and T. G. Marks

CIBA Agrochemicals Ltd., Duxford, Cambridge

Summary Extensive trials in 1967 and 1968 have shown that C7019 can be safely used as a pre- or post-emergence herbicide for cabbages and Brussels sprouts. Dose rates of 1.75 to 2.0 lb/ac gave good control of a wide range of annual weeds when applied pre-emergence or at the 2-3 leaf stage of the weeds; application at the post-emergence stage gave a slightly better control of some species. The dose rate for good weed control was not dependent on soil type, but it was found that pre-emergence treatments on very light soils could lead to crop damage if heavy rain fell shortly after application.

INTRODUCTION

2-azido-4-isopropylamino-6-methylthio-s-triazine, was introduced into the U.K. in 1966 with the code number C7019 and was first reported by Green, Ebner and Schuler (1967). Preliminary investigations carried out in 1966 confirmed the suggestion that C7019 was herbicidally active and selective in a number of brassica crops. Pre- and post-emergence applications were tolerated by Brussels sprouts, cabbage and kale although swede, turnip and cauliflower were damaged by C7019 at either time of application.

Accordingly, trials were laid down in 1967 to evaluate various rates of C7019 on cabbage and Brussels sprouts at a number of growth stages of the crop and weeds. Trials were continued in 1968 to obtain further information on the weed spectrum, dose rates and crop and weed susceptibility at different growth stages.

METHOD AND MATERIALS

C7019 was used as a 50% wettable powder in all trials and doses are expressed as lb a.i./ac. In 1967 doses of 1.5, 2.0 and 3.0 lb C7019 were compared but in 1968 these were altered to 1.75, 2.0 and 4.0 lb. An appropriate herbicide, from those commerically available, was used as recommended in each trial as a comparative standard. Applications were made with a precision plot sprayer using a spray volume of 25-50 gal per acre.

Randomised block trials with not less than 3 replicates and a minimum plot size of $^1/_{400}$ ac were laid down on a wide range of soil types. A total of 19 trials with C7019 on Brussels sprouts and cabbage in 1967 and 14 trials in 1968 are reported. The 1967 series consisted of 9 pre-emergence trials (8 on cabbage and 1 on Brussels sprouts), 2 trials when the crop was in the cotyledon-1 leaf stage (1 on cabbage and 1 on Brussels sprouts) and 8 trials when the crop was in the 3-4 leaf stage (3 on cabbage and 5 on Brussels sprouts). The 1968 series consisted of 5 pre-emergence trials (3 on cabbage and 2 on Brussels sprouts), 4 trials when the crop had reached the 2-4 leaf stage (3 on cabbage and 1 on Brussels sprouts) and 5 trials when the crop had reached the 4-5 leaf stage (4 on cabbage and 1 on Brussels sprouts).

Crop and weed assessments by counting and the EWRC scoring system were made twice within 8 weeks of spraying, as was appropriate to crop stage and application time. The EWRC scoring system consists of a 1-9 scale where 1 represents perfect weed control with no visible effect on the crop and 9 represents no weed control or total crop kill.

Whenever possible, trials were taken to yield, the area harvested being such as to contain not less than 30 plants per plot.

RESULTS AND DISCUSSION

Dose rate and application timing

Figure 1 shows the results of trials in 1967 (Figure 1a, b and c) and 1968 (Figure 1d, e and f) in which total weed control and effect on the crop of various dose rates of C7019 is compared at different stages of application to the crop.

Figure 1a, b and c, showing the results of the 1967 trials, shows clearly that of the 3 application times, C7019 was not sufficiently selective when applied to either Brussels sprouts or cabbage at the cotyledon stage. Applied pre-emergence (Figure 1a) or at the 3-4 leaf stage of the crop (Figure 1b), crop tolerance compared well with the standard chemical at up to 2.0 lb rate, although above this rate the crop safety gradually decreased. Conversely, weed control by C7019 following pre- or post-emergence applications (Figure 1a and Figure 1c) improved with increasing dose, being equivalent to the standard at the 2.0 lb rate.

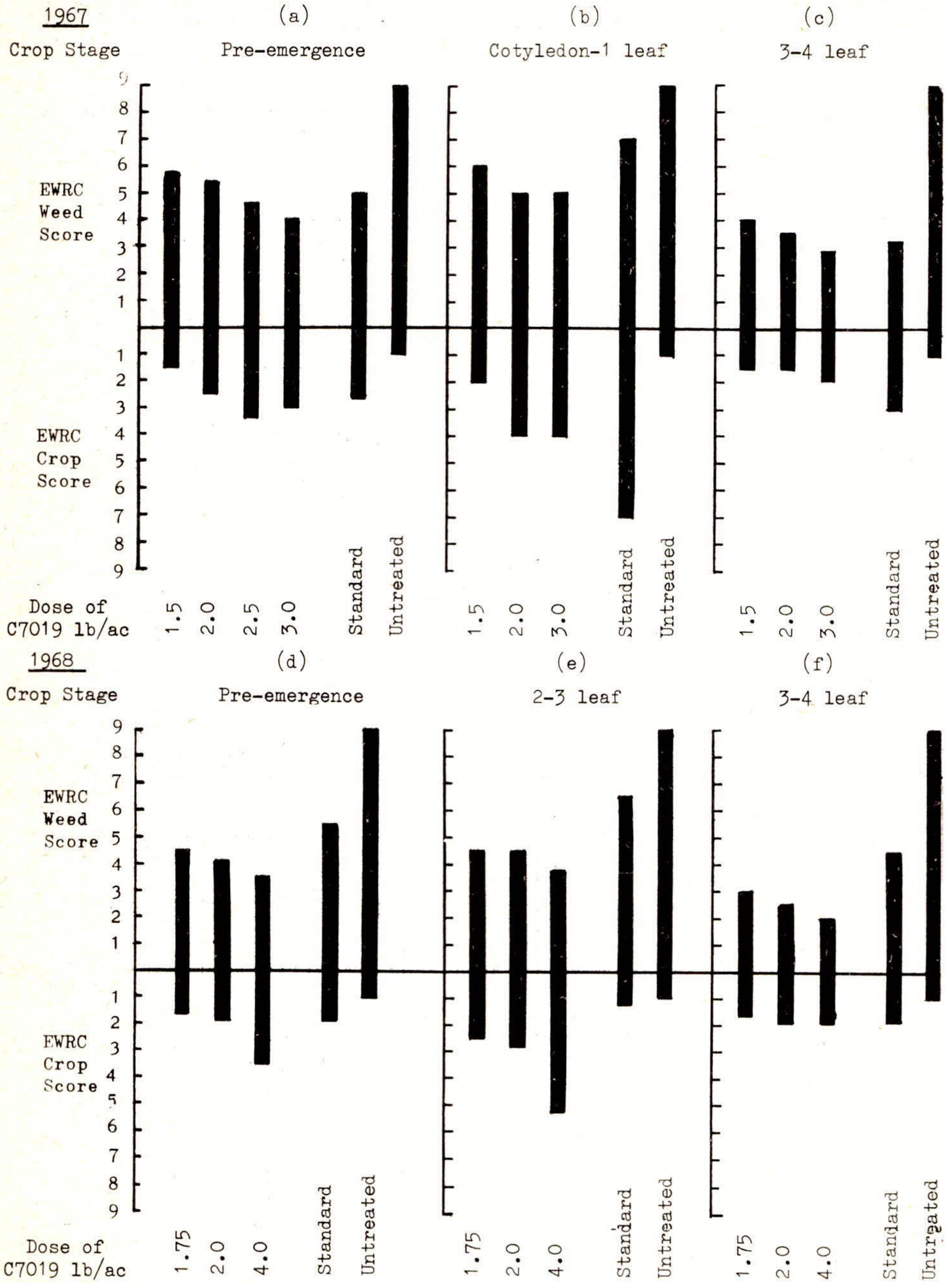
This work therefore indicated that the optimum dose of C7019 was around 2.0 lb/ac applied pre-crop emergence, or when the crop had 3-4 true leaves. Consequently, it was decided to modify the trial design for 1968 by replacing the 1.5 lb C7019 rate by a 1.75 lb rate, and testing C7019 at the 2-3 leaf stage of the crop rather than at the cotyledon stage.

It can be seen from Figure 1e however, that crop tolerance of C7019 applied at the 2-3 leaf stage was consistently lower than that of the standard, or of C7019 applied at the other two growth stages and was therefore unsatisfactory. Figure 1d and f show that C7019 applied pre-emergence and at the 3-4 leaf stage of the crop gave excellent weed control and had adequate crop tolerance in comparison with the standard chemical. Weed control at both growth stages and with all rates of C7019 was clearly superior to the standard. The 1.75 lb rate was almost equivalent to the 2.0 lb rate, in terms of weed control and marginally less damaging to the crop and would appear to be the optimum dose for use in brassica crops.

Observations from the trials reported above suggested that soil type did not influence the activity of C7019 as regards the optimum dose for selective weed control. It was observed, however, that where heavy rain followed pre-emergence applications of C7019 on loamy coarse sand soils unacceptable damage to the crop occurred in some instances.

Figure 1

Mean Weed and Crop Scores 1967 and 1968



Weed control

The results of over 50 trials with C7019 on various crops are summarised in Table 1. Weeds are categorised according to their response to C7019 applied at 1.75-2.0 lb/ac either before weed emergence or post-weed emergence and before the 3 leaf stage.

Table 1

Weed control 1967 and 1968

	Pre-weed emergence				Post-weed emergence <3 leaf			
	No. of sites occurring	% weed control 100-80	79-25	<25	No. of sites occurring	% weed control 100-80	79-25	<25
Poa annua	14	10	4		3	3		
Anagallis arvensis	3	3						
Capsella bursa-pastoris	18	12	5	1	8	7	1	
Chenopodium album	21	13	6	2	10	9	1	
Fumaria officinalis	2	1	1		1	1		
Lamium amplexicaule	5	3	2		2	2		
Tripleurospermum and Matricaria spp.	24	22	1	1	16	14	1	1
Polygonum aviculare	18	9	6	3	11	9	2	
P. convolvulus	10	5	2	3	2	2		
P. persicaria	7	4	2	1	2	2		
Senecio vulgaris	17	17			8	8		
Sinapis arvensis	11	4	5	2	7	6	1	
Solanum nigrum	3	3			2	2		
Sonchus spp.	3	1	1	1				
Spergula arvensis	1	1						
Stellaria media	29	26	3		13	13		
Urtica urens	10	8	2		7	7		
Veronica persica	8	4	2	2	6	5	1	
V. hederifolia	8	5	2	1	3	1	1	1
Viola arvensis	2	2			5	4	1	
Thlaspi arvense					1	1		

The results given in Table 1 indicate that C7019 is effective when applied pre-emergence and when weeds are at the <3 leaf stage. Of the common annual weeds listed only Veronica hederifolia was not well controlled by C7019 applied at the 3 leaf stage. C7019 applied pre-weed emergence also gave satisfactory weed control, although the following spp. were not always completely controlled:- Polygonum spp., Fumaria officinalis, Lamium spp., Sinapis arvensis, Sonchus spp., Veronica spp. Susceptible species to pre-emergence treatment were:- Poa annua, Capsella bursa-pastoris, Chenopodium album, Tripleurospermum and Matricaria spp., Senecio vulgaris, Solanum nigrum, Spergula arvensis, Stellaria media, Urtica urens, Viola spp., and Anagallis arvensis.

It was found from results not reported here that perennial weeds and annual grasses other than Poa annua were not controlled by C7019.

Effect on yield

Table 2

Yield results 1967 and 1968

Trial Number	Soil type	Yield as % control C7019 @ 1.5	C7019 @1.75	C7019 @ 2.0	C7019 @ 3.0	C7019 @ 4.0	Standard	Control yield tons/ac
				CABBAGE - Pre-emergence				
1	CSL	72.5*		101.0	121.5		77.5	29.6
2	CL	94.0		95.0	84.0		93.0	14.2
3	LCS	160.0*		142.0	114.0		180.0*	5.8
4	CL	106.0*		116.0	117.0		140.0	12.3
5	CSL	134.0		127.5	103.0		107.5	5.4
6	CSL		114.0	121.0		121.0	110.0	15.2
				Post-emergence				
7	CSL	101.0		144.0	117.0		120.0	23.0
8	CSL	82.5		90.5	103.0		122.0	20.1
9	CL	104.5		108.0	110.5		102.5	9.3
10	CL	95.5		103.0	100.0		92.5	9.25
11	CSL		164.0	134.0		145.0	151.0	10.1
12	CSL		110.0	125.0		120.5	109.0	16.6
13	CSL		108.0	105.0		95.0	119.0	17.65
				BRUSSELS SPROUTS - Pre-emergence				
14	CSL	86.0		105.0	92.0		86.0	2.9
				Post-emergence				
15	CSL	90.0		106.0	118.0		103.0	1.82
16	CSL	90.0		108.0	128.5*		132.0*	2.09
17	ML	92.0		100.0	107.0		98.0	1.85
18	CL	101.0		96.5	91.0		112.0	2.02
19	CL	90.0		105.0	77.0		94.5	1.79

Soil type: CL = clay loam; CSL = coarse sandy loam; ML = medium loam; LCS = loamy coarse sand.

* Denotes treatments significantly different from untreated at P = 0.05.

The yield results in Table 2 show that C7019 used pre- or post-emergence did not cause any significant reduction in the yield of either cabbage or Brussels sprouts. Crops treated with the 1.5 lb rate were frequently the lowest in weight, probably due to weed competition. In most cases the control plots were hoed in the normal manner. Soil type did not have any effect on yield at different dose rates, except in trial number 3 where the soil type was a loamy coarse sand and heavy rain followed application.

These results show that C7019 has a high potential as a herbicide for brassica crops. It gives good control of a wide range of important weeds and its residual and contact effect give it a novel versatility as a herbicide in these crops.

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EXPERIMENTS WITH CONTACT AND RESIDUAL HERBICIDES ON BRASSICA CROPS IN NORTHERN IRELAND

D. J. Allott

Horticultural Centre, Loughgall, Co. Armagh, Northern Ireland

Summary Experiments in transplanted cauliflower, cabbage and Brussels sprouts showed that simazine, C 7019 (2-azido-4-isopropylamino-6-methythio-S-triazine), lenacil, propachlor, GS 14260 (2 methylthio-4-ethylamino-6-tert. butylamino-S-triazine) and phenmedipham were promising herbicides and merit further examination. Direct drilled broccoli however, was relatively susceptible to herbicide damage, propachlor and prometryne being the only herbicides which failed to reduce growth. A pre-planting root dip of activated charcoal reduced the susceptibility of cauliflower to simazine injury. Further trials are necessary with soil-acting herbicides under a wider variety of soil conditions before they can be universally recommended.

INTRODUCTION

Trials were reported in 1966 (Allott 1966) which suggested that simazine at doses up to 1.0 lb/ac might provide a suitable herbicide treatment for post-emergence or post-planting applications to direct drilled or transplanted brassica crops. It is, however, probable that this herbicide will be phytotoxic in some soil types particularly at the above dose, consequently further investigations were considered necessary in which this and other soil-acting herbicides were compared to obtain additional evidence with respect to crop tolerance. Due to the potential hazard of using soil-acting herbicides in brassica crops at anything above minimal doses it was decided to determine whether the use of a pre-planting root dip of activated charcoal would reduce their toxicity to cauliflower.

METHOD AND MATERIALS

Herbicide screening trials were conducted in transplanted cauliflower (var. Canberra), cabbage (var. Golden Acre), Brussels sprouts (var. Irish Elegance) and in direct drilled broccoli (var. Whitsuntide). The cauliflower and Brussels sprout experiments were conducted in 1967 and the cabbage in 1968. In 1967 simazine, atrazine, lenacil and linuron were also applied to transplanted cauliflower (var. Melbourne Market) to determine whether activated charcoal, applied as a pre-planting root dip to act as a herbicide adsorbent, would prevent injury by these treatments. Where the charcoal root dip technique was employed the roots of individual plants were dipped in activated charcoal immediately before planting. The direct drilled broccoli experiment was conducted during 1968. Herbicides were applied to transplanted crops 2 - 3 weeks after planting. The direct drilled crop was sprayed at the 3 - 4 true leaf stage. Treatments were applied from a pressure-retaining knapsack sprayer in a spray volume of 50 gal/ac water.

Crop yields were recorded as appropriate except in the cauliflower charcoal root dip experiment and the direct drilled broccoli. In these experiments crops were not grown to maturity due to adverse weather conditions. Treatment effects on the cauliflower are illustrated by a count of living plants made in October 1967, 4 months after planting, and by the mean plot weight of the broccoli recorded in March 1968. Weeds were scored on a scale from 0 - 5 where 0 = No weeds and 5 = Weeds dominant.

The treatments in each trial were arranged in randomized blocks with three replicates unless otherwise stated.

Fertilizer treatment, pest and disease control followed normal practice.

RESULTS

Experiments 1 and 2

These experiments were designed to examine the tolerance of transplanted cauliflower and cabbage respectively to a number of soil-acting herbicides. The soil on the two sites had the following physical analyses:

	% Coarse sand	Fine sand	Silt	Clay	Loss on ignition
Experiment 1	21.1	34.6	9.9	23.1	13.7
Experiment 2	29.9	41.2	8.8	11.3	6.2

Table 1

Mean yield of cauliflower (var. Canberra) and cabbage (var. Golden Acre) following post-planting herbicide treatments

Herbicide	Dose lb/ac	Cauliflower (1967) Mean number of marketable curds	Cauliflower (1967) Mean weed score	Cabbage (1968) Mean plant wt/lb	Cabbage (1968) Mean weed score
Unsprayed control	-	12.0	4.0	3.1	5.0
Simazine	0.5	11.0	2.3	3.1	2.7
Simazine	1.0	9.3	2.0	3.1	3.0
Lenacil	1.0	10.7	3.3	2.7	3.7
Lenacil	2.0	11.0	3.0	2.7	3.7
Propachlor	5.0	12.0	3.3	3.7	2.0
Propachlor + Chlorpropham	5.0 + 1.0	5.3	3.0	1.4	1.7
Prometryne	0.75	-	-	3.3	2.0
Prometryne	1.0	6.0	1.6	-	-
C 7019	1.5	-	-	3.8	2.3
C 7019	2.5	8.0	1.0	-	-
Trietazine	1.0	10.3	3.0	-	-
Ametryne	1.0	9.7	1.0	-	-
Trietazine + Ametryne	1.0	-	-	3.6	2.0
GS 14260	0.5	-	-	3.1	3.0
Methoprotryne + Simazine	0.25	-	-	2.8	3.3
Phenmedipham	2.0	-	-	3.2	2.0
S.E. of a difference between two treatment means		2.42 (22 d.f.)	-	0.41 (26 d.f.)	-
Variance within treatment means		N.S.	-	**	-

Note: Phenmedipham application was delayed until seedling weeds were present and was consequently applied two weeks after the other treatments.

It is evident from Table 1 that the propachlor and chlorpropham mixture significantly reduced the yield of cauliflower and cabbage when compared to the unsprayed controls. Prometryne also reduced the yield of cauliflower. No other treatment had a significantly adverse effect. Weed scores show that ametryne, C 7019, prometryne and simazine gave an adequate general weed control in 1967. In 1968, an unusually dry season, propachlor with and without chlorpropham, trietazine and ametryne, phenmedipham and C 7019 gave the best weed control.

Experiment 3

This experiment was conducted in 1967 to examine the effect on yield of post-planting herbicide treatments to Brussels sprouts. The soil on this site had the following physical analysis:

% Coarse sand	Fine sand	Silt	Clay	Loss on ignition
22.9	39.8	11.0	19.7	7.8

Table 2

Mean yield of Brussels sprouts (var. Irish Elegance) following post-planting herbicide treatments

Herbicide	Dose lb/ac	Mean yield (tons/ac)
Unsprayed control	-	5.0
Nitrofen	2.5	5.2
Propachlor	3.0	5.0
Propachlor	5.0	5.2
Lenacil	1.0	4.5
Lenacil	2.0	5.8
Terbacil*	1.0	1.9
Terbacil	2.0	0.1
C 7019	2.5	4.4
Simazine	0.5	5.3
Simazine	1.0	4.7
GS 14260	0.5	4.6
GS 14260	1.0	4.0
Methoprotryne + Simazine	0.5	5.0
Simazine	1.0	3.8
Desmetryne	0.75	5.3
Prometryne	0.75	3.5
Ametryne + Trietazine	3.0	2.3
S.E. of a difference between two treatment means		0.79 (34 d.f.)
Variance within treatment means		***

* 3-t-butyl-5-chloro-6-methyluracil

Crop yields are presented in Table 2, from which it is evident that terbacil cannot be used in Brussels sprouts at doses as high as 1.0 lb/ac. The significantly higher yield at 1.0 lb/ac than at 2.0 lb/ac, however, suggests that doses lower than 1.0 lb/ac would merit investigation. Compared to the unsprayed control the ametryne and trietazine mixture also reduced yield but no other treatment had a significantly adverse effect.

Experiment 4

This experiment was established in 1967 to examine the value of a pre-planting charcoal root dip in the prevention of herbicide injury to cauliflower. The soil on this site had the following physical analysis:

% Coarse sand	Fine sand	Silt	Clay	Loss on ignition
20.0	35.5	12.9	24.4	8.9

This experiment had a factorial design comprising four herbicides at two doses and two root treatments. There were three replicates of each treatment combination. An unsprayed control plot for each root treatment was included in each replicate in the original design, but not in the analysis, when it was considered that the interesting points of comparison were between the herbicide doses and the root treatments. The mean numbers of living plants per plot in October are presented in Table 3 from which it is evident that linuron at both doses and atrazine at 2.0 lb/ac were appreciably more toxic to cauliflower than the other herbicides, which all had a similar effect. The charcoal root dip increased the tolerance of cauliflower to simazine and lenacil.

Table 3

Mean number of living plants following herbicide treatments to cauliflower (var. Melbourne Market) in conjunction with an activated charcoal root dip

Herbicide	Herbicide dose lb/ac		Root treatment	
	1.0	2.0	Undipped	Dipped
Simazine	14.8	13.3	12.7	15.5
Atrazine	15.0	11.3	13.8	12.5
Lenacil	14.5	13.8	13.2	15.2
Linuron	9.0	1.2	5.8	4.3
S.E. of a difference between two means	0.74 (30 d.f.)		0.74 (30 d.f.)	
Variance within treatment means	***		***	

Experiment 5

This experiment was established in 1967 to examine the tolerance of direct drilled broccoli to soil-acting herbicides; the crop was not grown to maturity but the fresh weights of the whole plants were recorded in March 1968 and are presented in Table 4.

The soil on this site had the following physical analysis:

% Coarse sand	Fine sand	Silt	Clay	Loss on ignition
29.9	41.2	8.8	11.3	6.2

The mean plant weights in Table 4 illustrate that with the exception of prometryne and propachlor all herbicides tended to reduce growth but these reductions only reached atatistical significance with respect to terbacil, desmetryne and nitrofen when compared to the unsprayed control.

Table 4

Mean plant weight following post-emergence herbicide applications to direct sown broccoli (var. Whitsuntide)

Herbicide	Dose lb/ac	Mean plant weight lb/plot
Unsprayed control	-	31.6
Prometryne	0.5	30.4
Propachlor	5.0	36.3
Lenacil	1.0	21.0
Terbacil	1.0	0.7
C 7019	2.5	21.9
Simazine	0.5	24.4
GS 14260	0.5	24.3
Methoprotryne	0.5	26.1
Desmetryne	0.25	19.1
Nitrofen	1.0	17.3
S.E. of a difference between two means		5.86 (20 d.f.)
Variance within treatment means		**

DISCUSSION

Herbicide weed control techniques in many vegetables are now in common use but available chemicals are not always satisfactory, particularly in brassica crops, due either to inadequate crop tolerance or weed control. Soil-acting herbicides such as simazine generally control a wide weed spectrum. If methods for their use in the brassicae can be established, they will provide an appreciable advance in weed control in these crops. The present experiments suggest that this might be possible, at least with transplanted crops, under the conditions of the trials reported. The evidence from experiments 1, 2 and 3 suggests that simazine can be used safely in transplanted cauliflower, cabbage and Brussels sprouts at 0.5 lb/ac under Loughgall conditions.

The evidence indicates also that simazine doses up to 1.0 lb/ac could be used in certain circumstances. It is, however, particularly important to specify the soil conditions under which it should be used. The Loughgall experiments were conducted on soils which differ in mechanical structure but these differences were not sufficient to permit a universal recommendation for the use of this herbicide in these crops. In the absence of further evidence for the use of simazine or other similar herbicides they should be used with discretion. It would thus appear that further work is required in brassica crops to establish herbicide programmes that will provide consistently satisfactory results with adequate safety margins. The results from these trials failed to suggest a new chemical that would fulfil this requirement entirely adequately but propachlor, C 7019, lenacil, GS 14260 and phenmedipham were sufficiently promising to permit further examination.

It is evident from experiment 4 that a pre-planting root dip of activated charcoal can reduce the toxicity of some soil-acting herbicides to cauliflower. This treatment, however, has the disadvantage that it involves an additional production cost which would generally be uneconomic. For this reason the development of a herbicide treatment with an adequate safety margin, where charcoal dipping is not necessary, would be preferable.

The susceptibility of transplanted crops to herbicide damage can be reduced by relatively deep planting when the roots will be initially below the herbicide-treated soil layer. The roots of direct drilled crops, however, are likely to be more intimately associated with the herbicide-treated area of soil and consequently the possibility of injury will be greater. This is evident in experiment 5 where most herbicides tended to reduce growth in direct drilled broccoli with the exception of propachlor and prometryne which had no detrimental effects.

Whilst, therefore, it would seem that a number of soil-acting herbicides can be used with discretion in transplanted brassica crops only propachlor and prometryne can be used with safety in direct drilled broccoli. With the available chemicals the main problem appears to be to time the herbicide application to ensure that it is given at a time of maximum crop tolerance and weed susceptibility. In these circumstances a pre-sowing treatment using a herbicide such as trifluralin would be advantageous, followed where necessary, by a post-emergence application at the optimum time with respect to crop safety and weed control (Allott 1966, 1968).

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