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TOLERANCE OF MALUS cv. HILLIERI AND MALUS x PURPUREA cv.ALDENHAMENSIS POLLINATORS TO GLYPHOSATE APPLIED IN APRIL OR OCTOBER

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Summary. Glyphosate was applied at 2.4 and 4.8 kg a.e. in 450 l/ha to the soil around the base of the tree, or at the same concentrations to the trunk of *Malus* cv.'Hillieri' and *Malus* x purpurea cv.Aldenhamensis each on MM106, MM111 and seedling rootstocks. Applications in either April or October caused no visible damage to the trees and their efficiency as pollinators was not impaired.

Applications made to the distal 20 cm of a lower branch in April led only to the death of the one year wood of the branch sprayed. The trees flowered normally the following spring. But similar applications made in October led to extensive damage to leaves and flowers the following spring. The value of cv. Aldenhamensis as a pollinator was seriously reduced on all three rootstocks, as was the value of cv. Hillieri on MM111 and seedling rootstocks but not on MM106. In commercial practice this damage would be avoided if the lower branches were removed.

Resumé.Le glyphosate a été appliqué à 2,4 et 4,8 kg é.a. dans 450 l/ha autour de la base de l'arbre, ou dans les mêmes concentrations au tronc de *Malus* cv. Hillieri et de *Malus* x *purpurea* cv. Aldenhamensis, tous deux sur MM106, MM111 et porte-greffes de semis. Des applications faites soit en avril, soit en octobre n'ont pas causé de dégâts visibles chez les arbres. Leur efficacité comme pollinisateurs n'a pas été diminuée.

Des applications faites à la partie distale (20 cm) d'une des branches inférieures en avril ont abouti seulement à la mort du bois d'une année de la branche pulvérisée. Les arbres on fleuri normalement au printemps suivant.

Des applications pareilles faites en octobre ont occasionné des dégâts étendus sur les feuilles et les fleurs au printemps suivant. La valeur du cv. Aldenhamensis comme pollinisateur a été sérieusement diminuée sur tous trois porte-greffes, ainsi que celle du cv.Hillieri sur MM111 mais pas sur MM106. En pratique commerciale, on pourrait éviter ces dégâts en enlevent les branches inférieures.

INTRODUCTION

Glyphosate,(N-(phosphonomethyl)glycine) is a valuable broad-spectrum weedkiller (Davison 1972; Hodkinson 1974; Seddon 1974), used in orchards to control grasses and perennials beneath the trees (Bailey and Davison 1974). The horticultural practice of applying herbicides to a strip along the tree rows can result in direct herbicide contact with the trunk. However, the application of glyphosate to the trunks of mature trees is not harmful (Clay 1972; Davison 1975; Putnam 1976).

Damage occurs when branches are sprayed (Bailey and Davison 1974; Stott *et al.* 1974) but in reviewing 16 trials in which individual apple shoots were sprayed, Davison (1975) reports that in only four could damage be described as serious the year after treatment. Occasionally, growers have reported damage following the accidental spraying of lower branches, but with more careful application this hazard can be avoided. Since there have been so few reports of glyphosate damage in traditional apple orchards (Anon 1978) it was notable when in 1977 growers reported serious damage to the *Malus* cv. Hillieri which is increasingly planted as a pollinator in modern orchards.

The object of the work reported here was to determine

a. whether *Malus* pollinator species on different rootstocks differ in their tolerance to glyphosate and
b. whether the response is affected by dose, the season of application and the point of application.

METHOD AND MATERIALS

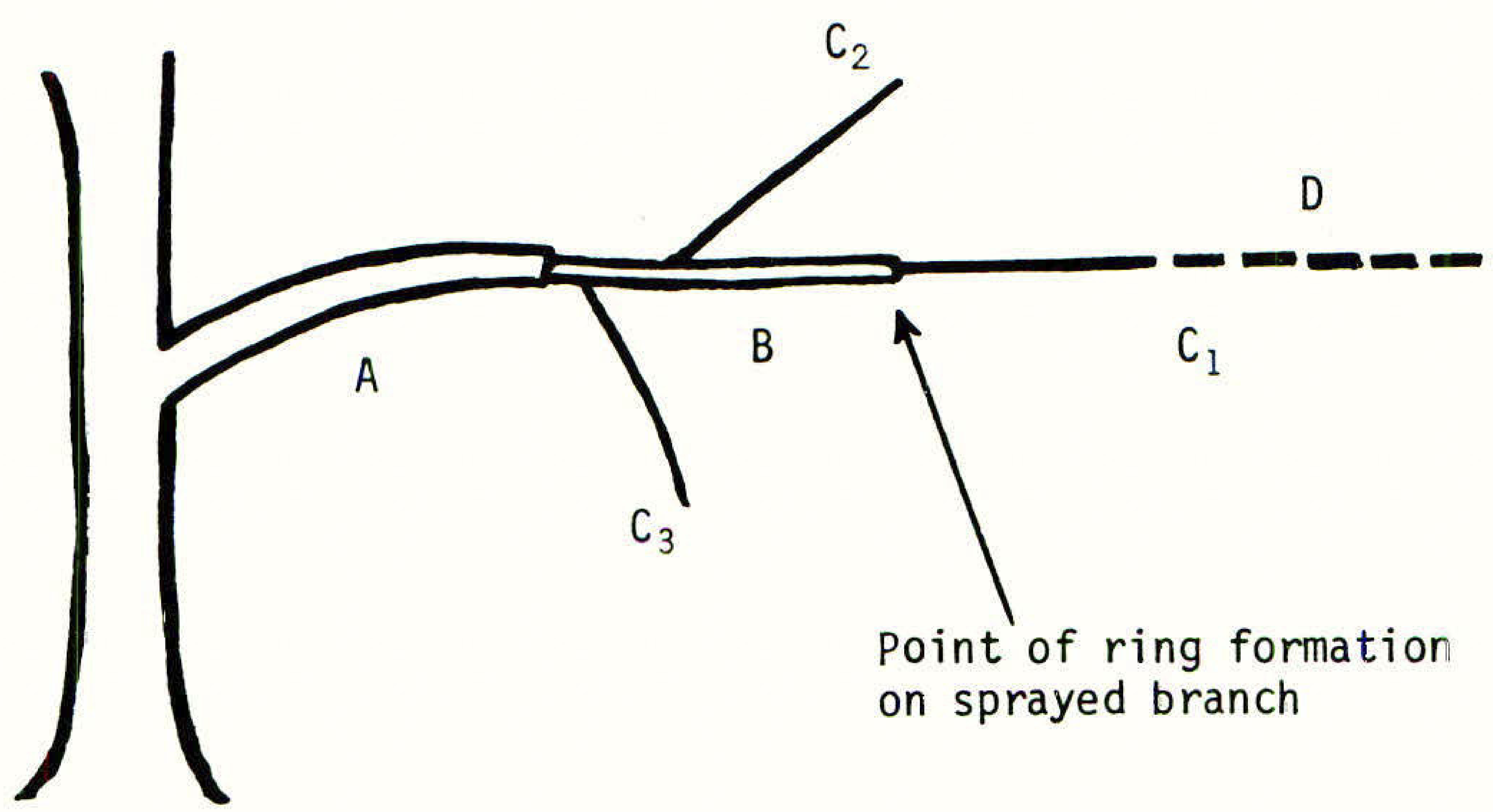
Four year old trees of *Malus* cv. Hillieri and *Malus* x *purpurea* cv. Aldenhamensis were used. Both were on MM106, MM111 and seedling rootstocks planted at 3.6 x 1.8 m, in a random block design. Of the 230 experimental trees available, 170 were sprayed on 14th April 1977 when the flowers were at the green cluster stage. The remainder were sprayed on 27th October 1977 when still in full leaf. At least 4 x 1 tree replicates were used on each cultivar on each rootstock for each spray treatment.

Glyphosate, as the isopropylamine salt, was applied

1. to 1 m^2 of ground round the base of the tree at rates of 2.4 and 4.8 kg a.e. in 450 l/ha or the same solutions (5000 and 10,000 ppmw) were sprayed to run off to
2. the basal 50 cm of the trunk, or
3. to the distal 20 cm of one year old wood on a lower branch (D, Figure 1).

Figure 1

Representation of 3 year old branch system



A = 3 year old branch

B = 2 year old branch

$C_{1,2,3}$ = 1 year old branches

D = sprayed distal 20 cm of a one year old branch

Application (a) simulates a commercial application to control weeds in the tree row, whereas (b) and (c) simulate accidental spray drift.

The herbicide was applied using a single-nozzle knapsack sprayer operating at a pressure of 0.65 Kg/cm^2.

Visual assessments of damage on Spring treated trees were made on 20th May, 8th August and 5th October, 1977. In early May 1978, tree damage and pollen viability were assessed for both Spring and Autumn treated trees. Counts were made to assess the proportion of damaged flower clusters on Autumn treated trees. A paired comparison tested was used on $\log_e$ of the cluster numbers to test if the treatments had affected the number of flowers produced.

Pollen viability test. Pollen from 9 flowers from each treatment was brushed onto sucrose-agar part covering a microscope slide and after incubation at room temperature for 24 hrs the germination was recorded (Church and Williams 1977). Pollen grains were counted as germinated if they had produced a tube longer than the grains diameter.

RESULTS

Spring application of glyphosate (1977)

Observations of trees treated in April 1977 were made between May and August 1977 and showed that no injury occurred when either low or high rates of glyphosate were applied to 1 m^2 of ground around the base of the trees, or when the same solutions were sprayed onto the basal 50 cm of the trunk; but spraying the distal 20 cm of lower branches completely killed the one year old wood. A distinct ring formed at the junction between the one and two year old wood. Damage was confined to the one year old wood of the sprayed branch; leaves, buds, and flowers on the second year wood appeared healthy. No damage was observed on the rest of the tree, and none appeared the following spring. Statistical analysis showed that in all treatments flowers produced in 1978 gave pollen of normal viability (Table 1).

No difference in susceptibility for any of these factors was found between cv. Hillieri and cv. Aldenhamensis or due to rootstock at either concentration.

Table 1

Viability of pollen in Spring 1978 from trees sprayed with glyphosate (4.8 kg/ha rate) in Spring 1977 (% germination)

Malus species and rootstock	Point of application: Ground	Trunk	Distal 20 cm*	Unsprayed control tree	S.E.D.
Hillieri					7.1
106	43	46	51	50	
111	54	50	50	52	
Seedling	49	47	40	51	
Aldenhamensis					5.6
106	55	52	47	55	
111	48	50	51	52	
Seedling	45	52	46	51	

* Flowers sampled from the branch system subtending the sprayed branch, (A, B, C_2, C_3 etc., Figure 1).

Autumn application of glyphosate (1977)

Observations made between 20-25th May 1978 showed that glyphosate applied in

October 1977 to 1 m^2 around the base of a tree or to the basal 50 cm of the trunk did not damage the trees. No damaged flower clusters were recorded and statistical analysis showed that the number of flower clusters and the viability of the pollen was similar to that of unsprayed trees (Table 2). No difference in response was found between cv. Hillieri and cv. Aldenhamensis.

Table 2

Effect on flowers (1978) of Glyphosate applied to ground or trunk in October 1977. No. of blossom clusters and pollen viability.

Malus species and rootstock	Point sprayed	No. of blossom clusters/tree	Pollen viability % germination
Hillieri			
MM111	Ground	450	56
	Trunk	480	61
	Unsprayed	429	63
Seedling rootstock	Ground	585	58
	Trunk	609	65
	Unsprayed	584	66
MM106	Ground	1680	58
	Trunk	1575	61
	Unsprayed	1600	60
S.E.D.			4.0
Aldenhamensis			
MM111	Ground	390	54
	Trunk	410	53
	Unsprayed	461	60
Seedling rootstock	Ground	370	54
	Trunk	420	51
	Unsprayed	407	53
MM106	Ground	380	58
	Trunk	320	61
	Unsprayed	395	66
S.E.D.			7.1

Application to the distal 20 cm of a lower branch had led by November to the death of all tissue sprayed and in the following spring to extensive damage to the unsprayed branches. In both cv. Hillieri and cv. Aldenhamensis many leaves were small, narrow, cupped longitudinally and in cv. Hillieri they were chlorotic. A paired comparison test on $\log_e$ of the number of flower clusters showed that there was no difference in the number of flowers produced between sprayed and unsprayed trees. Flowers on sprayed trees were small and misshapen. They developed late, produced small twisted anthers, the majority of which did not dehisce. However, a little pollen could be collected and this was found to be viable (Table 3).

Damage was most severe on those parts of the sprayed branched system that were not killed by the glyphosate in autumn 1977,(A,B,C_2,C_3 etc., Figure 1) and this amounted to about 15% of the tree. These flowers did not produce viable pollen (Table 3).

The rootstock was found to affect the amount of damage in cv. Hillieri but not cv. Aldenhamensis (Table 3).

Hillieri on MM 111. The whole tree had damaged leaves and Table 3 shows that all flowers were damaged and produced no viable pollen.

Hillieri on seedling rootstocks. Approximately 80 per cent of the tree had damaged leaves and flowers. No viable pollen was produced from flowers on the sprayed branch system (A,B,C_2,C_3 etc.) and although the flowers on other branches produced very little pollen, samples collected were found to be of normal viability.

Hillieri on MM106. Only the sprayed branch system, approximately 15 per cent of the tree, had damaged leaves and flowers and the latter produced no viable pollen. The remainder of the tree was undamaged, with healthy flowers which dehisced readily producing pollen of viability similar to that of the unsprayed control trees.

Aldenhamensis on MM111, 106 and seedling roostocks. Table 3 shows that the response on all rootstocks was similar to that of cv. Hillieri on seedling rootstocks.

Table 3

Effect on flowers (1978) of glyphosate applied to the distal 20 cm of a lower branch in October 1977

Malus species and rootstock	Point sprayed	No. of blossom clusters and pollen viability (% germination): No. blossom clusters/tree	No. damaged blossom clusters/tree	Damaged blossom clusters %	Pollen viability: Sprayed tree: Part of tree sampled: Sprayed* branch system	Remainder of tree	Unsprayed tree
Hillieri MM111	Branch	458	458	100	0	0	
	Unsprayed	429					63
Seedling rootstocks	Branch	596	471	79	0	61	
	Unsprayed	584					66
MM106	Branch	1269	190	15	0	62	
	Unsprayed	1600					60
Aldenhamensis MM111	Branch	439	331	75	0	58	
	Unsprayed	461					60
Seedling	Branch	294	276	94	0	53	
	Unsprayed	307					53
MM1o6	Branch	292	212	73	0	61	
	Unsprayed	395					66

* (A,B,C_2,C_3 etc., Figure 1).

DISCUSSION

Reports by growers of serious damage to *Malus* pollinator species after using glyphosate for weed control in orchards have led to the belief that *Malus* cv. Hillieri is particularly susceptible to glyphosate. We questioned whether ground applications could cause such serious damage because glyphosate is rapidly inactivated in the soil (Sprankle 'et al.' 1975a, Davison 1975) and it has low intrinsic activity when made available to the root system (Hance 1976). Nor would spray drifting onto trunks be likely to cause damage; many workers have shown that even two year old trees are resistant to applications directed at the trunk (Baird 'et al.' 1971, Davison 1975 and Putnam 1976).

Our work has shown that glyphosate applied to the ground around *Malus* pollinator trees or to their trunks causes no damage; they produce copious blossom with pollen of normal viability the following year. These findings were confirmed in collaborative trials at Efford and at Luddington Experimental Horticulture Stations;

spring applications to M cv. Hillieri, M x purpurea cv. Aldenhamensis, M cv. John Downie and M cv. Golden Hornet, and the dessert apples cv. Coxs Orange Pippin and cv. Reine des Reinettes resulted in no tree damage. Thus the response of Malus pollinator species to ground and trunk applications is similar to that described for other fruit trees (Davison 1975, Putnam 1976).

Unlike the bark tissue of the trunk the green, relatively immature one year branch tissue allowed the penetration of glyphosate, whether applied in spring or autumn. The tissue was killed, but the amount of damage elsewhere in the tree depended on the season of application.

Damage from the spring application was restricted to the one year wood of the branch sprayed. A distinct ring formed at the junction with the living two year old wood, suggesting a physical barrier to further translocation. Glyphosate is readily translocated (Rom 'et al.' 1974, Wyrill and Burnside 1976), moving via the phloem to regions of high meristematic activity (Sprankle 'et al.' 1975b). Hence the predominance of assimilate movement towards active meristematic regions in spring would not favour the movement of glyphosate out of the sprayed branch tissue. Possibly for this reason, the translocation of glyphosate in spring appears limited and though localised damage would occur from the accidental spraying of an occasional branch the consequences would not be serious. Davison (1975) has reported similar findings in dessert apples.

In contrast, spraying a branchlet in autumn resulted in such extensive damage to flowers the following spring that the trees were useless as pollinators. The severity of damage suggests that the glyphosate was actively translocated throughout the tree. Probably in autumn the general mass flow of assimilate back to the roots aids the translocation of glyphosate and its accumulation in the roots and trunk. In the following spring the general upward movement of assimilate towards active meristematic regions could well result in the redistribution of glyphosate and account for the widespread damage observed.

The marked differences found between spring and autumn applications are of considerable interest. Davison (1975) reports that variation in susceptibility seems to be a feature of crop response to glyphosate. Possibly small differences in the date of application affect the response. We found extensive damage to Malus from October sprays, but not previously from December, January or March applications (Stott 'et al.' 1974). Davison (1975) also reported only localised damage after spraying individual apple shoots between November and April, and variable results from summer applications. Further, there was only limited translocation when suckers of apple, pear and plum were sprayed in January, April, June and July (Atkinson 'et al.' 1978). It was translocated within the suckers, but not into the parent trees in quantities sufficient to cause damage in that season or the next. Also, Putnam (1976) reports the retention of radiolabelled glyphosate in apple suckers sprayed in June, with no translocation into the parent trees.

In contrast, our work with Malus pollinators and experiments with blackcurrants show that directed applications made in October led to extensive damage (Stott 'et al.' 1974). With blackcurrants the degree of damage appeared to be related to the proportion of leaf, and its state of senescence at the time of spraying.

Thus it seems that applications made around leaf fall are particularly damaging, whereas those made to dormant shoots in winter or to actively growing shoots in summer are unlikely to lead to translocated damage.

The response of cv. Hillieri unlike cv. Aldenhamensis depended on the rootstock. There was widespread damage on MM111 but only localized damage on MM106. Putnam (1976) also found only localized damage from late September applications to single branches of cv. MacSpur apples on MM106 rootstock. Cv. Hillieri on seedling ootstock responded similarly to cv. Aldenhamensis on all three rootstocks. ootstocks affect scion vigour and possibly also the timing of senescence and hrough this, the absorption and translocation of autumn applied glyphosate. They ould also influence the movement of glyphosate into the roots and its redistribution he following spring.

These results show that cv. Hillieri is not more susceptible to glyphosate than ther *Malus* pollinators or dessert apples and that serious damage only arises when ranches are sprayed in autumn. The reputation it has gained is probably because its eeping habit predisposes it to accidental contact from ground applications of erbicides. Damage can best be avoided by pruning off the lower branches; there ould then be no reason why glyphosate should not be used for weed control in modern rchards containing cv. Hillieri and other *Malus* pollinators.

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EFFECTS OF CANE AND WEED CONTROL MANAGEMENT ON THE ESTABLISHMENT OF RASPBERRY PLANTATIONS

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Summary In newly-planted raspberry overall application of dinoseb in oil before cane emergence caused no crop injury and gave acceptable and prolonged weed control. Post-emergence application killed young canes as expected but, provided only a small proportion of the final numbers had emerged, there was little adverse effect on crop establishment. Cutting the parent cane to ground level, rather than trimming it at 45 cm after planting, encouraged earlier and more uniform emergence of young canes, but resulted in more damage by treatment with dinoseb in oil in early summer. Comparison of removal of young canes by cutting and by treatment with dinoseb in oil showed that the timing of removal was more important than the method employed. The presence of weeds on untreated plots from June onwards severely affected crop establishment. Earlier emergence of young canes on plots where the parent cane was cut to ground level did not decrease the effects of weed competition on crop establishment.

INTRODUCTION

Although several surface-applied residual herbicides can be used safely in the newly-planted raspberry crop before cane emergence, dry soil conditions following spring planting often prevent effective weed control. Incorporation of trifluralin before planting avoids this problem (Lawson & Wiseman, 1974) but difficulties in matching incorporation depth to planting operations have prevented widespread use of this technique. There are currently no selective herbicide treatments available for application after cane emergence, so that weeds escaping residual herbicide treatment can be dealt with only by soil cultivation. In established raspberry plantations removal of the first flush of young canes in spring with dinoseb in oil promotes the production of a second flush of canes and forms the basis of management techniques for the control of excess vigour (Lawson & Wiseman, 1977). As a bonus, the herbicide also gives excellent control of annual weeds. It was therefore decided to examine the reaction of the spring-planted crop to cane removal to find whether this non-selective weed control treatment would have any permanent adverse effect on establishment. Cutting the parent cane to ground level after planting stimulates earlier emergence of new canes than the normal practice of trimming it to 30 - 60 cm (Cormack, Lawson & Waister, 1976). This factor could be of importance in the ability of the young crop to withstand cane removal treatments and/or competition from weeds.

MATERIALS AND METHODS

Two experiments were planted (one each in 1976 and 1977) at the Institute farm. Plots consisted of single rows of 12 graded stock canes (hereafter called parent canes) of cv Malling Jewel, planted 60 cm apart with 120 cm between the rows. The experiments were laid out as randomised blocks with three replicates. In both experiments the parent canes were either cut to ground level or trimmed to 45 cm after planting. In Experiment I, half the plots were kept weed-free (by hoeing and hand-weeding) and the rest were left unweeded. Dinoseb in oil was applied once to a 60 cm band centred on the row at intervals during the growing season. Both weed-free and unweeded plots were treated at a standard rate equivalent to 6 kg a.i./treated ha. Application was made by Oxford Precision sprayer, using a 3% solution of dinoseb in oil (9% w/v e.c.) in water. Unweeded plots were scored regularly for percentage ground cover by weeds during 1976, before and after any herbicide treatments. All surviving weeds were removed by hand in November 1976. The layout of the treatments in Experiment I was as follows:-

Length(cm) of parent cane		Weed status		Dinoseb in oil applied
0		Weed-free		None 18 May
or	X	or	X	15 June
45		Unweeded		15 July 17 August

In Experiment II, all plots were kept weed-free throughout the first growing season; bromacil was applied at 1.1 kg a.i./ha immediately post-planting, followed by supplementary hoeing or hand-weeding. Half the plots received the dinoseb in oil treatment at intervals and the rest had their young canes removed by cutting with secateurs at the same date. The layout of the treatments in Experiment II was as follows:-

Length(cm) of parent cane		Removal treatment (young canes)		Date of removal of young canes
0		Cut		None*
or	X	or	X	3 June
45		Sprayed with dinoseb in oil		16 June 30 June 14 July

*Either uncut or sprayed on 15 May before the emergence of any young canes.

In the second year both sites were kept weed-free throughout, by means of bromacil at 1.1 kg a.i./ha applied before cane emergence, plus supplementary hand-hoeing. Numbers and heights of young canes were recorded at intervals during both growing seasons.

Table 1

Experiment I - Weed records

Dinoseb in oil applied	% ground cover by weeds on: 18 May	15 June	30 June	15 July	4 Aug.	17 Aug.	2 Sept.
Untreated	3	37	76	90	95	91	85
18 May	-	0	2	9	18	30	40
15 June	-	-	3	9	22	45	50
15 July	-	-	-	-	88	93	88
17 Aug.	-	-	-	-	-	-	85

Table 2

Experiment I - Mean numbers and heights of young canes per plot at dates of spray treatment and end of season - 1976+

Treatments: Weed status	Length(cm) of parent cane	18 May[a] No.	15 June Ht.	15 June No.	15 July Ht.	15 July No.	17 Aug. Ht.	17 Aug. No.	17 Nov. Ht.	17 Nov. No.
Weed-free	0	8.3	15	18.8	36	20.3	69	24.8	78	24.7
	45	6.6	17	16.4	45	19.9	83	25.7	90	28.0
Unweeded	0	9.8	15	17.8	29	13.7	37	14.3	31	16.7
	45	4.2	17	11.4	35	11.0	45	13.0	40	12.7
S.E. mean ±		1.18	0.9	1.35	2.3	2.21	4.4	1.80	5.5	2.71
Sig. of effect of										
Weed status		NS	NS	*	***	**	***	***	***	***
Cane length		**	*	**	**	NS	*	NS	NS	NS

Table 4

Experiment II - Mean numbers of young canes per plot at dates of spraying or cutting treatment and end of season - 1977+

Treatment: Length(cm) of parent cane	2 June[a] No.	16 June No.	30 June No.	14 July No.	21 Nov. No.
0	3.7	6.0	6.1	6.0	8.0
45	1.0	2.0	3.6	5.3	9.0
S.E. mean ±	0.32	0.45	0.62	0.79	1.73
Sig. of effect	***	***	**	NS	NS

+ Pooled data for hitherto unsprayed or uncut plots.
a Canes just through the ground. NS - Not significant.
*** Difference significant at the 5%, 1% or 0.1% level.

RESULTS

Experiment I, 1976 - 77 Parent canes were planted on 1 April, 1976. Both weeds and young canes first emerged in mid May. The principal weed species were *Polygonum aviculare*, *Chenopodium album*, *Matricaria* spp., *Poa annua* and *Fumaria officinalis*. Percentage ground cover by weeds increased rapidly until mid July and then remained fairly static as weeds flowered and senesced. Ground cover scores taken just prior to herbicide application show the density of weed growth at the time of treatment (Table 1). Herbicide treatment in mid May killed the few seedling weeds present and prevented further weed development of any significance until August. Treatment in mid June gave virtually complete control of dense weed growth and again delayed weed development until August. Treatment in mid July and mid August desiccated weed foliage and accelerated senescence of weeds which were in full flower or seeding, but had relatively little effect on ground cover by weeds because of the density of vegetation present.

Untreated weeds had no effect on early growth of young canes, but affected cane numbers with increasing severity from June onwards (Table 2). Cane height was not significantly affected by weeds until mid July. Emergence of young canes was earlier on plots where the parent cane had been cut to ground level than on those where it had been left at 45 cm, but by mid July numbers were similar; mean cane height was however greater throughout the growing season on plots given the latter treatment. There were no interactions between weed status and treatment of the parent cane on unsprayed plots. Herbicide treatment killed all emerged young canes in May and June, but in July and August was totally effective only on weed-free plots, because of the height and density of the weed canopy on weedy plots. Dinoseb in oil also killed any laterals produced on trimmed parent canes. New canes emerged within a few days after treatment in mid May, but further emergence on plots treated in mid June was sparse and the canes were thin and weak. Plots where parent canes had been cut to ground level were more severely affected than where they had been trimmed to 45 cm. Recovery was more rapid and new cane growth of better quality following spray treatment in July and August.

Records taken at the end of the first growing season (Table 3) indicate that herbicide treatment just as the first new canes emerged had no adverse effect on final cane production on weed-free plots and avoided the losses caused by totally untreated weeds. Height differences between weed-free and unweeded plots sprayed in mid May were attributed to the effect of late summer weed growth on the latter plots. Herbicide treatment in mid June caused severe losses in cane production by the end of the season on both weed-free and unweeded plots. With later treatments, the level of cane reduction on weed-free plots decreased as the summer advanced, the main effect being that at the end of the growing season, canes on sprayed plots were shorter than those on unsprayed plots. However, on unweeded plots sprayed in July or August cane production was no better than on totally unweeded plots. Leaving the parent cane at 45 cm rather than cutting it to ground level resulted in taller canes being recorded on many plots at the end of the season, particularly on those sprayed in mid June, where it also increased the numbers of stations producing young canes. This latter effect showed up much more clearly at the end of the second year. By this time it was evident that the only herbicide treatment which had not caused a severe set-back to crop establishment and cane production was that applied in mid May. Treatment in mid June had caused the

Table 3

Experiment I - Cane production 1976 and 1977

Treatment of young canes in 1976	November 1976						November 1977					
	No. stations with young canes		No. canes /station		Mean cane ht.(cm)		No. stations with young canes		No. canes /station		Total cane length m/plot	
Length(cm) of parent cane	0	45	0	45	0	45	0	45	0	45	0	45
Spraying date												
Weed-free												
A None	11.7	11.7	2.1	2.4	78	90	12.0	11.7	8.4	10.0	126	141
B 18 May	11.0	11.3	1.8	1.8	86	85	11.3	11.7	8.2	8.1	115	114
C 15 June	6.0***	9.3*	1.1***	1.6*	18***	43***	2.7***	8.0*	2.7***	5.8***	12***	54***
D 15 July	11.3	12.0	1.7*	1.8	30***	43***	8.7*	9.0	3.7***	3.7***	43***	40***
E 17 Aug.	11.3	12.0	2.4	2.6	58***	46***	10.7	11.0	5.1***	5.7***	63***	66***
Unweeded												
F None	10.7	9.3*	1.6*	1.4**	31***	40***	11.0	11.0	4.3***	4.4***	50***	52***
G 18 May	10.7	11.0	2.2	2.0	64**	72*	10.7	11.7	8.0	6.7**	98**	94**
H 15 June	8.3**	9.0*	1.3**	1.1***	10***	36***	1.7***	8.3*	2.9***	3.0***	7***	32***
J 15 July	11.7	10.0	1.7*	1.4**	24***	32***	4.7***	5.3***	2.5***	2.2***	12***	12***
K 17 Aug.	11.3	10.7	1.5*	1.6*	30***	34***	10.0	10.3	2.9***	3.6***	29***	39***
S.E. mean ±	0.79		0.24		5.5		1.04		0.78		10.6	
Sig. of effect of												
Cane length	NS		NS		+++		++		NS		NS	
Weed status	NS		++		+++		+		+++		+++	

*, **, *** Significantly different from A45 at the 5%, 1% or 0.1% level.
+, ++, +++ Difference significant at the 5%, 1% or 0.1% level. NS - Not significant.

Table 5

Experiment II - Cane production 1977 and 1978

Treatment of young canes in 1977	November 1977						August 1978					
	No. stations with young canes		No. canes /station		Mean cane ht.(cm)		No. stations with young canes		No. canes /station		Total cane length m/plot	
Length(cm) of parent cane	0	45	0	45	0	45	0	45	0	45	0	45
Removal date												
Cut												
A None	5.0	5.0	1.7	1.8	50	50	5.7	5.7	7.5	10.8	34.0	52.0
B 3 June	2.3	6.0	0.9	2.1	32	50	2.3*	8.3	4.6**	9.2	11.0***	61.5
C 16 June	0.7**	7.3	0.7*	1.9	11***	50	0.7***	7.7	2.0***	9.7	1.2***	62.0
D 30 June	0.3**	2.7	0.3**	1.5	3***	34	0.3***	4.0	1.3***	7.6	0.5***	19.4**
E 14 July	0.3**	2.7	0.3**	2.0	4***	28*	0.7***	4.0	1.0***	6.5*	0.3***	20.5**
Sprayed												
F 13 May (pre-em.)	7.7	4.7	1.3	1.7	70	32	8.0	5.3	7.7	7.8	49.3	36.6
G 3 June	1.0**	5.3	0.8*	1.5	29*	40	1.7**	6.0	5.1**	9.0	6.9***	43.8
H 16 June	0.7**	3.0	0.7*	1.1	12***	25*	0.7***	3.7	2.5***	4.7**	2.9***	18.4**
J 30 June	1.7*	1.7*	2.2	1.3	26*	22**	3.3	2.3*	3.4***	2.9***	6.2***	6.1***
K 14 July	0***	2.7	0***	1.4	0***	33	0.3***	3.7	1.0***	5.9*	0.1***	14.0***
S.E. mean ±	0.99		0.33		7.0		0.95		1.35		7.23	
Sig. of effect of												
Cane length	+++		+++		+++		+++		+++		+++	
Cut v sprayed ∅	NS		NS		NS		NS		NS		++	
Interaction	NS		++		+		++		+		++	

*, **, *** Significantly different from A45 at the 5%, 1% or 0.1% level. ∅ without A and F.
+, ++, +++ Difference significant at the 5%, 1% or 0.1% level. NS - Not significant.

greatest injury and the effect became less severe with each later date of application. Weed presence throughout the previous growing season had a major effect on cane productivity in 1977. This was largely avoided by herbicide treatment in mid May, but not by any later treatment applied to unweeded plots. There were no interactions between treatment of the parent cane and weed status.

Experiment II, 1977 - 78 Parent canes were planted on 15 April, 1977. About half of the planting stations failed to produce any new canes. This was evident well before any post-emergence treatment was applied and was possibly due to adverse conditions during storage prior to planting. Where young canes did emerge, growth and development were satisfactory, but not as vigorous as in the previous experiment. Cutting the parent cane to ground level again stimulated earlier emergence and the effect persisted into early July (Table 4), but height of young canes was not affected by this treatment. Mean height at treatment dates was 4 cm (16 June), 10 cm (30 June) and 14 cm (14 July).

Pre-emergence treatment with dinoseb in oil had no effect on subsequent growth of young canes. Post-emergence treatment killed all treated growth of young canes and laterals on parent canes at all dates. In this experiment the presence or absence of the parent cane had a major effect at all dates of treatment of young canes (Table 5) and interactions between this factor and the method of removal of young canes were significant for most parameters recorded. When the parent cane was present young cane growth by the end of the season on sprayed or cut plots was in most cases not seriously reduced in comparison with similar untreated plots. However, all treatments applied after cane emergence to plots where the parent cane had been cut to ground level severely injured the crop. There was no significant difference between cutting and spraying treatments in 1977. Some improvement in numbers of stations producing new canes was noted in August 1978 compared with November 1977. However, the general picture changed little. Cane height was largely unaffected by the previous year's treatment. In terms of total length of cane produced per plant by August 1978 there were no significant differences between plots where young canes were untreated or sprayed pre-emergence in 1977, whether or not the parent cane was present. Leaving the parent cane at 45 cm avoided crop loss following cutting on 3 June or 16 June or spraying on 3 June. All other cutting and spraying treatments caused severe reductions in cane production, especially on plots where parent canes had been cut to ground level. There was a significant interaction between treatment of the parent cane and whether the young canes were removed by cutting or by spraying.

DISCUSSION

The effects of weeds on crop growth were similar to those reported earlier by Lawson & Wiseman (1976a). The retention or cutting out of of the parent cane had no influence on the reaction of the crop to weeds. Although weeds did not emerge before the first young canes appeared, it was expected that earlier emergence of young canes where the parent cane had been cut to ground level might have given them a competitive advantage over weeds in comparison with those from plots where the cane had been left at 45 cm. It is possible that this was offset by the parent cane producing laterals carrying leaves well above the weeds in June and July, whereas on the other plots the crop plant depended solely on young canes to keep it alive. The contact effect of dinoseb in oil applied in mid May or June on emerged weeds was extremely good, but later treatments were of little value. There was also considerable residual effect of the earlier treatments on subsequent weed germination. Dinoseb in oil applied overall just pre-emergence of the young canes should therefore be a useful supplementary treatment where residual herbicides applied at planting fail to prevent weed emergence. However, the results show that the treatment should not be applied after the first few canes have emerged. In the first experiment, crop injury was greatest when young canes were removed one month after first emergence on weed-free plots; the effect decreased thereafter. In the second experiment the crop was highly vulnerable over a longer period, particularly where the parent cane had been cut to ground level. The second plantation was much less vigorous and may have taken longer to develop sufficient root reserves to produce replacement canes once the first flush had been removed. The presence of the parent cane improved survival in both experiments but whether this was related solely to fewer canes having emerged at treatment dates or also to beneficial effects on establishment under stress is not clear. Cormack et al (1976) found no significant differences in survival whether the parent cane had been removed or not, but the levels of survival never fell below 95% in their experiments. This aspect may merit closer investigation under less favourable establishment conditions. Lawson & Wiseman (1976b) found no differences in cane regrowth between cutting or effectively spraying off the first flush of young canes in established plantations. In Experiment II the two techniques produced similar results on plots where the parent cane had been removed. However, post-emergence treatments where it had been trimmed to 45 cm resulted in cut plots producing more cane growth in 1978 than sprayed plots. This may also have been related to beneficial effects of presence of the parent cane on survival under stress. The laterals on the parent canes were undamaged where young canes were removed by cutting, but were killed when dinoseb in oil was applied overall at the same dates. Spray treatment of the laterals before or at first emergence of the young canes did not accelerate cane emergence and had no significant adverse effect on cane production in either experiment.

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Proceedings 1978 British Crop Protection Conference - Weeds

THE EFFECT OF RUNNER SIZE AND SOURCE ON THE SENSITIVITY OF NEWLY PLANTED STRAWBERRY RUNNERS TO LENACIL

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Summary An experiment was designed to investigate the influence of runner source and size on the subsequent growth and cropping of the strawberry cultivar 'Cambridge Favourite'. The runners were planted on 13 April, 1978 into soil which had been treated 20 days earlier with trifluralin. The plants were sprayed with lenacil at 2.2 kg/ha 12 days after planting and by 10 May symptoms typical of lenacil injury were observed. The plots planted with small runners were less vigorous and contained a higher percentage of dead plants than those planted with large runners. Leaf chlorosis and marginal necrosis were also more severe on small rather than on large plants. For both size grades those plants propagated in the east of Scotland were less vigorous and suffered more deaths than plants propagated in the west of Scotland. It is suggested that the size and source of the planting material may affect the severity of any injury caused by the use of lenacil on newly planted strawberry runners.

INTRODUCTION

An experiment was planted at the Scottish Horticultural Research Institute (SHRI), Invergowrie to examine the effect of runner size and source on the subsequent growth of strawberry plants. The area was treated routinely with trifluralin before planting and with lenacil after planting. Fifteen days after the lenacil was applied severe leaf chlorosis and marginal necrosis, typical of lenacil injury, was visible. The most striking feature of this trial was the effect of runner size on the percentage of damaged plants. Lenacil has been used as a strawberry herbicide for at least ten years and is considered to be the safest herbicide for freshly planted strawberry runners (Fryer & Makepeace, 1972). At SHRI no serious injury was observed even when three times the recommended dosage was applied (Lawson & Wiseman, 1978). However, plant damage can follow the use of lenacil (MAFF, 1977) and 'Cambridge Favourite' appears to be particularly sensitive to this chemical (Hughes, 1970). Although the experiment was not designed as a herbicide investigation it provided an opportunity to study some of the factors which may affect the severity of injury from lenacil.

METHODS AND MATERIALS

Plants from the same stock of the strawberry cultivar 'Cambridge Favourite' were planted out of doors at the West of Scotland Agricultural College, Auchincruive (WOSAC) and at SHRI on 25 March, 1977. The plants were grown in beds of compost (3 parts peat and 1 part sand) from the same bulk mix. The runner plants produced from them were lifted on 10 and 13 March, 1978 at WOSAC and SHRI respectively. All runners considered by commercial standards to be too small for planting were discarded and the remainder were classified into two size grades - large and small - by the same personnel.

The graded runners were 'heeled in' in a bed of the compost until field conditions permitted planting. Other runners of cv 'Cambridge Favourite' were obtained from commercial beds at Invergowrie and Lincolnshire, those from Invergowrie having been lifted in late March and 'heeled in' in field soil: the ones from Lincolnshire had been lifted in early April, sent by post and stored in a cold room. These runners were not size graded. Runners from each source or each size/source combination were planted by dibber at SHRI by the same person on 13 April, 1978. The soil, which was a sandy clay loam (organic matter 6 - 8%), had been treated with trifluralin at 1.1 kg/ha on 24 March.

Eight replicates of the six runner-source and size treatments were laid out in a randomised block design. Each plot consisted of a single row of 20 plants set 45 cm apart, the rows being 90 cm apart. Lenacil was applied on 25 April at the standard rate of 2.2 kg/ha and on 27 April there was a rainfall of 38.5 mm. The Spring at Invergowrie was wetter than average, the rainfall of 59.0 and 78.2 mm in March and April being respectively 15.9 and 36.5 mm above the long term averages for these months.

Dead, severely stunted and chlorotic plants were counted on 17 May. Vegetative vigour was scored on an arbitrary scale of 1 - 10 at the same time. Plant height was recorded by measuring the vertical distance from the soil surface to the leaf canopy on 26 June and runners were counted on 10 July.

RESULTS

The mean fresh weight of samples of runners from the six treatments before planting showed that the large runners from SHRI and WOSAC and the commercial runners from Lincolnshire were about 2.5 times heavier than the small plants (Table 1). Records taken on 17 May showed that plots planted with large runners produced at WOSAC contained a lower percentage of chlorotic plants than plots planted with small runners or with runners from other sources (Table 1). Plots planted with small runners from either SHRI or WOSAC contained higher percentages of dead or stunted plants and were less vigorous than plots planted with large runners from these or the two commercial sources (Table 1).

Since size and source of runner appeared to be affecting the severity of the damage the data were re-analysed so that large runners could be compared with small, and runners produced at SHRI could be compared with those produced at WOSAC (Table 2).

Plots planted with large runners contained fewer dead, stunted or chlorotic plants and were more vigorous than plots planted with small runners. Plots planted with runners from SHRI contained more dead or stunted plants and were less vigorous than those planted with runners from WOSAC. Later records showed that plants derived from small runners were shorter and produced fewer new runners than either the plants from large runners or those from the two commerical stocks. The level of weed control on all plots was very high: plant growth was therefore not affected by the presence of weeds, which can be a major cause of inhibited stolon and leaf growth in strawberries (Lawson & Wiseman, 1976).

The surviving plants including some which had been severely stunted, had largely outgrown any herbicide symptoms by the middle of July.

DISCUSSION

The leaf chlorosis and marginal necrosis reported here were not typical of trifluralin injury (Lawson, 1978) but were similar to symptoms observed in adjacent plots which were untreated with trifluralin but had received a post-planting application of lenacil (Lawson, 1978). Since the symptoms in this experiment were not observed until about two weeks after spraying with lenacil, this herbicide was considered to be the cause of the injury.

The method of grading plants for size tended to minimise differences between large and small runners. Nevertheless the effect of runner size on the susceptibility of the plants to damage was significant, and was probably caused by differences in the length of their root systems at the time of planting. This emphasises the need to ensure that runners are planted with their roots in a vertical position and as deeply as possible without burying the crown bud.

Despite there being no significant effect of site of propagation on the incidence of chlorosis, runners propagated at WOSAC showed fewer dead or stunted plants than runners propagated at SHRI. Since the plants from both sites were similar in size (Table 1), the differences between them cannot be attributed to this factor *per se*.

It is well known that soil type and the amount of rainfall after spraying can influence the sensitivity of strawberry plants to a post-planting application of lenacil (Fryer & Makepeace, 1972; MAFF, 1977). This experiment showed the need to consider runner size and source when diagnosing the cause of lenacil damage in the field.

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Table 1

Injury and growth records

Runner Source	Runner Size	Runner Fresh weight at planting (g)	Vegetative vigour score (1-10) 17 May	Dead and stunted plants % 17 May	Chlorotic plants % 17 May	Surviving plants per plot 26 June	Plant height (cm) 26 June	Runners per plants 10 July
SHRI	Large	20.7	6.4	6.9	41.9	19.25	8.57	4.00
	Small	7.9	3.9	16.3	45.0	18.63	7.35	3.51
WOSAC	Large	19.7	7.4	2.5	25.6	19.88	9.58	4.47
	Small	7.6	4.8	10.6	42.5	19.13	7.78	3.73
Invergowrie Commercial		14.8	7.3	5.0	35.0	19.50	8.28	4.04
Lincolnshire Commercial		18.5	6.8	3.1	38.1	19.88	8.11	4.60
S.E. mean ±		-	0.24	1.87	4.96	0.281	0.203	0.142

Table 2

Effect of runner size and source on injury and subsequent growth

Runner Source	Runner Size	Runner Fresh weight at planting (g)	Vegetative vigour score (1-10) 17 May	Dead and stunted plants % 17 May	Chlorotic plants % 17 May	Surviving plants per plot 26 June	Plant height (cm) 26 June	Runners per plants 10 July
Size	Large	20.2	6.9	4.7	33.7	19.56	9.08	4.23
	Small	7.8	4.3	13.4	43.8	18.88	7.57	3.62
Significance of difference		-	***	***	*	*	***	***
Source	SHRI	14.3	5.1	11.6	43.4	18.94	7.96	3.75
	WOSAC	13.7	6.1	6.6	34.1	19.50	8.68	4.10
Significance of difference		-	***	*	NS	NS	**	*

*, **, *** Values significantly different at the 5%, 1% and 0.1% level.

The figures for the large and small runners are the means for the combined SHRI & WOSAC values.

The figures for the SHRI and WOSAC runners are the means for the combined large and small values.

EFFECT OF THE CHEMICAL MANAGEMENT OF ORCHARD SWARDS ON THE USE OF WATER AND MINERAL NUTRIENTS

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Summary Soil moisture deficits around 5-year apple trees were greater under grass than in herbicide treated soil. Where fruit trees were grown in a herbicide strip with a grassed alley the deficit under the herbicide strip was higher than that at a comparable position in an overall herbicide orchard.

The deficit under grass was reduced to a similar extent (1-2 cm) by frequent cutting, diquat used to check the grass, and maleic hydrazide + 2,4-D. A reduction of 2-3 cm in the deficit was obtained with maleic hydrazide + 2,4-D + the experimental growth regulator 7-methylindole. Relative to cut grass, the chemical treatments reduced the mineral nutrient content of the grass leaves; the greatest effects were on nitrogen and manganese. Chemical treatments have the potential to regulate competition between fruit trees and the orchard sward.

INTRODUCTION

In much of Western Europe fruit trees are grown in weed-free strips of bare soil, of varying width, with grassed inter-row areas. Atkinson and White (1976) showed that with this type of soil management the grass competed with the tree and reduced growth and cropping. The extent of the effect was related to the proportion of the orchard floor that was grassed. The presence of grass in the inter-row area restricted apple root growth mainly to the herbicide treated row and reduced the ability of those roots under the grass to absorb nitrogen (Atkinson, 1977). These effects are thought to be mainly due to competition for water (Atkinson and White, 1976).

As a soil management treatment, mown grass was found to have a number of advantages over cultivation (Rogers et al., 1948). In the extensive orchard systems common at that time grass competition was reduced by mowing (Goode, 1956) and the shading of the sward by the tree canopy. However, the current more intensive dwarf orchards intercept less of the incident radiation (Jackson and Palmer, 1971) and so more light falls on the sward which is able to use more water, increasing competition with the tree.

The elimination of all grass from the orchard has many advantages, but this is not always possible because of problems, such as erosion, associated with some soil types and slopes, although the need to reduce the competitive effects of the sward remains.

Lyons et al. (1972) found that grass growth could be suppressed by using maleic hydrazide and although Stott (1976) found no differences in the cropping of trees where the sward had been mown or treated with maleic hydrazide the possibility of reducing the competitive effects of grass with chemicals remains. This paper presents data on the effect of grass and several chemical treatments on soil moisture deficits.

METHOD AND MATERIALS

Young orchard experiments

Trees of Cox's Orange Pippin/M.26 were planted in March 1971 at a spacing of 2.4 x 2.4 m. They were grown in overall grass (*Phleum nodosum* sown at planting), overall herbicide or in a 1.2 m wide herbicide strip with grassed inter-rows. The soil moisture deficit to 75 cm depth was measured during 1975 using a neutron probe and access tubes 40 and 100 cm from the tree between rows. Readings were converted to soil moisture deficits (cm) using a calibration curve for the particular soil type.

Grass experiments

A mature sward of S50 timothy (*P. nodosum*) which contained some Italian rye grass (*Lolium multiflorum*) and a number of broad leaved weeds, was divided into 1.5 x 1.5 m plots separated by 1 m areas of mown grass.

The plots were treated during 1976 and 1977 as:

1) Uncut. Grass left uncut during the period April to September.

2) Cut. Grass cut to maintain sward height at 2-4 cm during the period April to September; usually about 6 cuts were needed.

3) Maleic hydrazide/2,4-D/PP757. Grass sprayed with a mixture of maleic hydrazide/2,4-D at 5.6 kg/ha) + an experimental growth regulator PP757 (7-methylindole) (at 4 kg/ha ai in 900 l. solution/ha) on 10th May, 21st June and 12th July 1976 and on similar dates in 1977.

4) Single maleic hydrazide/2,4-D. Grass sprayed at a similar rate to 3) on 10th May 1976 and a similar date in 1977.

5) Frequent maleic hydrazide/2,4-D. Grass sprayed with maleic hydrazide/2,4-D at a similar rate and on the sames dates as 3).

6) Diquat. Grass sprayed at 0.8 kg/ha ai in 400 l./ha solution when needed from April to September. The chemical was applied to kill back the sward when it reached 5 cm height.

All plots were cut during March of both years prior to the application of treatments. Treatments were applied to 4 replicates in a randomized block design.

Soil moisture deficits under grass were measured as described for the orchard study.

The quantity of grass and broad leaved species present was measured in November 1976 by clipping all the vegetation from the central 0.75 m^2 about 2 months after the last cut on treatment 2. Samples of young mature grass leaves were taken in August 1977 and analysed for major nutrients.

RESULTS

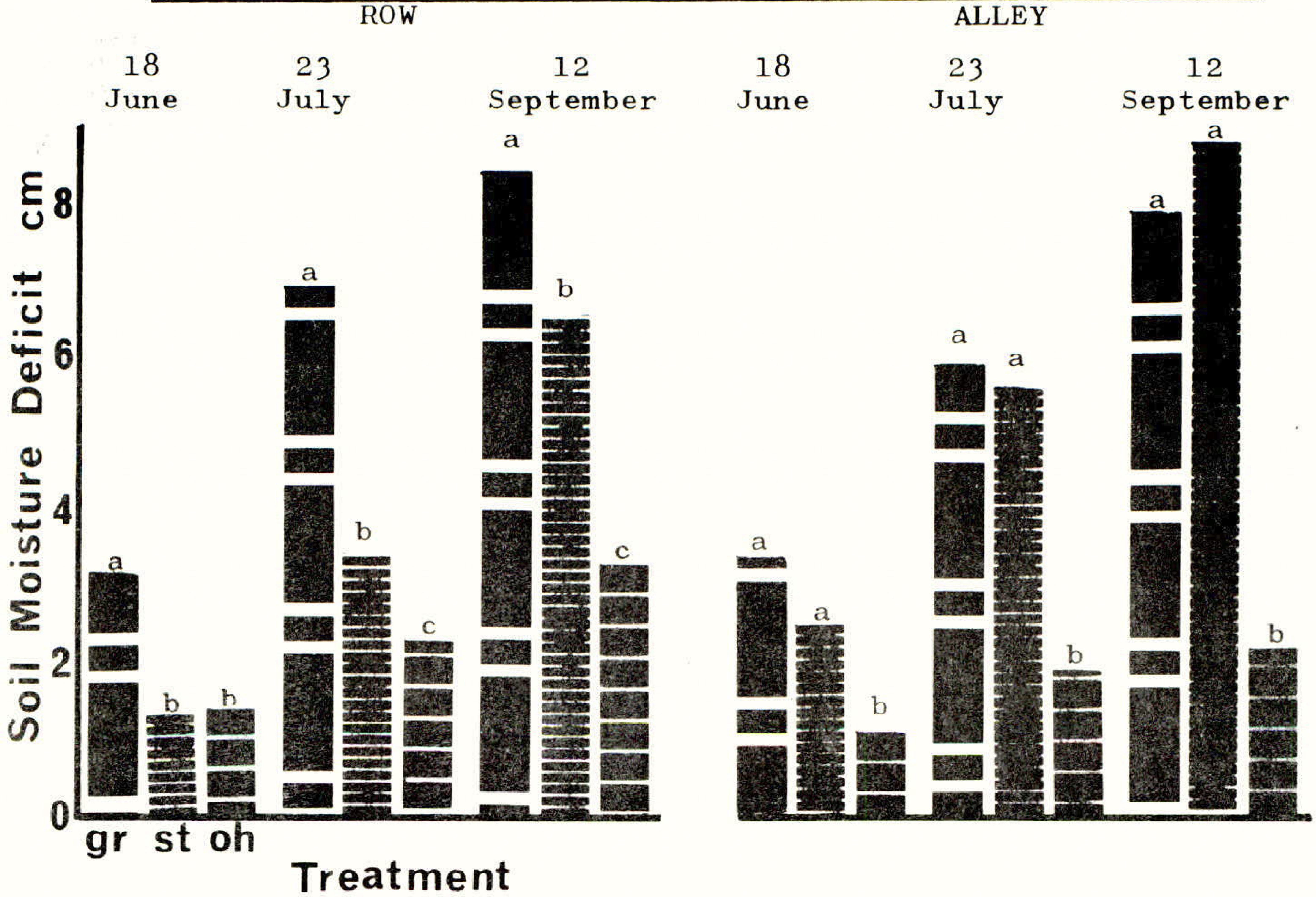
Orchard water use

In all treatments and at both positions soil moisture deficits increased during the course of the season (Figure 1). In the tree row on all dates the soil moisture deficit was greatest under grass and after early July higher in this position in the herbicide strip treatment than with overall herbicide. In the alley deficits were greater under grass than under herbicide on all dates. There was no difference between the depletion under the grass with the herbicide strip and that in the overall grass treatments. In general deficits were higher in the row than in the alley for the overall treatments.

Fig. 1

The effect of orchard soil management on the soil moisture deficit at two positions around apple trees in 1975

gr Overall grass, st herbicide strip, oh overall herbicide



Columns on any date headed by different letters are significantly different at P> 0.01

Grass water use

Deficits under grass during 1976 increased during the season although with the greatest rates of increase occurring up to the beginning of July (Figure 2). On all recorded dates the highest deficits were developed with the uncut and the smallest with the maleic hydrazide + 2,4-D + PP757 treatment. Water depletion by cut grass and that sprayed with maleic hydrazide or diquat were similar. The differences between all treatments were small, i.e. 2 cm approximately between treatments 1 and 3, while water use was generally high compared to that in the orchard (Figure 1).

Deficits developed at the different depths increased during the season and decreased with increasing depth (Figure 3). At 25 cm and 75 cm depth the pattern between treatments was similar to that of the total soil moisture deficit (Figure 2), while at 50 cm there was less difference between treatments particularly on 2nd June.

In the generally wetter year of 1977 results were generally similar to those in 1976 although deficits were lower in most treatments (Figure 4). Differences between the uncut and the other treatments were greater and between maleic hydrazide + 2,4-D + PP757 and the other chemical treatments smaller than in 1976.

The weight of grass harvested from the plots in November 1976 was lowest for the cut and the maleic hydrazide + 2,4-D + PP757

Fig. 2

The effect of the treatments on soil moisture deficit on a number of dates in 1976

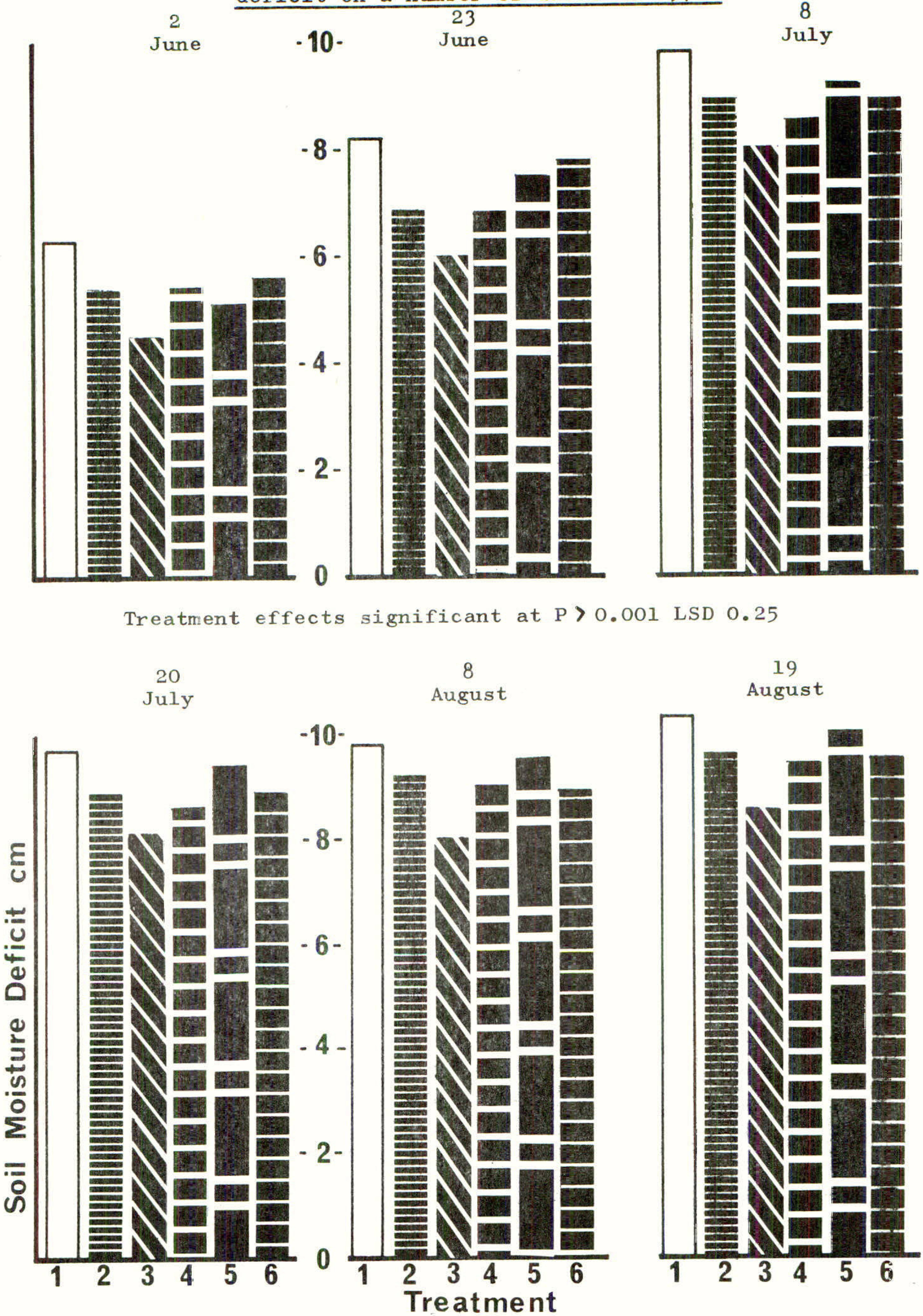
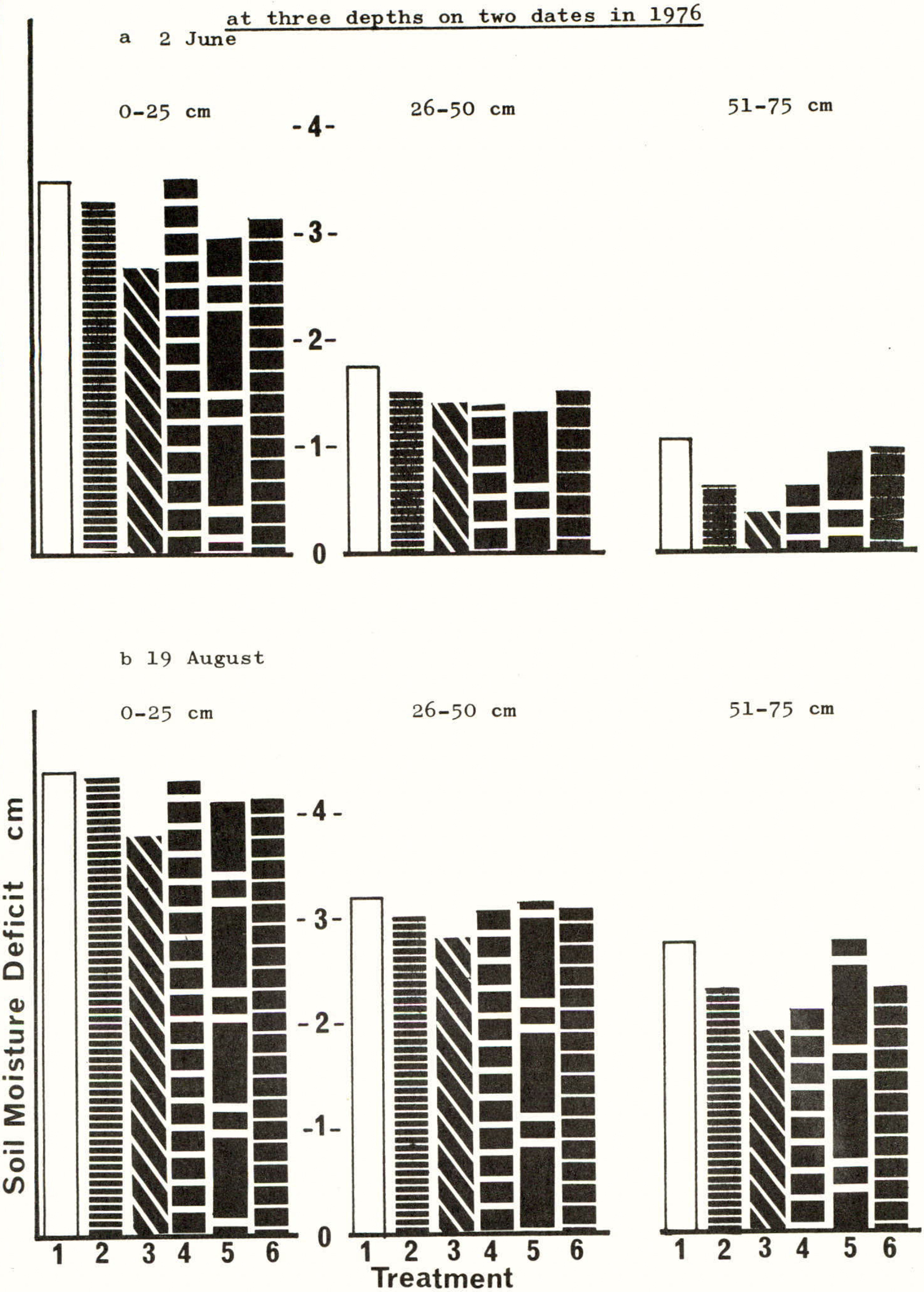


Fig. 3

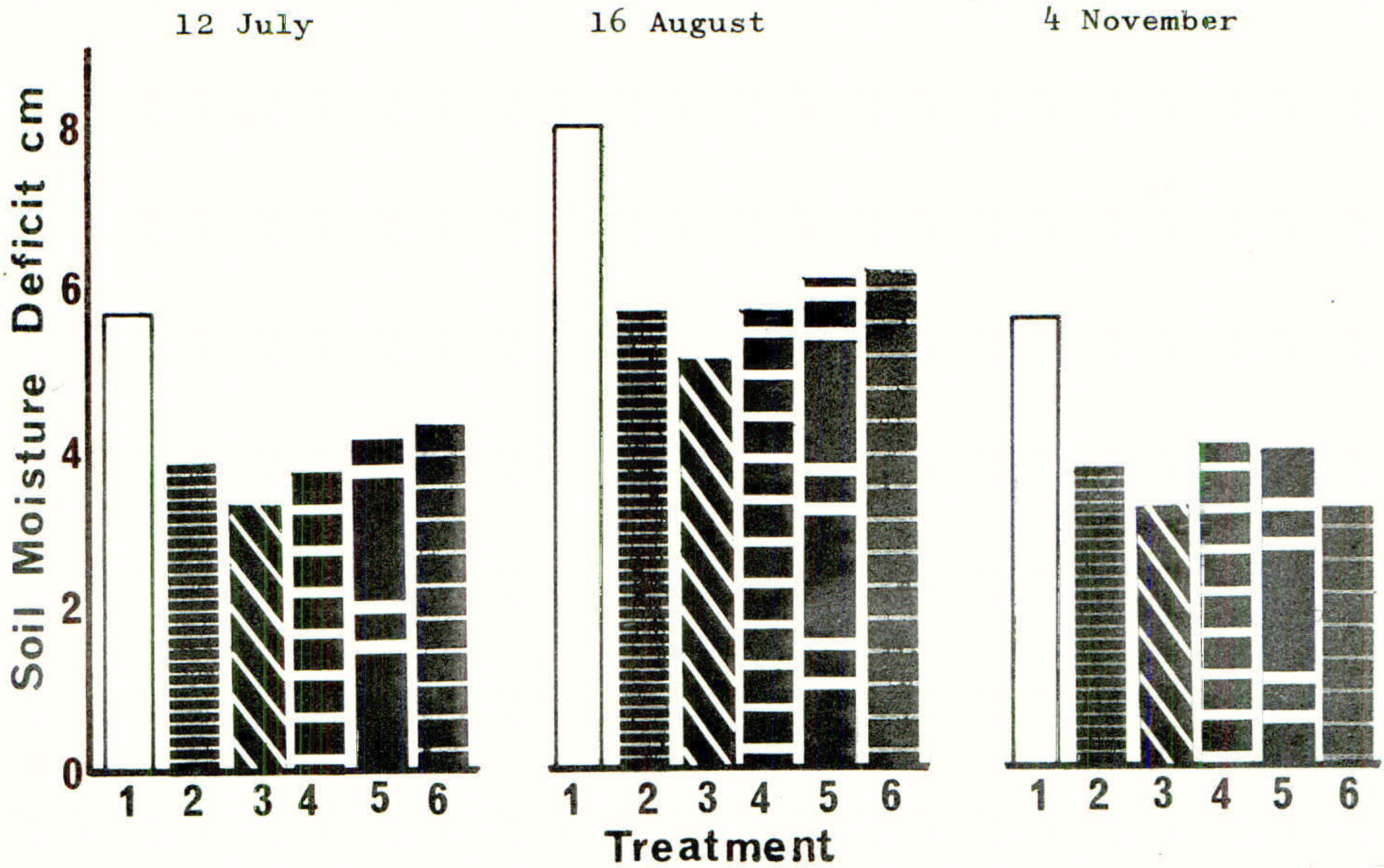
The effect of treatment on soil moisture deficit at three depths on two dates in 1976



treatments and similar in the other treatments. All treatments receiving 2,4-D had few broad leaved weeds.

Fig. 4

The effect of the treatments on soil moisture deficit on a number of dates in 1977



Treatment effects significant at P > 0.001 LSD 0.34

The mineral composition of the foliage, relative to uncut, was increased by all treatments (Table 1). The composition of chemically treated grass was generally lower than that of cut grass. Treatment effects seemed greatest on nitrogen and manganese.

Table 1

The effect of the treatments on the mineral composition % DW of the grass in 1977

Treatment	Mineral element N	P	K	Ca	Mg	Mn (ppm)
Uncut	0.80	0.17	1.15	0.22	0.05	52
Cut	1.69	0.31	1.89	0.53	0.10	146
Maleic hydrazide/PP757	1.34	0.28	1.59	0.48	0.08	141
Single maleic hydrazide	1.19	0.28	1.61	0.40	0.08	99
Frequent maleic hydrazide	1.01	0.22	1.41	0.33	0.07	99
Diquat	1.43	0.30	1.57	0.41	0.08	90
LSD P > 0.05	0.17	0.027	0.21	0.05	0.014	50

DISCUSSION

It has been suggested (Atkinson and White, 1976) that the main effect of grass on apple trees is due to competition for water. In a young orchard (Figure 1) the depletion of soil water was up to 4 times greater under grass than under herbicide soil management. The presence of grass in the inter-row area influenced the amount of water removed from a herbicided row as well as from the grassed area. This is due to the effect of a grassed alley on root distribution functioning (Atkinson and White, 1976). Root growth in apple trees and in grass shows an overlap in both depth and periodicity (Atkinson, 1977).

A reduction in the water use of an orchard sward must involve a reduction in either sward ground cover or grass root density or a restriction of most grass roots to a limited soil horizon. The impact of a reduction in ground cover would depend upon compensatory exploitation by adjacent plants. In these experiments grass plots treated with maleic hydrazide had many bare patches which were particularly obvious in the maleic hydrazide + 2,4-D + PP757 treatment. Root densities in apple trees (Atkinson and Wilson, 1979) are lower (2-24 cm/cm^2 soil surface) than those of 300-3000 cm/cm^2 reported under grass by Newman (1969). This difference in root density is smaller than the difference in water depletion between bare and grassed soil (Figure 1) and so it is probable that a large effect on root density would be needed to reduce water depletion. However, in 1977 the maleic hydrazide + 2,4-D + PP757 treatment did have a small effect on water depletion at the surface presumably by a combination of these mechanisms. Goode (1956) showed that as a result of reduced exploitation at depth smaller deficits were developed under short (cut) than under long (uncut) grass. A similar result was obtained in this study. Water depletion at depth (Figure 3) was reduced by all chemical treatments, but particularly by the maleic hydrazide + 2,4-D + PP757 treatment.

Lyons <u>et al</u>. (1972) showed that maleic hydrazide could reduce grass growth while this study indicated that water use could be reduced to a similar level to a cut sward and slightly lower with the addition of PP757. The differences in water use between the uncut and the other treatments were less in 1976 when the very dry conditions would have tended to cause maximum water use in all treatments than in 1977, which was much wetter. Relative to the other treatments the effect of maleic hydrazide + 2,4-D + PP757 was much less in 1977, which was at least partly due to the smaller use of water at depth in 1977. The use of diquat to damage, but not eradicate, the grass had a similar effect to cutting.

Compared with a cut sward all chemical treatments reduced the mineral content of the grass. After allowing for the higher crop of grass in the maleic hydrazide treatments (Table 1) less nitrogen would be contained in the standing crop of grass in winter here and in the cut treatment additional N would be bound in the cuttings until this was recycled.

These results suggest that using chemicals it is possible to reduce the water use by uncut grass to the same or less than that of a cut sward. A similar effect can be obtained for nitrogen. Chemical treatments having the greatest effect in dry years when competition is most serious, are likely to be those which affect apical dominance and greatly restrict the depth of water use.

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THE CONTROL OF CONVOLVULUS ARVENSIS WITH CULTIVATIONS AND/OR GLYPHOSATE AND MCPA

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Summary The period before planting a perennial crop such as fruit gives an opportunity to control perennial weeds with cultivations and herbicides not normally used in these crops. The effect of spring cultivations alone or in combination with glyphosate or MCPA on Convolvulus arvensis is described.

Mouldboard ploughing to 30 cm delayed shoot emergence and gave a 53% reduction of roots in the top 60 cm of soil. Rotary cultivation to a depth of 15 cm reduced roots by 33%.

Glyphosate and MCPA without cultivations reduced roots by 61% and 52% respectively. A combination of ploughing and glyphosate was the most effective treatment reducing the roots by 78%. Glyphosate controlled more deep roots than MCPA.

It is concluded that even with the most effective combination of cultivation and herbicide some additional form of control will be needed in subsequent crops.

INTRODUCTION

Convolvulus arvensis (field bindweed) is a problem weed in perennial crops such as fruit and nursery stock. It is controlled by glyphosate and the growth-regulator herbicides (Davison and Bailey, 1974) but their use is restricted in many crops. There is more scope for herbicides and cultivations before the crops are planted.

Two experiments are described. Experiment A compared the effect of spring cultivations, alone or in combination with glyphosate or MCPA, on C. arvensis in a fallow. Experiment B. compared the influence of spring cultivations on the emergence of C. arvensis in spring barley and on the regrowth after the crop had been harvested.

METHOD AND MATERIALS

The experiments were carried out in 1977 on a clone of C. arvensis established in 1971 in a sandy loam soil at Begbroke. The plots were 3 x 3m with discards of 1.2 m. They had been undisturbed since planting and until 1976 the annual weeds had been controlled with simazine. In 1977 paraquat was applied to Experiment A as the first shoots of C. arvensis were emerging to control annual weeds. No herbicides were applied in Experiment B.

In Experiment A the main treatments were mouldboard ploughing to a depth of

30 cm, coarse rotary cultivation to a depth of 15 cm or no cultivations. Subsidiary treatments were summer cultivations, glyphosate at 3 kg/ha a.i., MCPA at 3 kg/ha a.i., or untreated. The main treatments were carried out in March and the summer cultivations were carried out in the dates given in Table 1. The herbicides were applied on 10 October with an Oxford Precision Sprayer fitted with Lurmark LP20 fan nozzles. The pressure was 0.5 bars and the volume rate 400 l/ha. All treatments were replicated four times.

Visual scores were made on the dates given in Table 1 for the percentage ground cover of C. arvensis foliage.

Soil cores were taken in the winter to determine the amount of root in the soil. Six 20 cm cores per plot were taken with a Jarratt Auger at depths of 0-10, 10-30 and 30-60 cm. The roots were retrieved by sieving, then washed and weighed. A sub-sample of five 5 cm lengths of root was taken for tests on regenerative ability. These sub-samples were placed on moist filter paper in Petri-dishes, kept indoors in the dark at approximately 20°C and the number of shoots counted after six weeks. The remainder of the samples were dried at 95°C for 24 h and weighed.

In Experiment B the main treatments were mouldboard ploughing to a depth of 30 cm or tine cultivation to a depth of 7.5 cm. These were carried out in March and the whole area was drilled with spring barley on 8 April. Subsidiary treatments were removing the barley when in ear but still green on 20 July (as arable silage) or harvesting the grain on 29 August; in both cases the crop was cut 7.5 to 10 cm above ground level.

Visual scores were made for the % ground cover of C. arvensis foliage prior to the silage cut, before grain harvest and on 10 October.

No assessments were made on the barley.

RESULTS

Experiment A. Cultivations and herbicides in a fallow

Ploughing reduced the amount of C. arvensis emerging and the respective ground cover scores on 26 August and 10 October were 5% and 10% (Table 1). There was more foliage on ploughed plots that had been summer cultivated; on 26 August the ground cover was 53%. Rotary cultivation reduced the amount of foliage in May but by June there was as much as on uncultivated plots.

Table 1

The % of the ground covered by C. arvensis foliage as influenced by cultivations

Spring cultivation	Summer treatment	30 May	24 Jun	2 Aug	26 Aug	10 Oct
		Assessment dates				
Plough	No cultivations	2	0	0	5	10
Rotovation	No cultivations	12	85	100	69	41
None	No cultivations	55	88	100	93	24
Plough	Summer * cultivations	1	0	20	53	0
Rotovation	Summer * cultivations	10	0	45	83	0
None	Summer * cultivations	43	0	39	66	0
	S.E. ±	5.3	3.1	6.8	9.3	6.9

* 30 May (tines), 20 June and 8 Sept. (rotary cultivation)

The effect of the treatments on the amount of root in the soil is given in Table 2. Ploughing and rotary cultivation reduced the amount in the top 60 cm of soil by 53% and 33% respectively compared with uncultivated plots. Summer cultivations reduced the roots by approximately 50% regardless of the spring treatment.

MCPA reduced the roots by approximately 55% with or without cultivations. Glyphosate was more effective with reductions of over 60% on uncultivated and rotary cultivated plots and 78% on plots that had been ploughed. There were fewer roots in the 30-60 cm sampling depth with glyphosate than MCPA.

Table 2

The effect of cultivations and herbicides on the dry weight (g) of roots

Main treatment	Depth of sampling (cm)	Subsidiary treatments: No summer cultivations	Summer cultivations	Glyphosate	MCPA	SE±
Plough	0-10	3.1	1.4	0.2	0.6	1.18
	10-30	11.2	12.4	5.5	8.2	3.37
	30-60	8.5	10.6	5.2	12.3	1.87
	0-60	22.8 (47)	24.4 (50)	10.9 (22)	21.1 (43)	5.04
Rotary cultivation	0-10	3.1	1.9	1.4	0.8	1.18
	10-30	19.9	14.7	8.7	9.9	3.37
	30-60	9.6	10.5	7.4	12.1	1.87
	0-60	32.6 (67)	27.1 (56)	17.5 (36)	22.8 (47)	5.04
Uncultivated	0-10	6.1	1.8	2.9	1.2	1.18
	10-30	26.6	14.2	10.3	12.3	3.37
	30-60	16.0	10.2	5.7	9.8	1.87
	0-60	48.7 (100)	26.2 (54)	18.9 (39)	23.3 (48)	5.04

SE		±
	0-10 cm	1.12
	10-30	4.28
	30-60	1.99
	0-60	6.04

Figures in parentheses are the % of uncultivated plots with no summer cultivations

Spring cultivations had no effect on the total number of shoots developing on the samples taken for regenerative tests (Table 3), but glyphosate and MCPA reduced the numbers by between 20% and 51%.

Experiment B. Growth of *C. arvensis* in a barley crop.

Ploughing delayed emergence of *C. arvensis* in the barley and the ground cover score prior to the grain harvest was only 3%. The scores on the tine cultivated plots were 77% just prior to the arable silage cut and 88% at grain harvest.

After the removal of the barley from the ploughed plots the maximum ground cover of *C. arvensis* was 4%. On tine cultivated plots the ground cover reached a maximum of 23% following the arable silage cut but only 5% on plots harvested for grain.

Table 3

The number of shoots produced on 25 cm of underground fragments

Spring cultivation	Depth of sampling (cm)	Untreated	Treatment glyphosate	MCPA	SE ±
Plough	0-10	7.3	5.3	1.5	2.52
	10-30	12.5	8.0	9.7	3.54
	30-60	13.0	5.0	13.3	2.90
	0-60	32.8 (105)	18.3 (59)	24.5 (79)	5.66
Rotovation	0-10	8.8	2.3	1.5	2.52
	10-30	7.8	13.0	5.5	3.54
	30-60	12.8	9.5	8.3	2.90
	0-60	29.4 (94)	24.8 (80)	15.3 (49)	5.66
None	0-10	12.8	0.8	7.8	2.52
	10-30	10.7	11.2	5.0	3.54
	30-60	7.5	6.5	8.3	2.90
	0-60	31.0 (100)	18.5 (60)	21.1 (68)	5.66

SE between cultivations		
	0-10 cm	± 2.73
	10-30	3.50
	30-60	2.97
	0-60	5.51

Figures in parentheses are the % of the uncultivated and untreated plot

DISCUSSION

Convolvulus arvensis spreads by lateral roots that can extend by as much as 5 m in four months and penetrates deeply in the soil (Frazier, 1943). Davison (1970) reported that spread of young plants in the sandy loam soil at Begbroke can be as much as 4.5 m in the season after planting and that in the following year most of the plants had roots that were in depths greater than 90 cm. With this rapid spread both horizontally and vertically it can be assumed that the root density and distribution of the *C. arvensis* in the experimental plots, which had been established six years before the experiment began, would be comparable to that in a perennial crop where the ground had not been cultivated for several years.

Swan and Chancellor (1977) reported that root fragements of *C. arvensis* taken from the field and kept in controlled conditions readily produce shoots but they do not root very easily particularly during the period November to March. The spring cultivations in these experiments were in March therefore the majority of fragments in the cultivated layers may have died. Two-thirds of the roots in the sampling depth were in the 0-30 cm layer and this would explain the large reductions of roots due to cultivations. The late emergence of shoots particularly following ploughing is the result of buds having to be initiated on lateral roots below the cultivation depths.

It is difficult to explain why there should be more shoot growth of *C. arvensis* on ploughed plots that were also cultivated in the summer. This unexpected summer growth did not influence the amount of root remaining at the end of the season.

There was no advantage in applying MCPA after cultivations since the reduction of roots was no greater than that given by cultivations alone. Glyphosate following cultivations, and especially ploughing, improved the control because it was able to give a better control of deep roots than MCPA.

The amount of regrowth in the year after treatment might be less than the amount of surviving root would indicate because tests showed that fewer buds developed where glyphosate or MCPA were used.

Application of the herbicides was delayed to allow the maximum emergence of C. arvensis, particularly on the ploughed plots. By this time the foliage on the weedier plots was beginning to senesce. The effect on the roots may have been greater if the application had been earlier. With such a small amount of regrowth after the barley had been harvested it is doubtful whether any foliage applied herbicide would give any long term control of the roots. The only opportunity for foliage-applied sprays would seem to be just before the barley is harvested, provided there is no adverse effect on the crop.

These experiments have demonstrated the value of cultivations on the root reduction of C. arvensis and also that glyphosate gives a better control of deep roots than MCPA. However, even with the best combination of cultivation and herbicide, there was still some viable root in the soil and some form of additional control will be needed in subsequent crops, particularly if they are to be in the ground for several seasons.

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