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EFFECT OF HIGH AND VERY LOW VOLUME SPRAYING ON DISTRIBUTION OF DROPS IN BLACKBERRY THICKETS

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Summary Blackberry thickets (*Rubus cissburiensis* Barton & Riddelsd.) were sprayed with a tractor mounted fan cage sprayer ("Span Spray"), high volume pressure atomizing equipment and Micron "Herbi" and Turbair "Forester" C.D.A. sprayers. Distribution of herbicide was measured by collecting a dye on glass slides at distances of 0, 20, 40, and 60 cm into the bush. High volume spraying resulted in similar amounts of dye being deposited at all levels, while spraying with very low volume "Span Spray" and C.D.A. equipment resulted in significantly greater (P = 0.05) deposition at the surface. Control of blackberries was similar with all treatments.

INTRODUCTION

When spraying herbicides with controlled drop application (C.D.A.) equipment at very low volumes the size of the drop used can influence penetration into the plant canopy (Bals, 1969). Small drops can penetrate into the canopy and impinge on small structures such as leaf hairs, while large drops are thought to mainly deposit on outside leaves. With high volume spraying in Australia blackberries are normally sprayed to "run-off" with equipment that produces a wide range of drop sizes. It is a common belief among operators that high pressure is needed to "get the spray into the bush" in order to ensure a good kill. This practice can lead to increased atomization and hence increased drift hazard and requires an increased energy input.

This paper examines the distribution of spray in blackberry bushes (*Rubus cissburiensis* Barton & Riddelsd.) after application with both high and very low volume equipment, and endeavours to relate spray distribution in the bush with drop size and control of the weed.

METHOD

Clumps of blackberries (*R. cissburiensis*), approximately 1.5 m tall were treated at a site near Mansfield, Victoria during December 1977 with 2,4,5-T iso-octyl ester. The "Span Spray" unit, a tractor mounted fan-cage sprayer, applied 5.6 l/ha of 40% a.i. 2,4,5-T diluted in deodorized kerosine or water to give a total volume of 50 l/ha. The actual application rate varied because of variation in ground speed caused by the rough terrain. The high volume pressure atomizer equipment consisted of a twin diaphragm pump and a Spraying Systems Tee-jet 6504 nozzle which ensured a similar VMD when operated at pressures of 3.45, 8.61 and 13.78 bar. The thickets were sprayed to "run off" (approximately 2,500 l/ha) with a 0.067% a.i. w/v solution of 2,4,5-T in water. The Micron "Herbi" and Turbair "Forester" C.D.A. equipment applied about 30 l/ha of a 10% a.i. w/v solution of 2,4,5-T in kerosine as described by Shaw and Combellack (1978). One "Forester" was modified to operate at 12V rather than 6V which increased its speed from 2200 rev/min to 4500 rev/min.

Waxoline red dye was added to the 2,4,5-T ester formulation at 1% w/v before dilution. Penetration of the herbicide into the thicket was measured as the recovery of dye from the glass slides (25 x 75 mm). These were mounted on wooden stakes that were placed horizontally in thickets at about half thicket height. The slides were positioned at the surface of the thicket and at horizontal distances of 10, 20, 40 and 60 cm into the thicket. The dye was later washed off the slides with ethanol and measured in a spectrophotometer.

RESULTS AND DISCUSSION

Comparisons cannot be made between the data presented in Figures 1 to 3 because it proved impossible to apply a comparable rate of herbicide per hectare with the different types of machines; e.g., the high volume pressure atomizer treatments were sprayed to "run off", the C.D.A. treatments were sprayed to a drop density of about 10 drops per cm^2 for the "Herbi", and the "Span Spray" was to apply a set rate per hectare but ground speed was difficult to control on rough terrain. The amount of herbicide deposited in the blackberry canopy is assumed to be proportional to the amount of dye recovered from the slide and is expressed in arbitrary units.

Deposition of Herbicide

(a) Pressure atomizer. There are no significant differences ($P = 0.05$) in deposition of herbicide at any one depth when applied at different pressures using high volumes (Fig. 1). Furthermore at 8.61 and 13.87 bar similar amounts were recovered at all depths while at 3.45 bar there was significantly less deposited at 20 cm than at 0 cm but no difference between 0 and 60 cm (Fig. 1). These results show that increasing pressure does not necessarily increase penetration into the bush. There is a trend towards increasing deposition with increasing pressure, i.e., the summation of deposits for each level at each pressure (Table 1), probably because of increased throughput of the nozzle as the pressure is increased.

(b) "Span Spray". Herbicide applied with the "Span Spray" was mainly deposited on the outside of the bushes. Significant differences ($P = 0.05$) between the amount deposited at the perifery and at depths of 20 to 60 cm were found (Fig. 2). Penetration into the bush appeared to be hindered by the high velocity air stream which caused the leaves to flatten against each other and shield the interior of the bush. There were no significant differences in the level of deposition between oil and water.

(c) C.D.A. Equipment. Significant differences ($P = 0.05$) in deposition at various levels in the bush occurred with the "Herbi" and "Forester" 6V C.D.A. equipment (Fig. 3). However, similar deposition was obtained at each level with the "Forester" operating at 12V. This reflects variation in drop sizes produced by these machines. The "Forester" 6V and "Herbi" produce drops of about 280 μ in diameter which tend to impinge upon the first obstacle they encountered. The Forester 12V, however, produces drops of about 150 μ which tend to drift further into the bush.

Herbicide Effectiveness

The effectiveness of the herbicide treatment was estimated five months after spraying and the results are shown in Table 2. There does not appear to be any consistent relationship between distribution of herbicide and the effectiveness of the treatment in killing blackberry. The "Span Spray" with poor herbicide distribution into the bush gave marginally worse results. The C.D.A. Equipment gave control that was also inconsistent with penetration i.e., the "Herbi" and the "Forester" 6V which had very similar penetration gave different results.

Thus it can be concluded that varying nozzle pressure from 3.45 to 13.78 bar does not alter penetration of herbicide into the bush and does not alter the effectiveness of the kill. Though the "Span Spray" may be only marginally more effective in killing blackberry its main advantage is the rapid speed at which it can treat large areas.

These results show that distribution may not be important in obtaining good control of blackberry. The "Herbi" and "Forester" 12V units were very similar in effectiveness to high volume spraying and the results are consistent with those previously reported (Combellack et al, 1978; Combellack & Harris, 1978). However, the "Forester" 6V was slightly and inexplicably worse.

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Table 1

Total deposition of herbicides on bushes

Machine	Deposition
"Span Spray" (water)	16.17
"Span Spray" (oil)	12.33
High volume (3.45 bar)	5.85
High volume (8.61 bar)	7.52
High volume (13.87 bar)	9.15
Micron "Herbi"	8.76
Turbair "Forester" 6V	13.12
Turbair "Forester" 12V	8.42

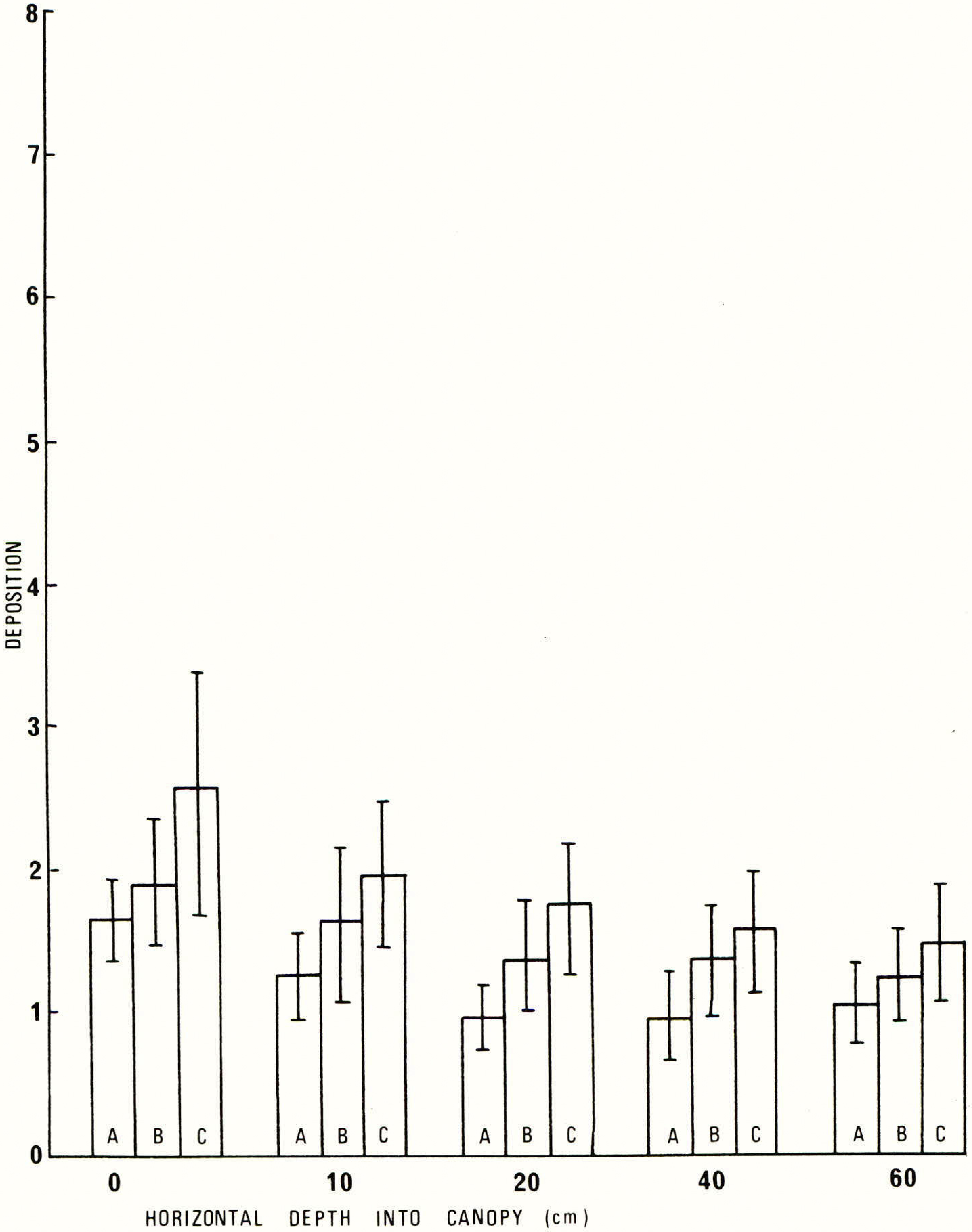
Table 2

Effectiveness of herbicide spraying five months after treatment

Machine	% Cane Kill	Foliage reduction	Regrowth
"Span Spray" (water)	100	9	7
"Span Spray" (oil)	95	9	5
High volume (3.45 bar)	80	7	5
High volume (8.61 bar)	90	8	7
High volume (13.87 bar)	80	8	5
Micron "Herbi"	90	9	5
Turbair "Forester" 6V	70	8	3
Turbair "Forester" 12V	80	8	5

Fig. 1

Deposition of dye on glass slides at various depths into bush after high volume application at 3.45 bar (A) 8.61 bar (B) and 13.87 bar (C). The 95% confidence limits are shown.



<u>Fig. 2</u>

Deposition of dye on glass slides at various depths into the canopy after spraying with "Span Spray" applying water (W) and oil (O) formulations. The 95% confidence limits are shown.

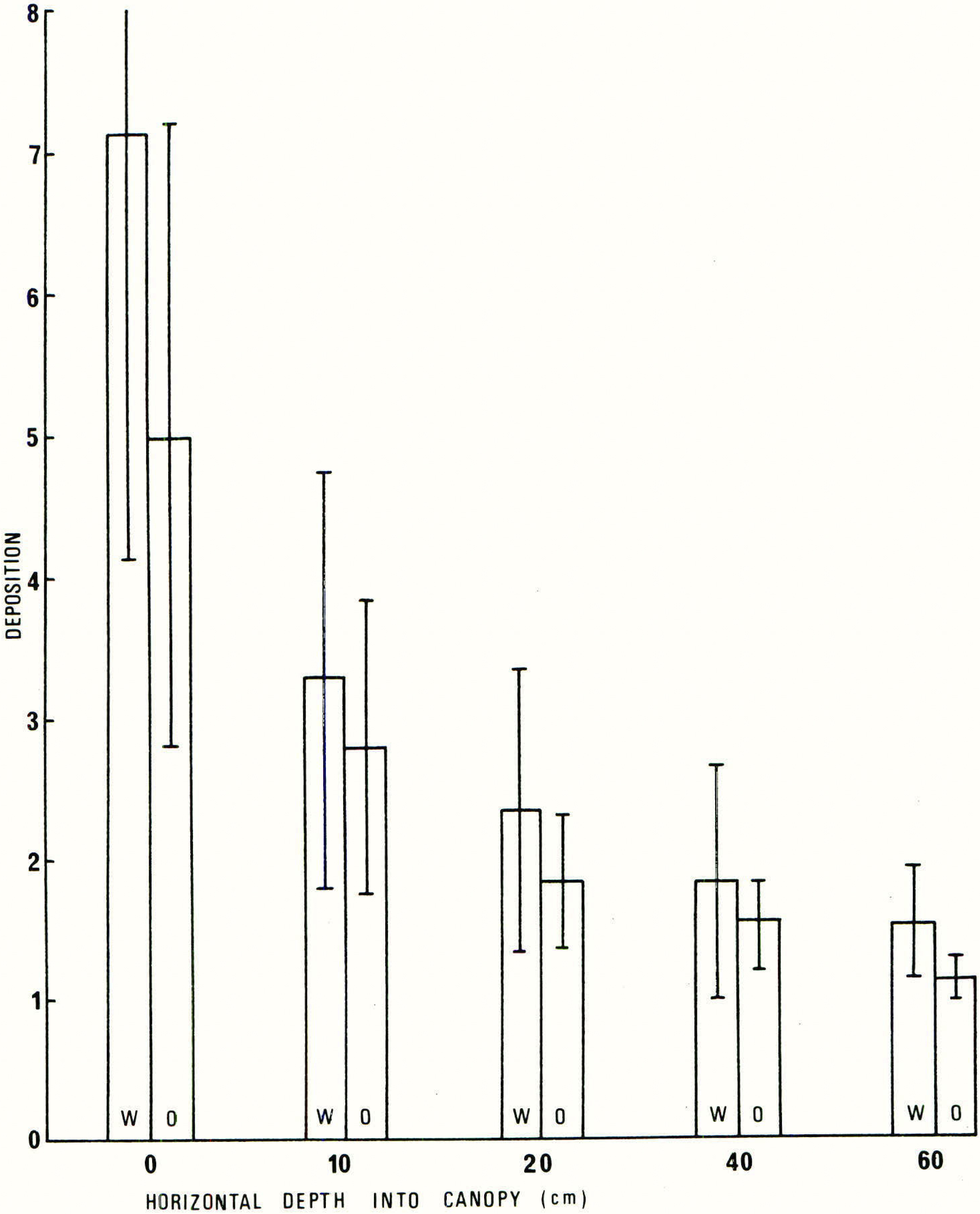
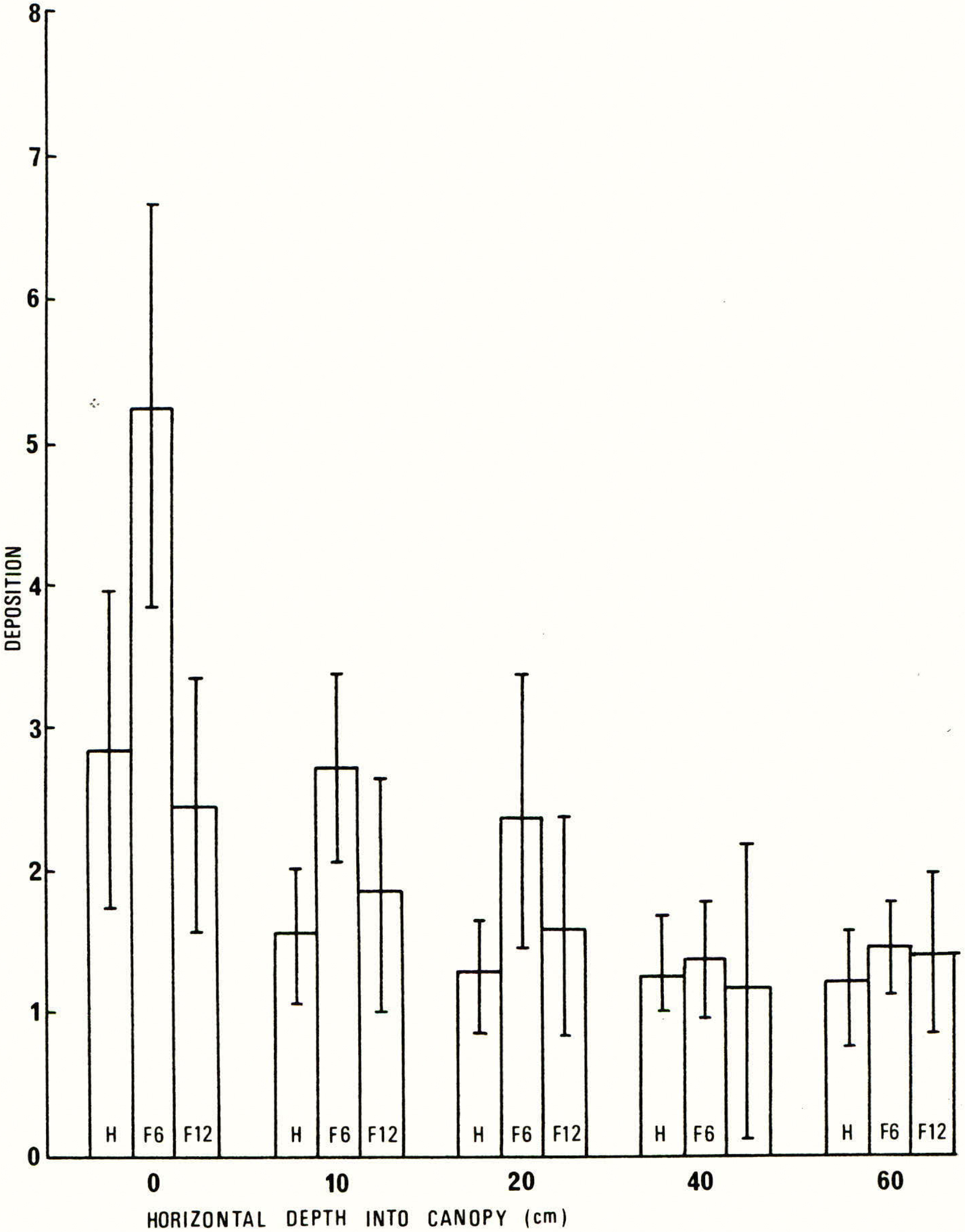


Fig. 3

Deposition of dye on glass slides at various depths into the canopy after applying herbicide with the "Herbi" (H), "Forester" 6V (F6) and "Forester" at 12V (F12). The 95% confidence limits are shown.



NOTES

FLURIDONE - A NEW SELECTIVE HERBICIDE FOR USE IN COTTON

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Summary Fluridone (1-methyl-3-phenyl-5-[3-trifluoromethyl)phenyl]-4(1H)-pyridinone), formerly EL-171, is a new soil applied herbicide which has shown potential for selective control of annual weed species in cotton. In field trials fluridone applied at 100-200 g a.i./ha provided excellent initial and residual control of a number of species including *Amaranthus retroflexus*, *Chenopodium album*, *Portulaca oleracea*, *Solanum nigrum* and *Echinochloa crus-galli*. At these application rates there was no effect on either cotton or the following rotation crops, barley, wheat, sugar beet, and maize. Studies are in progress on the use of higher dose rates of fluridone for perennial weed control.

Results from acute and subacute toxicology studies indicate that fluridone has a low order of toxicity. The mode of action of fluridone has been shown to be inhibition of carotenoid biosynthesis.

Résumé Fluridone (1-methyl-3-phenyl-5- 3-trifluoromethyl)phenyl -4(1H)-pyridinone), EL-171 est un nouveau herbicide de pré-levée qui presente un interet considerable pour la lutte sélective des adventices annuelles du cotton. Dans des essais en plein champs, fluridone, à des doses de 100-200 g m.ai/ha, a donné un control excellent d'un grand nombre d'espèces d'adventices, entre autres d'*Amaranthus retroflexus*, *Chenopodium album*, *Portulaca oleracea*, *Solanum nigrum* et *Echinochloa crus-galli*. A les doses mentionées plus haut fluridone à été entierement selectif aussi bien pour le cotton que pour les plantes qui le suivent d'habitude dans les rotations comme l'orge, le blé, la betterave et le mais. Des travaux complémentaires sout en cours pour étudier l'utilisation de fluridone à des does plus hautes pour le control des adventices perennes.

Les resultats des études de toxicite aigüe et á terme (3 mois) on montré que fluridone est un produit d'une toxicité relativement faible. D'autres études ont demontré que fluridone agit sur les plantes par inhibition de la biosynthèse des carotenoides.

INTRODUCTION

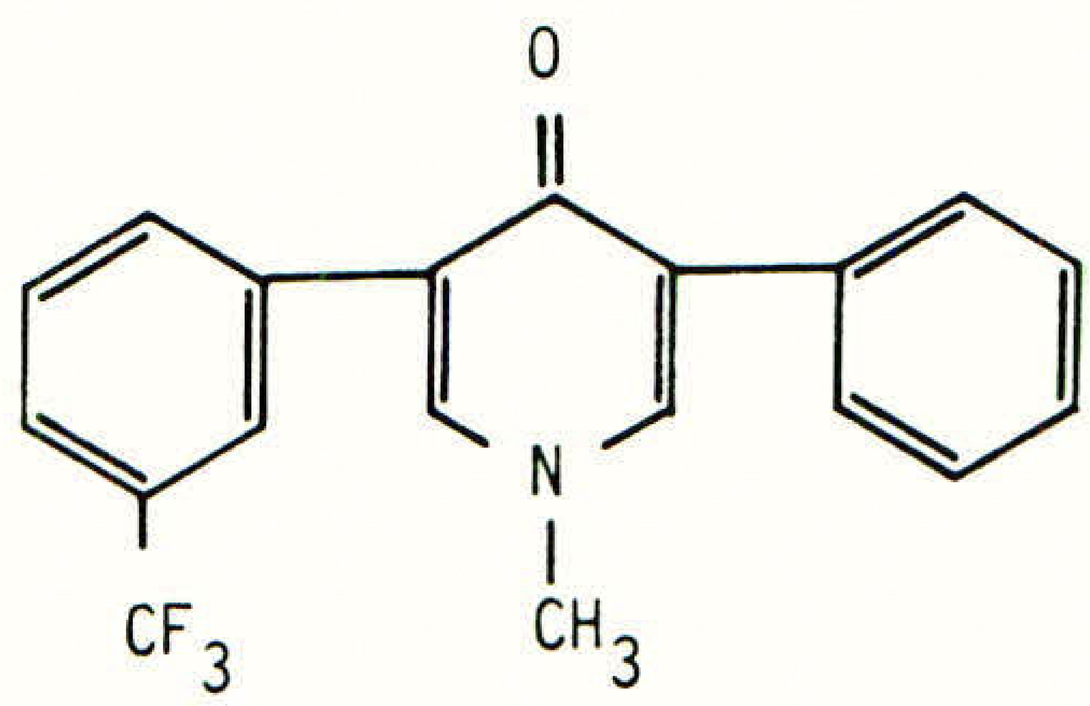
The herbicidal properties of a number of substituted pyridinones and related compounds have been demonstrated in a greenhouse screening programme carried out by Eli Lilly and Company. The greenhouse activity of the most promising compound, fluridone (coded EL-171) was first described by Waldrep and Taylor (1976) who observed tolerance of cotton at application rates up to 1.2 kg a.i./ha.

The mode of action of fluridone was later shown to be inhibition of carotenoid biosynthesis (Bartels & Watson, 1978) and the tolerance of cotton was primarily attributed to the limited translocation of the compound (Berard *et al*., 1978).

The chemical and physical properties of fluridone are summarised below.

Preliminary field trials in 1976 demonstrated excellent control of annual weed species at application rates down to 200 g a.i./ha as well as excellent selectivity at 1.5 kg a.i./ha. A field experiment programme was, therefore, initiated in a number of European countries in 1977 to test even lower application rates for control of annual weeds. Data from 1977 cotton trials in Spain and Syria as representative of the Mediterranean cotton-growing area are presented in this paper.

PHYSICAL AND CHEMICAL PROPERTIES

Chemical name	1-Methyl-3-phenyl-5-[3-(trifluoromethyl)phenyl]-4(1H)-pyridinone
Chemical structure	
Common name	Fluridone
Molecular weight	329.3
Appearance	Off-white to tan coloured crystalline solid.
Melting point	151-154°C.
Solubility	Water 12 ppm, methanol and chloroform > 10 000 ppm, diethyl ether > 1000 ppm, ethyl acetate > 5000 ppm and hexane < 500 ppm.
Vapour pressure	$< 1 \times 10^{-7}$ mm Hg at 25°C.
Formulation	Wettable powder (50% w/w), aqueous suspension (50% w/v).

TOXICOLOGY

Results from acute and 90-day subacute toxicology studies indicate that fluridone has a low order of toxicity.

Species	Material	Test	Toxicity per kg bodyweight
Rat	Technical	Oral	LD_{50} > 10 000 mg.
	Technical	Subcutaneous	LD_0 > 5 000 mg.
	Aqueous suspension	Oral	LD_0 > 0.5 ml.
	Wettable powder	Oral	LD_0 > 10 000 mg.
Mouse	Technical	Oral	LD_{50} > 10 000 mg.
	Technical	Subcutaneous	LD_{50} > 2 000 mg.
Cat	Technical	Oral	LD_0 > 250 mg.
Dog	Technical	Oral	LD_0 > 500 mg.

Rats appeared normal after exposure for 1 hour to inhalation of the wettable powder at a concentration of 2480 mg/m^3 of air. In 90 day feeding tests, no treatment related effects were noted in rats at dietary doses of 1400 ppm.

METHOD AND MATERIALS

Field trials in Spain and Syria were carried out on three cotton cultivars, Acala, Coker 201 and Coker 310. The trial plots varied in size from 15 to 20 m^2 and were arranged in 4 randomized blocks. Fluridone as the 50% aqueous suspension or 50% wettable powder was applied with a knapsack sprayer at a volume rate of 250-900 l/ha. Incorporation was carried out with a disc harrow in all trials.

Herbicidal efficacy was determined either by weed counts, in 8 random 625 cm^2 quadrats per plot or by a visual estimate of the soil surface area covered by individual species.

Selectivity to cotton and effect on rotation crops were evaluated by stand counts and vigour and injury ratings.

RESULTS

Selectivity Field trials in 1977 confirmed the excellent selectivity of fluridone in cotton. No reductions in either crop emergence or crop vigour were observed at application rates of 50-200 g a.i./ha. Similarly there were no signs of injury at these rates when fluridone was either incorporated before sowing or applied to the soil surface before emergence.

Herbicidal efficacy The efficacy of fluridone against six broadleaf and three grass weeds is illustrated in Table 1. The response was very similar in the trials in Spain and Syria.

It is apparent that fluridone at 100 g a.i./ha provides excellent control of most of the species presented in Table 1. Acceptable control (> 85%) of A. retroflexus, C. album and Setaria spp. was demonstrated at 50 g a.i./ha in one Syrian trial. However, in order to control Physalis spp, a major problem in Syria, at least 200 g a.i./ha was required.

Table 1. Effect of fluridone on annual grasses and broadleaf weeds in cotton in Spain and Syria

	% Control (7-9 weeks after application) Dose rate g a.i./ha			
	50	100	150	200
Broadleaf weeds				
Amaranthus retroflexus (8)	91.3*	91.4	97.5	96.8
Chenopodium album (7)	86.4*	96.6	99.0	96.0
Physalis spp. (6)	51.2	78.1	78.5	84.0
Portulaca oleracea (6)	-	99.1	96.9	98.1
Solanum nigrum (5)	-	97.1	91.5	97.3
Sonchus arvensis (3)	-	87.9	100	100
Grass weeds				
Echinochloa colonum (2)	65.4	70.1	76.9	76.9
E. crus-galli (4)	-	97.0	100	100
Setaria spp. (1)	87.1	86.8	100	96.0

Number of trials in parentheses.

* Data from one trial only.

The data in Table 1. were obtained between 7 to 9 weeks after application of fluridone (5 to 7 weeks after crop emergence). Weed competition that results in measurable yield decrease has been shown to commence at around this time or even earlier in cotton. (Buchanan & Burns, 1970).

It has also been demonstrated that weeds which survive until late in the season can interfere with cotton harvesting operations (Arle & Hamilton 1975). It is important, therefore, to have some residual herbicidal activity in the cotton crop.

Fig. 1 illustrates the duration of control of S. nigrum in Spain with fluridone at 100, 150 and 200 g a.i./ha. Control of S. nigrum was greater than 90% at all rates, for up to 4 months after application. Although there was a subsequent decline in control, nevertheless, after 5½ months, there was still approximately 80% control at the two highest rates. Despite the limited data available a similar response was apparent for E. crus-galli at 150 and 200 g a.i./ha where acceptable control was maintained for 5½ months (Fig. 2). At an application rate of 100 g a.i./ha there was an obvious decline in control after 3 months. However, the addition of 500 g a.i./ha trifluralin (half the recommended dosage rate) increased the level of control at 5½ months to that attained with higher rates of fluridone alone.

Rotation crops   The common rotation crops wheat and barley were sown following cotton harvest, approximately seven months after fluridone application and maize and sugar beet were also sown the following spring ten months after application. There was no observable injury or effect on the vigour of these crops when fluridone was applied at up to 400 g a.i./ha to the preceding cotton crop.

Fig. 1   Control of Solanum nigrum with fluridone at 100 (○), 150 (●) and 200 (□) g a.i./ha during the growth period of cotton in Spain (mean of 5 trials).

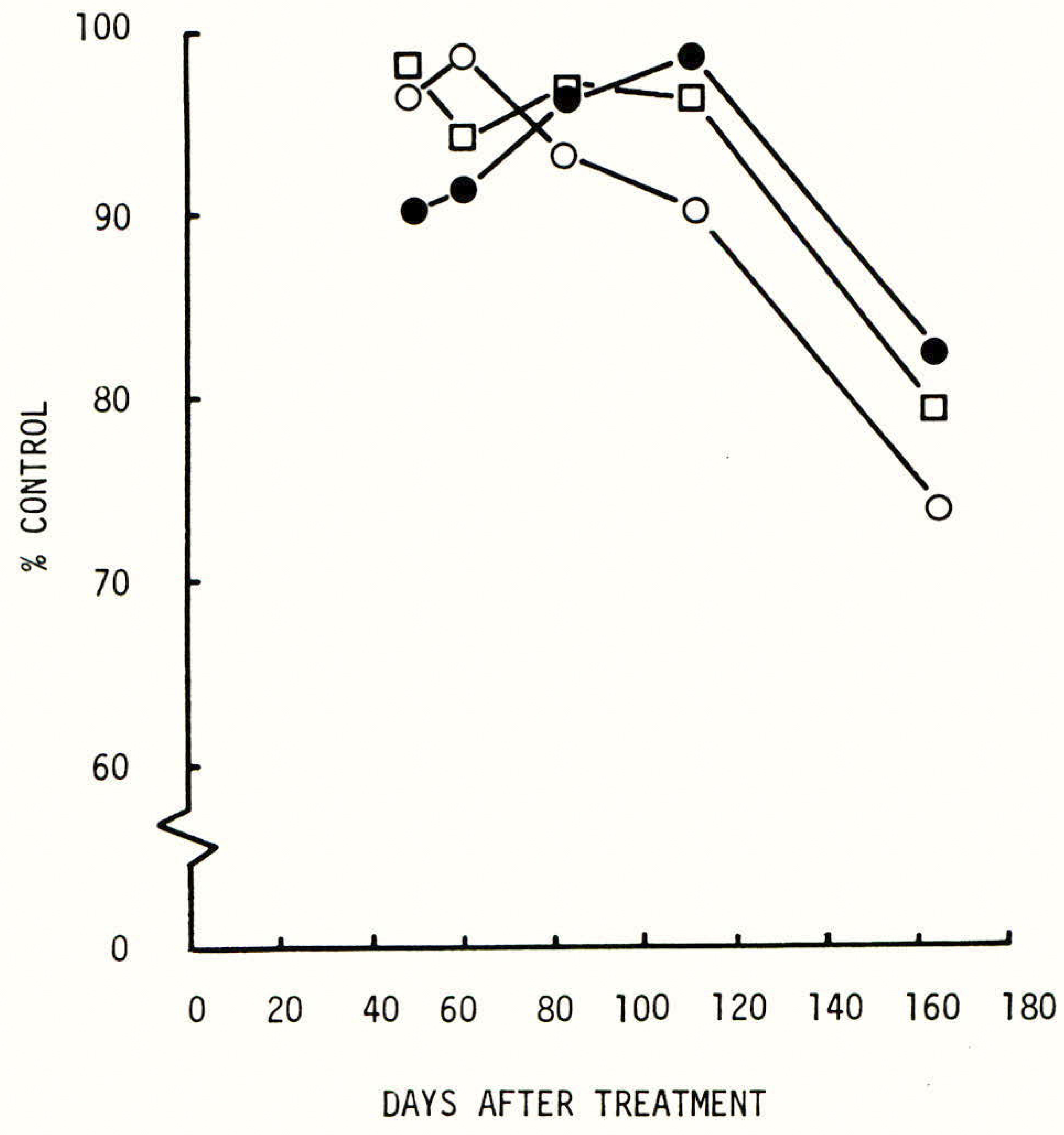
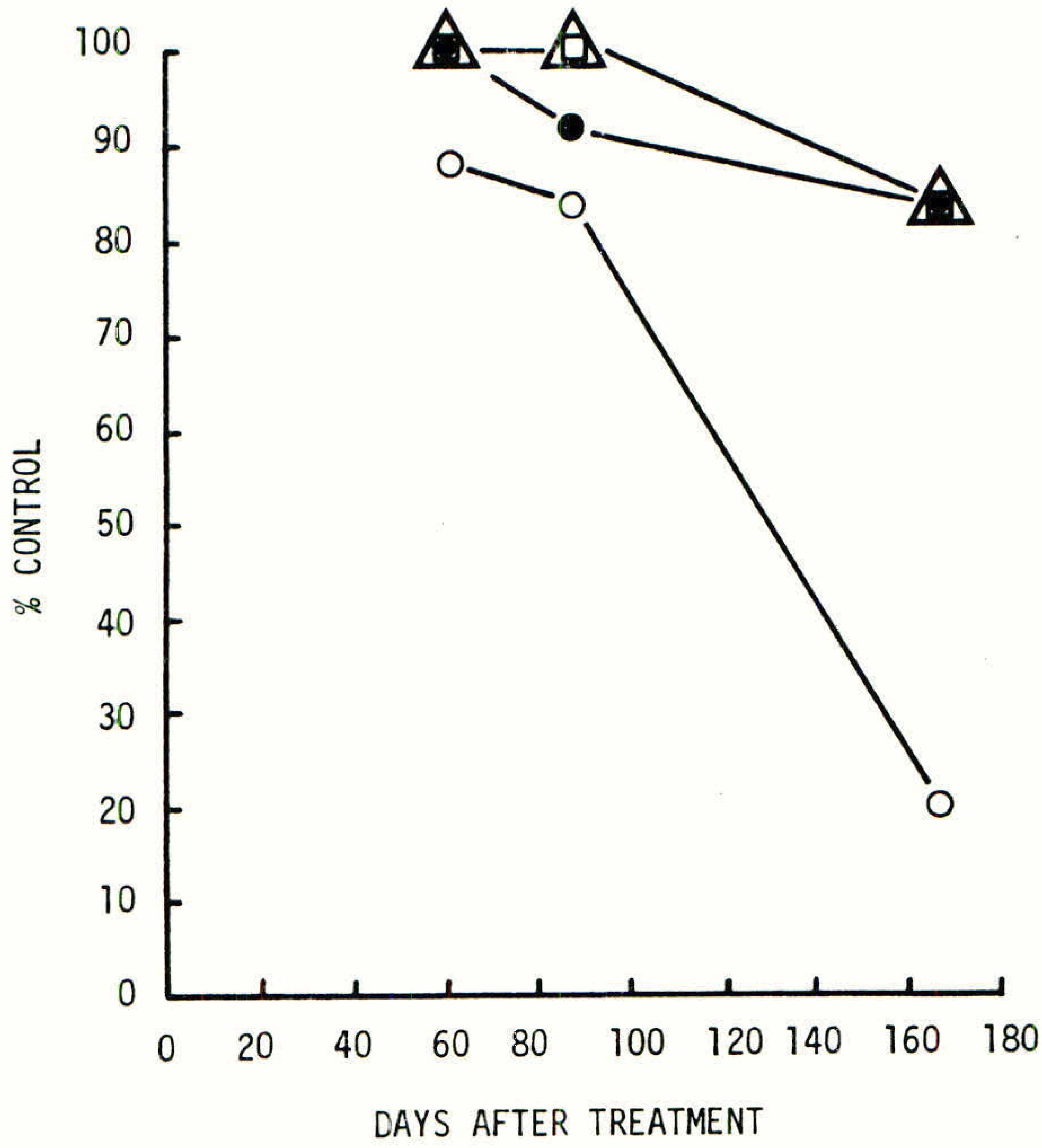


Fig. 2 Control of Echinochloa crus-galli with fluridone at 100 (○), 150 (●) and 200 (□) g a.i./ha and fluridone plus trifluralin (△) at 100 + 500 g a.i./ha, respectively, during the growth period of cotton in Spain (data from 1 trial).



DISCUSSION

The potential for selective use of fluridone at low application rates for control of annual broadleaf and grass weed species in cotton has been established in a number of field trials.

The application of low rates of a combination of fluridone and trifluralin to improve grass weed control is another possibility which is being explored. In addition, effective control of perennial species has been demonstrated at higher application rates (Webster et al., 1977; Wills, 1977) and trials are in progress to study this in detail.

It has been determined, in both laboratory and field experiments, that fluridone, like most other soil applied residual herbicides, requires moisture for activation. In further research, the optimum timing of application for maximum herbicidal activity is being examined.

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ALLOXYDIM-SODIUM FOR GRASS WEED CONTROL IN BROAD LEAVED CROPS IN THE UK

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Summary Alloxydim-sodium has been evaluated in a range of annual and perennial broad-leaved crops including rapeseed, cabbages, peas, potatoes, onions, sugar beet and strawberries and has been well tolerated at the maximum rates used, 1.4 to 4.5 kg a.i./ha.

Annual grass weeds such as *Avena fatua*, *Alopecurus myosuroides* and volunteer cereals were controlled by 0.56 to 0.94 kg a.i./ha from the 2-leaf to early tillering stages. Control of *Agropyron repens* in arable crops was acceptable at 1.5 kg a.i./ha. No broad-leaved weeds were controlled, even at 4.5 kg a.i./ha, and mixtures are required for broad spectrum weed control.

Resumé L'alloxydim-sodium a été evalué sur un grand nombre de dicotylédones annuelles et pérennes comprenant les colza, les choux, les petits pois, les pommes de terre, les oignons, les betteraves à sucre et les fraises. Il a été bien toléré pour les doses maximales employées: 1,4 a 4,5 kg ma/ha.

Les graminées adventices annuelles, par exemple l'*Avena fatua*, l'*Alopecurus myosuroides* et les repousses de céréales ont été maîtrisées aux doses de 0,56 à 0,94 kg ma/ha du stade deux-feueilles jusqu' ou début du tallage. Le contrôle de l'*Agropyrum repens* dans les cultures arables était acceptable à 1,5 kg ma/ha. Aucune adventice dicotylédone n' a été maîtrisée, même à une dose de 4,5 kg ma/ha et les associations sont nécessaires pour le contrôle d'un plus grand spectre de mauvaises herbes.

INTRODUCTION

Alloxydim-sodium, formerly known as NP 48, was discovered by the Nippon Soda Co. of Japan in 1973 (Hirono *et al.*, 1976; Iwataki & Hirono, 1978). The product possesses both pre- and post-emergence activity specifically against *Gramineae*. As the residual activity is of short persistence, the product is preferentially used post-emergence. Wide-scale trials in Europe have demonstrated the efficacy of alloxydim-sodium against annual grass weeds (Quece *et al.*, 1977; Beaudoin *et al.*, 1977; Vernie, 1977; Salembier & Belieu, 1977; Durgeat & Richard Mullard, 1977; Formigoni & Hirono, 1977; Derycke, 1978) and have demonstrated its high selectivity in broad-leaved crops.

A series of small plot trials were commenced in the UK in Autumn, 1977. Because of the specificity against grasses, mixtures with commercially available broad-leaved herbicides were tested as appropriate. Some tests carried out by co-operators are reported separately (Knott, 1978; May, 1978).

METHODS & MATERIALS

Methods

(i) Application:- All treatments were applied with a self-propelled precision small-plot sprayer at a volume rate of 235 l/ha for annual grass weeds and 356 l/ha for couch grass using flat fan 'Teejets' at a pressure of 2.07 bars.

(ii) Layout:- Applications were in a randomized block design with 3 or 4 replicates. Plot sizes were usually 2.5m x 7m.

(iii) Assessments:- (a) Crop tolerance
Visual assessments of crop condition using the EWRC 1-9 crop safety scale at usually 7, 14 and 28 days post spraying and at further intervals through the growing period.

Combine yields:
Cut of 1.83m x 7m with Claas 'Columbus', per plot.

(b) Weed control
Quadrat counts - 2 x $0.5m^2$ per plot, number and height of all weeds present.

Crops

The following varieties were tested:-

Sugar beet	Peas	Oilseed rape	Potatoes	Field Beans	Summer Cabbage	Onions	Strawberries
Nomo	Bertie	Primor	Desiree	Maris Bead	1st June	Rivato	Gorella
Vytomo	Carpo	Rapora	Pentland Crown		Primo		Cambridge Favourite
Amono	Vedette						
Bush Mono	Maro						
Amber							
Monotri							
S.K.Monobeet							
Kawecora							
Anglo Maribo Poly							
S.K.Poly							

Materials and formulations:-

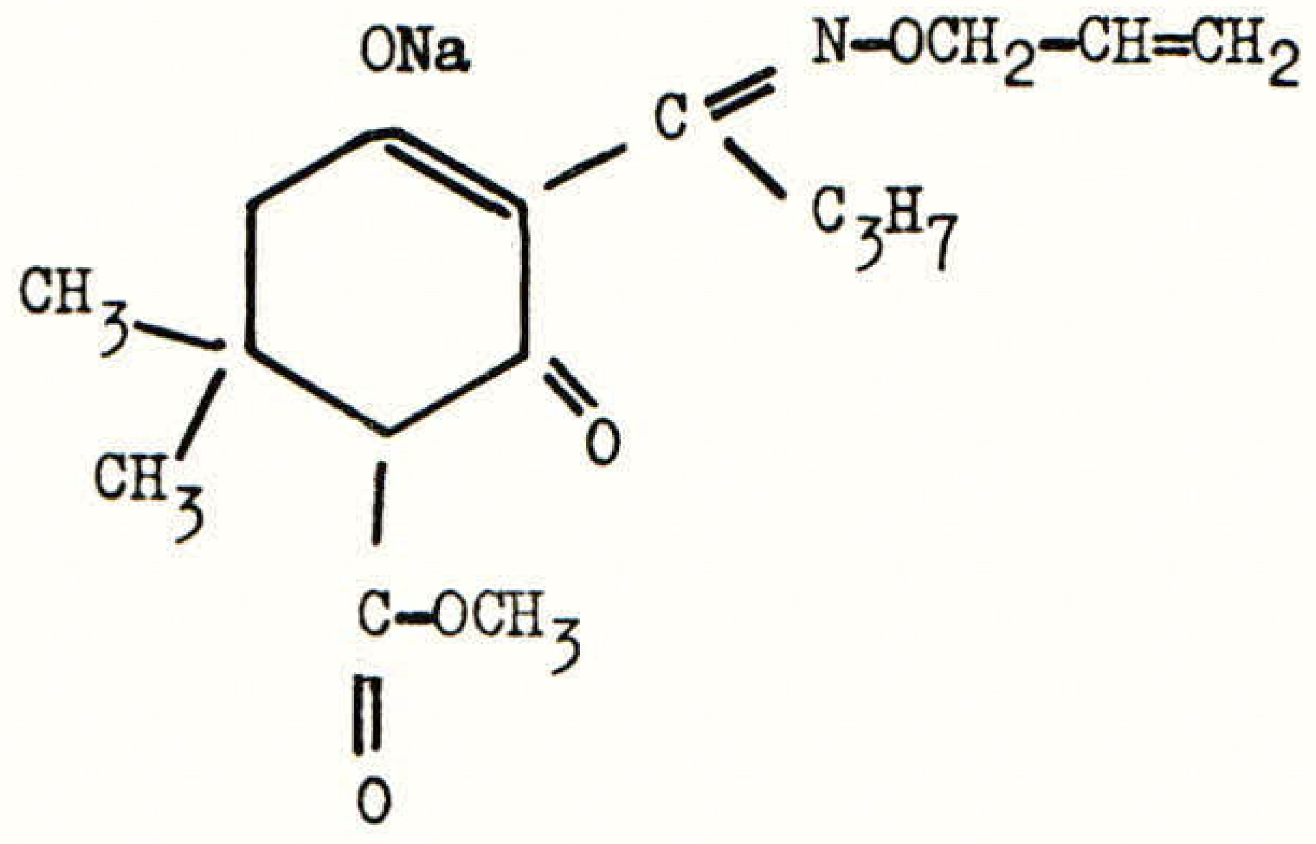
Common name	Formulation
Alloxydim-sodium	75% w/w s.p.
Diclofop-methyl	36% w/v e.c.
Phenmedipham	11.4% w/v e.c.
Bentazone	48% w/v a.c.
Metribuzin	70% w/w w.p.
Carbetamide	70% w/w w.p.

Chemical properties

Common name: alloxydim-sodium

Chemical name: sodium salt of 2-(1-alloxyamino butylidene)-5,5-dimethyl-4-methoxycarbonyl-cyclohexane-1,3-dione.

Chemical structure:



Appearance: odourless white crystals

Melting Point: 185.5°C (decomposed)

Solubility in g/100 ml of solvent at 30°C degrees:

Water	>200.0
Dimethyl formamide	100.0
Methanol	61.9
Ethanol	5.0
Methyl ethyl ketone	1.5
Acetone	1.4
Cyclohexanone	0.3
Ethylene dichloride	0.3
Ethyl acetate	0.2
Xylene	0.002

Toxicity

Acute oral LD 50 (mg/kg)	Rats :	male 2.322	female 2.260
	Mice :	male 3.200	female 3.000

The compound has low dermal toxicity, it is non irritant, and also has very low chronic toxicity for warm blooded animals.

RESULTS AND DISCUSSION

The following results and accompanying discussion summarize the work carried out in the 1977-78 winter crops and 1978 spring crops.

Table 1

Control of *Avena fatua* with alloxydim-sodium

Materials	Dose kg a.i./ha	Mean % control of weed bulk (numbers x height) Sugar Beet (4 sites)	Peas (3 sites)	Potatoes (2 sites)	Winter Rape (2 sites)	Field Beans (1 site)
Alloxydim-sodium	0.56	-	61 b		83	70
	0.75	82 b	85 ab	88	96	89
	0.94	-	88 ab		97	93
Alloxydim-sodium + phenmedipham	0.75+1.14	89 ab	-	-	-	-
	0.94+1.14	92 a	-	-	-	-
Alloxydim-sodium + bentazone	0.75+1.44	-	46*	-	-	-
Alloxydim-sodium + metribuzin	0.75+1.05	-	-	94	-	-
	0.94+1.05	-	-	94	-	-
Diclofop-methyl	1.26	62 c	78 ab	60	-	85
Diclofop-methyl + phenmedipham	1.26+1.14	64 bc	-	-	-	-
Diclofop-methyl + bentazone	1.26+1.44	-	55*	-	-	-
Diclofop-methyl + metribuzin	1.26+1.05	-	-	82	-	-
Carbetamide	2.1	-	-	-	97	-
Growth stage - range of *Avena fatua* at spraying.		1 leaf-2tillers mainly 3-4 leaves	1 leaf-4tillers mainly 2 lvs-2 tillers	1 leaf-2tillers mainly 3 lvs-1 tiller	1 leaf-2tillers mainly 2 lvs — 3 lvs	1 leaf-2tillers mainly 3 lvs - 1 tiller
Average population (m^{-2}) at assessment.		32	23	12	44	33
Spraying assessment interval - weeks		4-6	4-6	4-6	12-14	4-6

Duncan's range test significant at 1% level in sugar beet and peas.

* Two sites only not included in statistical analysis.

(a) Wild oats (*Avena fatua*) (Table 1)

Alloxydim-sodium alone at 0.75 kg a.i./ha gave acceptable control of wild oats at up to the 4 leaf stage, whilst on larger plants, i.e. early tillering, 0.94 kg a.i./ha gave more reliable results. It was interesting to note that autumn treatments (those in winter rape) were more efficaceous than spring treatments, possibly reflecting the better moisture conditions in the autumn for growth.

When used in mixtures with broad-leaved herbicides to give broad spectrum control, it was found that both phenmedipham and metribuzin further improved activity against wild oats. Conversely, the addition of bentazone to alloxydim-sodium resulted in marked antagonism on wild oats. This effect was also noted in mixtures of bentazone with diclofop-methyl.

Table 2

The control of annual grass weed species with alloxydim-sodium

		Mean % control of weed bulk (numbers x height)			
Material	Dose kg a.i./ha	*Alopecurus myosuroides*	Volunteer barley		Volunteer wheat
Alloxydim-sodium	0.56	95	93	45	-
	0.75	97	98	77	100
	0.94	97	99	93	100
Carbetamide	2.10	87	100	-	89
Diclofop-methyl	1.26	-	-	7	-
Growth stage range at spraying		1 leaf - 8 tillers	mainly 3 lvs	2 lvs - 4 tillers	2 lvs - 1 tiller
Population (m^{-2}) at assessment		71	38	60	8
No. of sites		3	2	1	1
Crop		Winter rape	Winter rape	Peas	Winter rape
Assessments made at		12-14 weeks		6 weeks	
post spray in		Winter rape		Peas	

(b) Other annual grasses (Table 2)

In winter rape, *Alopecurus myosuroides*, volunteer barley and volunteer wheat were all satisfactorily controlled with 0.56 to 0.75 kg a.i./ha alloxydim-sodium. Treatments were applied to grasses at a wide range of growth stages and, nevertheless, results were comparable to the established standard carbetamide.

In the spring drilled pea crop, the control of barley was not as good as at comparable rates applied in the autumn, perhaps due to dry conditions causing a retardation of growth and hence "hardening", and to the wide range of growth stages (1 leaf to 5 tillers) encountered. Nevertheless the control at 0.94 kg a.i./ha was acceptable.

Table 3

The control of Agropyron repens in arable crops with alloxydim-sodium

Material	Dose kg a.i./ha	% control of weed bulk (numbers x height) Peas	Cabbage	Strawberry runners	Cabbage	Peas	Onions
Alloxydim-sodium	1.5	99	93	85	100	97	94
	1.88	99	99	90	100	97	78
	2.25	99	100	93	100	99	97
Growth stage and height range (cm) of Agropyron repens at spraying		1-4 lvs 5-25	3-4 lvs 12-25	3-4 lvs 15-37	3-4 lvs 10-20	3 lvs-flag 50-60	2 lvs-flag 10-40
Population (m^{-2}) at assessment		333	123	171	523	98	190

Spraying/assessment interval - 6-8 weeks

(c) Agropyron repens (Table 3)

In arable crops where rhizomes are fragmented during the course of normal cultivations, it was found that alloxydim-sodium at 1.5 kg a.i./ha gave acceptable control of Agropyron repens at the 2 leaf stages. These levels of control persisted through the growing season of the crop, thus giving a desirable "releasing" effect by being able to control the weed in the crop itself, rather than using conventional techniques which require control measures outside the crop seasons. which are not always possible due to such factors as land leasing and sequential cropping.

Further work is planned on the long term control of couch grass.

(d) Broad-leaved weeds

There was no effect on any broad-leaved weeds at doses up to 2.25 kg a.i./ha. At doses up to 4.5 kg a.i./ha, slight stunting of Chenopodium album was observed.

Crop tolerance (Table 4)

Alloxydim-sodium was well tolerated by all the crops tested at the maximum doses used (1.5 to 4.5 kg a.i./ha depending on the trial type), all of which were designed to test double the anticipated "normal" doses of 0.75 and 2.25 kg a.i./ha for annual and perennial grass weeds, respectively.

In mixtures, some phytotoxicity was noted with phenmedipham in sugar beet and metribuzin in potatoes. This phytotoxicity was no more, or only marginally more severe, than that experienced with the broad-leaved herbicide component alone. Hence it is not anticipated that any problems will arise in this respect. It was noted that overall applications of SMA (sodium monochloracetate) after alloxydim-sodium caused increased phytotoxicity compared with SMA treatment alone. The symptoms were those of SMA, not alloxydim-sodium.

Table 4

Crop tolerance shown as the mean highest scores recorded at any assessment timing throughout the period of evaluation

(EWRC score)

Materials	Dose kg a.i./ha	Sugar beet (6 sites)	Peas (6 sites)	Potatoes (2 sites)	Winter Rapeseed (5 sites)	Field Beans (1 site)	Onions (1 site)	Summer Cabbage (2 sites)	Strawberries (3 sites)
Alloxydim-sodium	0.75	1.3	1.0	1.0	1.3	1.3	-	-	-
	1.5	-	-	-	1.4	-	1.0	1 (2.5)*	1.8
	1.88	1.5	1.0	2.0	-	1.5	1.0	-	-
	3.7 - 4.5	1.7	1.5	-	-	-	1.2	1.1(3.5)*	2.6
Alloxydim-sodium + phenmedipham	0.75+1.14	1.6	-	-	-	-	-	-	-
	1.88+1.14	1.9	-	-	-	-	-	-	-
Alloxydim-sodium + bentazone	0.75+1.14	-	1.0	-	-	-	-	-	-
Alloxydim-sodium + metribuzin	0.75+1.05	-	-	2.2	-	-	-	-	-
	1.88+1.05	-	-	2.4	-	-	-	-	-
Diclofop-methyl	1.26	2.1	1.0	1.3	-	1.8	-	-	-
Diclofop-methyl + phenmedipham	1.26+1.14	2.5	-	-	-	-	-	-	-
Diclofop-methyl + bentazone	1.26+1.44	-	1.5	-	-	-	-	-	-
Diclofop-methyl + metribuzin	1.26+1.05	-	-	1.8	-	-	-	-	-
Carbetamide	2.1	-	-	-	2.0	-	-	-	-
Phenmedipham	1.14	2.1	-	-	-	-	-	-	-
Bentazone	1.44	-	1.1	-	-	-	-	-	-
Metribuzin	1.05	-	-	2.7	-	-	-	-	-
Range of growth stages and height (cm) at spraying		2-8 lvs 25	3-6 lvs mainly 15	80%-90% em. 20	Cot - 4 lvs 13	6 lvs 20	2-3 lvs 13	6 - 8 lvs 25	in bud
Spraying assessment interval - weeks		←	4-6	→	12-14	←	4-6		→

* Score following commercial application of sodium monochloracetate 8 days after alloxydim-sodium application.

GENERAL CONCLUSIONS

Alloxydim-sodium at 0.75 to 0.94 kg a.i./ha applied post-emergence will permit farmers to control annual grass weeds including Avena fatua, Alopecurus myosuroides and volunteer cereals at a wider range of growth stages than is possible with existing commercially available products in all non-graminaceous crops tested.

In addition, at higher doses (1.5 to 2.25 kg a.i./ha), farmers will now be able to obtain season-long post-emergence "in crop" couch control in non-graminaceous arable and vegetable crops.

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NEW HERBICIDES FOR FIELD BEAN

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Summary Herbicides recently introduced for weed control in pea and horticultural bean crops were evaluated in 1976 and 1977 as alternatives to simazine and dinoseb acetate for use in field bean (*Vicia faba* minor L.). Trietazine/simazine, terbutryne/terbuthylazine and cyanazine applied pre-emergence of the crop at rates used in peas gave better weed control than simazine and showed no evidence of greater phytotoxicity to field bean. Trietazine/simazine had less adverse effect than simazine in a crop drilled with only 2.2 cm of settled soil above the seed. Trifluralin at 1.12 kg a.i./ha incorporated to 5 cm before sowing caused delayed emergence and some distortion and stunting of young plants in both years, but gave better control of *Polygonum aviculare* than did any other herbicide. A chlorthal-dimethyl/methazole mixture gave no more effective weed control than did simazine. Bentazone at the rate used in *Phaseolus* beans reduced crop yields in both years, but particularly in 1977 when dinoseb acetate had little adverse effect on the crop, and gave less effective control of weeds in both years than the latter herbicide. Weed competition on untreated plots in two experiments in 1977 reduced yield of beans per plant by 24% and 30%, mainly by decreasing the number of pods per plant.

INTRODUCTION

Annual weeds can seriously reduce seed yield in spring-sown field bean (Glasgow, Dicks & Hodgson, 1976), as can injury by herbicide treatment (Roebuck, 1970). Simazine has been for many years the main residual herbicide used to control annual weeds (Kerr, Hebblethwaite & Holloway, 1975). Although very effective in the autumn-sown crop in many situations, it fails to control several important spring-germinating weeds, particularly *Polygonum* species which can be a severe problem in the spring-sown crop. Its limited safety to the crop necessitates a recommendation for drilling with at least 7.5 cm of settled soil covering the seed if injury is to be avoided. This depth is not always achieved easily under field conditions and Kerr *et al* (1975) found that only just over 50% of crops surveyed in 1973 met the requirement. Even so, simazine injury was recorded in some fields sown at the correct depth, while half the crops sown at depths between 5 and 10 cm were damaged by the herbicide. For post-emergence weed control, dinoseb acetate is very effective on seedling weeds of many species, but good results require careful timing of application and crop tolerance is limited by weather conditions (Fryer & Makepeace, 1972). There is therefore a need for safer and more versatile herbicide treatments for this crop.

MATERIALS AND METHODS

Three experiments were carried out (one in 1976, two in 1977) at the Institute farm on soils classified as sandy loam and with organic matter content (as determined by loss on ignition) of 6 - 8%. Plots consisted of single beds of 13 rows drilled 12.7 cm apart, plot length being 3.7 m. Seed of cv Herz Freya was drilled at 242 kg/ha using a tractor-mounted Stanhay drill. Plots were rolled after drilling. All herbicide treatments were applied by Oxford Precision Sprayer in 540 l water/ha. Trifluralin was applied and incorporated to 5 cm depth by rotary cultivation before crop drilling. Other residual herbicides were applied pre-emergence of the crop. Post emergence herbicides were applied when the crop was 5 or 15 cm high.

Plots were scored regularly for percentage ground cover by crop and weeds. Weed counts were taken on 2 x 1 sq.m quadrats per plot in early June. Weed-free plots were kept clean by handweeding until the crop canopy closed over. Records were taken of plant numbers and heights at intervals during the growing season. In 1976, 5 sq. m areas of each plot were harvested and vined, but in 1977 crop lodging and damage by feral pigeons made this impracticable. In all three experiments detailed records were taken at harvest on 10 plants selected at random from each plot. These were used in 1977 to give estimates of yield per unit area.

Experiment I Beans were sown on 11 March, 1976. Trifluralin was applied and incorporated on the previous day. The seed was sown at 7.5 cm depth, but the effective depth after rolling was 6.4 cm. Seed bed conditions were good, but wind and rain thereafter prevented application of the pre-emergence herbicides until 1 April. Dry weather followed for the next 3 - 4 weeks but early May was very wet. The post-emergence herbicides were applied in dry sunny conditions on 21 May when the crop on hitherto untreated plots was 15 cm high. The experimental design involved six seedbed herbicide treatments in factorial combination with four supplementary weed control treatments, all randomised and replicated three times.

Seedbed	Rate kg a.i./ha		Supplementary	Rate kg a.i/ha
Untreated			Handweeded	
Simazine	1.12		Unweeded	
Terbutryne/terbuthylazine	1.40	X	Dinoseb acetate	3.50
Trietazine/simazine	1.40		Bentazone	1.44
Cyanazine	1.75			
Trifluralin	1.12			

Experiment II Trifluralin was applied and incorporated on 29 March 1977 and the crop was sown later that day. This was part of a larger experiment involving three sowing depths which was seriously damaged by feral pigeons at crop emergence and again at harvest. Results for this one sowing depth, at which the least overall crop injury was recorded, have been analysed separately. The effective seed depth after rolling was 2.2 cm. Wet weather during March delayed sowing; soil conditions for incorporation and drilling were reasonable. Windy weather prevented further herbicide application until 8 April, by which time the soil surface was dry. Light rainfall occurred in the next few days.

Eight weed control treatments were replicated three times in a randomised block design.

Treatment	Rate kg a.i./ha	Treatment	Rate kg a.i./ha
Unweeded		Cyanazine	1.75
Simazine	1.12	Chlorthal-dimethyl/ methazole	4.44
Terbutryne/ terbuthylazine	1.40	Trifluralin	1.12
Trietazine/simazine	1.40	Handweeded	

<u>Experiment III</u> The crop was sown adjacent to and on the same day as the previous experiment, but at a depth of 2.9 cm after rolling. It suffered very little pigeon injury at emergence and the plant stand averaged 87/sq.m.

Six weed control treatments were replicated four times in a randomised block layout:-

Treatment	Rate kg a.i./ha	Crop size(cm)
Unweeded		-
Handweeded		-
Bentazone	1.44	5
Bentazone	1.44	15
Dinoseb acetate	3.50	5
Dinoseb acetate	3.50	15

Herbicide treatments were applied on 18 and 30 May, at which time weeds were at the 2 - 4 leaf and young plant stages respectively. The weather during the second half of May was warm, dry and sunny.

RESULTS

Experiment I

Weeds emerged later than the crop and were few in number, even on untreated plots. The main species was *Polygonum aviculare*, which was also virtually the only surviving species on plots treated with residual herbicides, other than those given trifluralin, where a few plants of *Capsella bursa-pastoris* emerged. By the date of application of the post-emergence herbicides (21 May) ground cover by weeds was 18% on untreated plots, 5% on plots treated with trietazine/simazine or cyanazine and 8 - 9% on other plots. Dinoseb acetate largely eliminated surviving weeds on plots treated previously with residual herbicides and reduced weed cover on untreated plots by 75%. Bentazone by comparison, had no useful effect on *P. aviculare* and gave no improvement over plots given no supplementary treatment, other than reducing the population of *C. bursa-pastoris* on plots treated earlier with trifluralin. Weeds were thereafter effectively shaded by the crop canopy.

Weeds had no adverse effect on crop growth and yield on totally untreated plots and there were no significant interactions between the two treatment factors. Crop records are therefore presented as pooled means for seedbed and for supplementary treatments (Table 1).

The crop emerged in mid April. Only plots treated with trifluralin showed adverse effects of seedbed herbicide treatment;

<u>Table 1</u>

<u>Experiment I - Crop records</u>

Weed control treatment	Plants /2 sq m	Mean stem ht.(cm)	10 plant records: Wt. beans (g)	No. pods	Beans/ pod	Mean wt. g/1000 beans	Harvest records/5 sq m: Wt. beans (kg)ø	Wt. haulm (kg)	No. stems
	4 May	11 June	13 September				13 September		
<u>Seed-bed</u>									
Untreated	135	85	85	72	3.17	377	2.10	4.25	274
Simazine	139	84	74	66	2.97	384	2.07	4.00	285
Terbutryne/ terbuthylazine	136	82	90	68	3.62	381	2.28	4.19	273
Trietazine/ simazine	139	83	83	72	2.99	381	2.20	3.96	286
Cyanazine	137	84	91	71	3.34	390	2.25	4.15	275
Trifluralin	133	77***	94	74	3.27	396	2.06	3.73**	241
S.E. mean ±	2.9	1.3	7.4	3.8	0.264	8.6	0.082	0.127	19.6
<u>Supplementary</u>									
Handweeded	134	89	88	70	3.36	383	2.33	4.24	282
Unweeded	132	89	77	66	3.25	366	2.17	4.35	299
Dinoseb acetate	140	68+++	105	83++	3.16	402	2.00++	3.44+++	203++
Bentazone	139	84++	75	62	3.14	388	2.13+	4.15	306
S.E. mean ±	2.4	1.1	6.1	3.1	0.216	7.0	0.067	0.104	16.0

*, **, *** Significantly different from Untreated at the 5%, 1% or 0.1% level.
+, ++, +++ Significantly different from Handweeded at the 5%, 1% or 0.1% level.
ø Adjusted to 15% moisture content.

crop emergence was delayed and erratic and a proportion of the plants was distorted and stunted, but final plant stand was not reduced. Supplementary treatment with bentazone caused some leaf-scorch and checked crop growth slightly but dinoseb acetate blackened leaves, injured growing points and killed a proportion of the treated plants. Effects of trifluralin and the two post-emergence herbicides were still clearly visible in mid June, particularly in mean plant height, but were much less obvious at harvest time, except that on plots treated with dinoseb acetate, ripening was delayed considerably in comparison with all other plots. These plots were also the only ones showing a significant reduction in plant stand - 28% lower than on hand-weeded plots. Analysis of 10 plant samples showed that plants treated with dinoseb acetate had compensated for reduction in height and numbers by increased pod production per plant. This combined with unripe seeds to raise fresh weight of beans per plant above that of all other supplementary treatments. However, seed yield per plot, adjusted to 15% moisture content, showed a 14% reduction with dinoseb acetate in comparison with hand-weeding. Plots treated with bentazone showed a 9% reduction. Haulm weights showed that the adverse effects of both dinoseb acetate and trifluralin on vegetative growth had persisted until harvest, but neither trifluralin nor any of the other seedbed treatments affected pod production or seed yield.

Experiment II

Weeds emerged in large numbers several days after the crop. P. aviculare was again the major species on untreated plots and on all herbicide-treated plots except on those treated with trifluralin where C. bursa-pastoris and Matricaria spp. predominated. Fumaria officinalis was also an important species on untreated plots and particularly on those treated with chlorthal-dimethyl/methazole and simazine, where it was not effectively controlled. In June and July when most other weeds were well below the crop canopy, plants of this species were able to keep pace with the crop and avoid shading. However, they flowered and senesced before the crop leaves fell. Numbers of P. aviculare were greatly reduced on all treated plots other than on those sprayed with simazine. All herbicide treatments gave excellent control of Lamium amplexicaule and Veronica persica, but chlorthal-dimethyl/methazole was ineffective on Matricaria spp. Weed cover increased very rapidly in late spring, reaching 43% on untreated plots by 3 June. Trietazine/simazine, cyanazine and terbutryne/terbuthylazine gave excellent overall weed control, weed cover on these plots being 4 - 6% at this time, while other herbicides held weed cover to 11 - 15%. Thereafter, competition from the crop kept weeds from developing further until after leaf-fall, by which time P. aviculare was almost the only surviving species. On untreated plots and those treated with simazine plants of this species grew rapidly in the weeks before harvest and at 30 - 40% ground cover posed a considerable obstruction to harvesting operations.

Pigeon damage to seeds and seedling plants at emergence was fairly uniform across the experiment and differences in final plant stand were relatively small, except that on plots treated with trifluralin crop emergence was considerably delayed. Either this factor or possibly some effect of the herbicide on the palatability of the seeds resulted in these plots escaping much of the initial pigeon damage (Table 2). There were no visible effects of other herbicide treatments on crop emergence or vegetative growth. Trifluralin caused some stunting and distortion of plants, but the differences in height from those on

Table 2

Experiment II - Crop records

Weed control treatment	Plants /m² 5 May	Mean stem ht.(cm) 12 July	10 plant records 6 September				Wt. beans g/m²ø
			Wt. beans (g)	No. pods	Beans/ pod	Mean wt. g/1000 beans	
Unweeded	55	101	146*	107	2.75	483	708
Simazine	44	104	151	113	2.86	470	606*
Terbutryne/ terbuthyl- azine	47	102	143*	104	2.96	470	612*
Trietazine/ simazine	49	99	182	121	3.22	470	816
Cyanazine	42	97	163	120	2.99	457	617*
Chlorthal- dimethyl/ methazole	45	101	156	108	3.13	460	637
Trifluralin	70***	94	145*	102*	3.01	470	893
Handweeded	48	103	191	132	2.85	507	823
S.E. mean ±	3.6	4.2	14.2	9.6	0.135	18.6	62.3

Table 3

Experiment III - Crop records

Weed control treatment	Crop ht. (cm)	Mean stem ht.(cm) 12 July	10 plant records 6 September					Wt. beans g/m²ø
			Wt. beans (g)	No. pods	No. nodes with pods	Beans /pod	Mean wt. /1000 beans	
Unweeded		104*	99*	72*	37.5	3.0	463	774
Handweeded		115	142	96	45.2	3.1	490	1032
Bentazone	5	105*	103*	83	42.0	2.5**	503	818
Bentazone	15	95***	106*	71*	32.7**	2.7*	570*	715*
Dinoseb acetate	5	104*	124	90	43.7	2.9	478	944
Dinoseb acetate	15	104*	114	77	40.7	3.0	488	883
S.E. mean ±		3.3	11.2	7.4	2.59	0.11	20.1	94.6
Sig. of effect of								
Herbicide		NS	NS	NS	NS	++	+	NS
Crop height		NS	NS	NS	+	NS	NS	NS

*, **, *** Significantly different from Handweeded at the 5%, 1% or 0.1% level. NS - Not significant.

+, ++ Difference significant at the 5% or 1% level.

ø Adjusted to 15% moisture content.

hand-weeded plots were not significant. Ten plant samples were taken on 6 September. The beans averaged 24% moisture content, there being no significant differences between treatments. Weeds reduced yield per plant on unweeded plots by 24% in comparison with hand-weeded plots. Similar yield reductions were also recorded from plots treated with terbutryne/terbuthylazine and trifluralin. The main factor involved in lower yields was number of pods per plant. Conversion to yield per unit area resulted in plots treated with trifluralin matching those kept hand-weeded, because of the difference in plant populations. On this basis terbutryne/terbuthylazine, simazine and cyanazine all showed a significant reduction in comparison with the hand-weeded treatment. Other treatments, including the unweeded standard did not.

Experiment III

The weed situation was similar to that on untreated plots in the previous experiment. Dinoseb acetate applied at either date gave good control of F. officinalis and C. bursa-pastoris, but only checked P. aviculare. Early applications of both herbicides gave good control of Matricaria spp. and L. amplexicaule. Bentazone was totally ineffective on P. aviculare. Overall, dinoseb acetate gave the better reduction in weed cover and the earlier applications were more effective than the later. Herbicide treatments reduced weed cover until the crop canopy was formed, but at harvest P. aviculare was almost as widespread on treated as on untreated plots. Dinoseb acetate caused some blackening of crop leaves and growing points at both dates of application, but the injury was slight. Bentazone applied at 5 cm caused some leaf scorching, but at 15 cm injury was much more widespread; subsequent stem elongation and the development of new leaves were visibly affected. The latter were much smaller and thinner than new leaves on untreated plots and the crop canopy was considerably reduced compared with other treatments. There was no indication that any treatment killed plants. All herbicide-treated plots and also the unweeded plots had shorter plants than those on hand-weeded plots during July but only the later bentazone treatment visibly affected leaf size and development (Table 3). At harvest on 6 September, moisture content of the beans was 23 - 26% except on those treated with bentazone at 15 cm, where it was 35%. The presence of untreated weeds reduced yield of beans per plant by 30%, mainly due to fewer pods per plant. Dinoseb acetate applied at either date prevented yield loss and had no significant effects on pod and bean records. Bentazone at both dates reduced yield per plant by 25 - 27%, the earlier treatment mainly through effects on number of beans per pod, while the later treatment also showed a reduction in number of pod-bearing nodes and hence in pods per plant. Conversion to 15% moisture content and yield per unit area maintained treatment differences, but experimental variation was too high for any treatment other than the later application of bentazone to be significantly lower than the hand-weeded standard.

DISCUSSION

The yield reductions on totally unweeded plots in 1977 confirmed the report by Glasgow et al (1976) that the field bean crop is highly vulnerable to competition from weeds. In particular, Fumaria officinalis kept pace with the crop canopy well after other species had been outgrown in 1977. The crop eventually smothered most other weed species, but Polygonum aviculare was able to survive under the crop canopy and spread once leaf-fall by the crop had occurred, thus offering potential obstruction to harvest operations.

At the sowing depth achieved (6.4 cm) in 1976 there was no adverse reaction to simazine or any of the alternative triazine formulations and mixtures. In 1977, at 2.2 cm depth, there was evidence of possible phytotoxicity with terbutryne/terbuthylazine and cyanazine as well as with simazine. Both newer herbicides gave much better weed control than simazine and it is not thought that weed competition was involved to any appreciable extent in yields on these two sets of plots. Trietazine/simazine gave excellent weed control, and showed no signs of phytotoxicity to the crop in either trial. Depth of seed placement in relation to crop tolerance requires further examination over a range of seasons and soil types, to find whether these three herbicides can be used with safety on crops sown at less than the depth necessary with simazine. Trifluralin delayed crop emergence and caused a variable amount of stunting and distortion in both years and with three different depths of seed placement in 1977 (H. M. Lawson, unpublished), but did not in fact reduce the final yield of seed per unit area in these experiments. The herbicide is used in broad bean in the United Kingdom at the same dosage, but with the recommendation that incorporation to 5 cm depth be followed by drilling seed at least 7.5 cm deep (Elanco Ltd. personal communication). This degree of precision is not easily achieved in the seedbed conditions encountered in March. Further examination may be justified, because of the outstanding control of P. aviculare obtained with this herbicide. Weed control with chlorthal-dimethyl/methazole was no better than with simazine, nor was crop yield. Bentazone had little to offer by way of improved crop safety or weed control performance in comparison with dinoseb acetate. It appears that the environmental and/or crop conditions involved in phytotoxicity are not the same for the two herbicides, since bentazone caused much less injury in 1976 when dinoseb acetate severely damaged the crop, while the positions were reversed in 1977. Failure by bentazone to control P. aviculare was a major limitation in these experiments, since this was the main species left by all seedbed herbicide treatments other than trifluralin. There was no evidence of any interaction between the seedbed treatments and the supplementary herbicide treatments in terms of crop phytotoxicity in 1976, despite injury by trifluralin, bentazone and dinoseb acetate. Further information is needed on possible interaction in situations where the triazine herbicides cause injury before programmes of pre- and post-crop emergence treatments can be recommended.

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