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EXPERIMENTS WITH SIMAZINE AND OTHER HERBICIDES IN SOFT FRUIT CROPS

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Summary: Three successive annual treatments with simazine at 1, 2 and 4 lb/ac had no adverse effect on raspberries. Results of band spraying different widths suggest that the tolerance of the crop does not depend on treatment of a narrow band only. Absence of serious injury on newly-planted raspberries following surface applications at 8 lb/ac and the occurrence of severe damage where this rate was placed 3 and 6 in. deep, suggest that the crop owes part of its tolerance to the retention of the herbicide near the soil surface. Simazine at 2 lb/ac gave excellent control of germinating weeds and this rate appears safe on established raspberries. Atrazine had no harmful effect on this crop, after treatment for one year at 4 lb/ac, but amino triazole at 4 and 8 lb/ac caused severe injury. Very promising results were also obtained with simazine and atrazine in blackcurrants and gooseberries.

INTRODUCTION

The chemistry and herbicidal properties of simazine and related herbicides have been described by Gysin and Knüsli (1957). Early trials with simazine in soft fruit crops have given very promising results. In Switzerland, no short term injury on raspberries or currants was caused by doses up to 5 kg/ha (Anon 1957). Good results were obtained by Wood and Sutherland (1960) in raspberry cane nurseries in Scotland, where 2 and 3 lb/ac kept ground virtually weed-free for over two months, whilst cane growth remained excellent. In Northern Ireland, applications of 1, 2, 4 and 8 lb/ac in a fruiting plantation of Malling Exploit raspberries caused no growth-check or reduction in yield (Robinson 1960). In England, rates of 2.5 and 5 lb/ac gave virtually complete weed control in blackcurrants and raspberries without causing any adverse effect (Anon 1960).

Work with simazine and other herbicides in raspberry, blackcurrant and gooseberry plantations was continued at Loughgall in 1959 and 1960.

METHODS AND MATERIALS

The experiments were conducted at the Horticultural Centre, on a medium-heavy loam soil. Treatments were applied with an Oxford Precision Sprayer in raspberries and with a knapsack sprayer in blackcurrants and gooseberries. Sprays were applied at 50 gal/ac and all rates of application are given in terms of active ingredient. Wettable powder formulations of simazine and atrazine were used. Except where otherwise stated, applications in raspberries were made as directed sprays to a band 3 ft wide, with the cane row at the centre. Similar treatments in blackcurrants were made to a 4 ft wide band, while in gooseberries, application was confined to an area of 1 sq yd at the base of each bush and the remainder of the area was cultivated mechanically. Treatments were arranged in randomised blocks, usually with four replications.

To obtain information on crop tolerance, higher doses than those needed to give good control were sometimes used. The main purpose of the trials in fruiting plantations was to study the effect of the herbicides on the crop and in most experiments the sprays were applied on hoed ground, the plots being kept clean by hoeing.

Weed counts in raspberries were made on 12 one foot square quadrats in each plot. This crop was grown on the hedge system and no thinning of young canes was done until the winter. Cane counts and measurements were made on all young canes in two two-yard lengths of row selected at random in each plot. In blackcurrants the vigour of each plot was determined by measuring a sample of one-year-old shoots on every bush as described by Freeman and Thompson (1960), while in gooseberries the maximum bush circumference was used.

RESULTS

Effect on fruit crops

Raspberries

In June 1958 simazine at 1, 2 and 4 lb/ac was compared with 2,4-DES at 6 lb/ac in a plantation of Malling Exploit in its first cropping year. These treatments were applied to the same plots in May 1959 and again in April 1960, All plots were hoed immediately prior to spraying. Throughout the three year period there was no significant difference ($P = 0.05$) between treatments in crop yield or cane vigour. A single application of simazine at 8 lb/ac in June 1958 also caused no crop reduction or plant injury in that or the two subsequent years.

In another experiment simazine was compared with atrazine and amino triazole* (activated) in a plantation of Malling Exploit raspberries in its third cropping year. The triazines were used at 4 lb/ac and amino triazole at 2, 4 and 8 lb/ac The sprays were applied on 5th February 1960 on unhoed plots.

Simazine had no apparent phytotoxic effect on fruiting canes or emerging suckers but slight marginal necrosis occurred on some leaves on suckers where atrazine had been used. This injury was temporary, however, and subsequent growth was normal. Amino triazole at 2 lb/ac caused no injury to sucker growth but leaf size on fruiting canes was reduced. 4 lb dose checked the growth of suckers and caused severe stunting of foliage on fruiting canes. Double this dose killed 70 per cent of fruiting canes and temporarily suppressed sucker growth. A number of basal buds produced shoots on injured suckers and, at the end of the season, the number of canes was significantly greater than on the control plot, but this was accompanied by a reduction in height. All rates of amino triazole caused leaf chlorosis on fruiting canes. In late March this was estimated as being 10, 30 and 90 per cent of the total leaf area for the 2, 4 and 8 lb doses respectively.

The effect of the herbicides on yield and cane vigour is shown in table I. Crop yield was significantly reduced by amino triazole at 4 and 8 lb/ac.

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* Propriety product - Weedazol T - L

(a)

(b)

Effect of dalapon 3.7 lb/ac on Lloyd George raspberry (July 1960)

(a) Injured primary lateral following application in October 1959.
(b) Uninjured laterals following application in December 1959.

TABLE I. EFFECT OF HERBICIDES ON YIELD AND VIGOUR OF RASPBERRIES (FOUR REPLICATES)

Treatment lb/ac 5/2/60	Yield in lb/ 8 yd row	Young canes - August 1960	
		No. per row yard	Height, ft.
None	16.2	24.2	4.46
Amino triazole 2	15.7	25.9	4.43
" " 4	11.9+	24.5	4.45
" " 8	3.7*	29.5+	3.97
Atrazine 4	19.2	25.3	4.55
Simazine 4	17.5	28.0	4.60
S.E. of difference	± 2.0	± 2.1	± 0.42

* Differs significantly from control (P = 0.01)
\+ " " " " (P = 0.05)

In these experiments the spray was applied to a narrow band 3 ft wide containing the cane row, with an unsprayed alleyway 3 ft wide between the plots. To determine if absence of injury on simazine plots was due to the treatment of a narrow strip only, a rate of 4 lb/ac was applied to bands 1.5, 3 and 6 ft wide with the cane row at the centre. The raspberries, variety Malling Exploit in its second cropping year, were in rows 6 ft apart and the treatments were equivalent to rates of 1, 2 and 4 lb/ac of crop respectively. Simazine at 16 and 8 lb/ac was also applied to bands 1.5 and 3 ft wide respectively with the cane row at the centre. Both these treatments were equivalent to a rate of 4 lb/ac of crop. Spraying was carried out on 28th April 1959 and was repeated on the same plots on 26th April 1960. None of these treatments had any adverse effect on crop yield or cane vigour (P = 0.05).

It was then decided to investigate the possibility that the tolerance shown by raspberries to simazine might be influenced by the rotention of the herbicide at the soil surface. On 7th March 1960, simazine was placed in plots 6 yd x 2 ft at depths of 3 in., 6 in. and 12 in. from the soil surface by removing the soil to the desired depth and spraying the base of the trench while protecting the sides and ends with sacking. Canes of the variety Lloyd George were planted 2 ft apart, with the base of the cane about 6 in. deep, according to normal practice. To avoid disturbing the treated area, planting was carried out before or after spraying, according to the depth of the layer of herbicide. Canes were cut down to a height of 6 in. after planting.

Four replicates of the following treatments were carried out:-

1 Untreated control
2 Simazine at 8 lb/ac sprayed on soil surface after planting canes.
3 Simazine at 8 lb/ac placed 3 in. below soil surface when canes were partly planted.
4 Simazine at 8 lb/ac placed 6 in. below soil surface before canes were planted.

(78178)

5 Simazine at 8 lb/ac placed 12 in. below soil surface canes were planted.
6 Simazine at 8 lb/ac; rates of 2 lb/ac placed at 12 in. and 6 in. depths before planting canes, and at 3 in. depth and on soil surface after planting.

No injury appeared until mid-May when severe leaf necrosis was caused by treatment 4 and slight injury by treatment 3. By late June severe damage had resulted from treatments 3, 4 and 6, and new growth was significantly reduced (P = 0.05) on these plots as compared with treatments 1 and 5 (table II). Treatment 2 caused slight marginal and interveinal necrosis on the foliage of old canes and there was a small, although non-significant, reduction (P = 0.05) in new growth as compared with the hand-hoed control. Treatment 5 caused no injury throughout the season.

TABLE II. EFFECT OF SIMAZINE PLACEMENT ON GROWTH OF RASPBERRIES (FOUR REPLICATES)

Treatment 7/3/60	Depth of placement of simazine in. from soil surface	Total amount new growth (in ft) per 5 yards August 1960
1. Hoed	-	24.5
2. Simazine 8 lb/ac	0	19.8
3. "	3	11.4+
4. "	6	11.9+
5. "	12	27.2
6. "	2 lb/ ac at 0 in., 3 in., 6 in. and 12 in.	11.2+

S.E. of difference ± 4.4

+ Differs significantly from control. (P = 0.05)

Blackcurrants

In July 1959 an experiment was started on blackcurrants to compare annual applications of simazine and atrazine at 2 and 4 lb/ac. A mixture of simazine 1 lb plus atrazine 1 lb/ac was also included. Each plot contained six bushes and treatments were replicated eight times - twice on each of the four varieties, Cotswold Cross, Mendip Cross, Goliath and Wellington XXX. The spray was applied on 27th July 1959 on ground which had been unhoed since May. In October weed growth was severe on the unsprayed plots and the entire area was hoed then and again in March 1960.

In 1960 there was no significant difference between treatments in the crop yield as shown in table III. During 1960, a slightly greater amount of one-year-old wood was produced on sprayed plots than on the control, and the increase was significant (P = 0.05) where atrazine was used at 4 lb/ac.

TABLE III. EFFECT OF SIMAZINE AND ATRAZINE ON YIELD AND VIGOUR OF BLACKCURRENTS

(eight replicates)

Treatment lb/ac 27/7/59	Yield (in lb) per 5 bushes July 1960	Amount of 1 year-old wood (in ft) per bush September 1960
None	29.2	59.2
Simazine 2	32.1	65.8
" 4	31.7	75.1
Atrazine 2	33.9	75.4
" 4	29.6	76.4+
Simazine 1 plus atrazine 1	29.0	73.9
S.E. of difference	±2.7	±8.1

+ Differs significantly from control (P = 0.05)

Gooseberries

A long-term experiment on the effect of simazine and atrazine on gooseberries was also started in 1959. These herbicides were applied on the 30th September at 2 lb/ac. Treatments were replicated four times and plots contained three bushes of each of the following varieties, Lancashire Lad, Leveller and Whinham's Industry. The bushes were eight years old and were planted 6 ft apart in each direction. During 1960 the treatments caused no reduction in yield or check to growth on any variety.

Effect on weeds

In most cases simazine and atrazine were applied to ground which had been recently hoed, but in some experiments established weeds were sprayed.

The most prevalent weeds in the experimental area were *Poa annua*, *Holcus lanatus*, *Agrostis stolonifera*, *Stellaria media* and *Senecio vulgaris*, while *Atriplex patula*, *Polygonum aviculare* and *P. persicaria* were present occasionally. All these species were controlled on recently hoed ground for at least two months by either herbicide at 2 lb/ac. Application of simazine at 1 lb/ac resulted in a substantial reduction in number of most species, but *Polygonum spp.* and *Atriplex patula* were not always effectively controlled.

In the year following treatment, fewer weeds were usually present on plots sprayed with simazine than on hand-hoed plots. This is probably due to a reduction in the seeding of the weeds but a residual effect of the herbicide may be partly responsible. Table IV shows the reduction in weeds in 1960, on plots sprayed with simazine and 2,4-DES in 1958 and 1959. The weed count was made ten months after the second application. A similar reduction in weeds was also observed a year after treatment with atrazine.

TABLE IV. EFFECT OF SIMAZINE AND 2,4-DES ON WEEDS, TEN MONTHS AFTER TREATMENT.

(four replicates)

Treatment lb/ac 16/6/58 and 25/5/59	Grass per sq yd 15/3/60		Broad leaved weeds sq yd 15/3/60	
	Actual count	Sq root	Actual count	sq root
Control	18.6	4.25	17.7	4.17
Simazine 1	8.9	2.82	9.7	3.05*
" 2	6.1	2.32 +	5.6	2.33*
" 4	5.6	2.23*	3.6	1.87*
2,4-DES 6	15.4	3.88	15.4	3.90
S.E. of difference (transformed data)		± 0.68		±0.34

* Differs significantly from control (P = 0.01)
\+ " " " " (P = 0.05)

In the raspberry experiment in which amino triazole was compared with simazine and atrazine, the dominant weeds were young established plants of Holcus lanatus, Agrostis stolonifera, Poa trivialis and P. annua. Simazine and atrazine at 4 lb and amino triazole at 4 and 8 lb/ac gave a complete kill. Control was also good with amino triazole at 2 lb/ac but some plants of Agrostis stolonifera and Poa trivialis were only checked.

Stellaria media, the dominant weed in the gooseberry experiment, was about 3 in. high and formed a complete ground cover at the time of spraying. This species was killed by atrazine in two weeks and by simazine in about a month and sprayed plots remained weed-free during the winter. Weeds on the control plots were killed back by a routine spray of tar oil in January and hand-hoeing was not necessary until June. The plantation was cross-cultivated twice with a rotary hoe between March and June leaving only an area of one sq yd undisturbed at the base of each bush. On 1st June a weed count was made on the uncultivated area and the time required for hand-hoeing the weeds at the base of the bushes was recorded for each plot. The control of weeds in the sprayed plots was still evident, even after this hoeing, and hoeing times were again recorded on 27th July. The results in table V indicate the excellent control of grass (mainly Poa annua) and broad leaved weeds (mainly Stellaria media) by both simazine and atrazine. As a result of treatment on 30th September the time required for hand-hoeing sprayed plots on two occasions was significantly reduced (P = 0.01) compared with the untreated control.

TABLE V. CONTROL OF WEEDS IN GOOSEBERRY PLANTATION BY SIMAZINE AND ATRAZINE

(four replicates)

Treatment lb/ac 30/9/59	Weeds per sq yd 1/6/60				Hoeing time per plot of 9 bushes man minutes	
	grass		broad leaved			
	actual count	sq root	actual count	sq root	1/6/60	27/7/60
0	40.25	6.20	38.25	6.16	9.5	17.5
Simazine 2	0.5	0.50*	1.0	0.71*	3.2*	4.7*
Atrazine 2	1.25	0.56*	1.5	1.00*	3.1*	5.6*
S.E. of difference		±0.81		±0.30	±0.66	±1.73

* Differs significantly from unsprayed control (P = 0.01)

DISCUSSION

The experiments reported in this paper indicate that simazine is a most promising herbicide for use in bush and cane fruit crops. A dose of 2 lb/ac on clean ground gave consistently good control of all weeds, and the most common annual weeds in the area, viz. *Poa annua*, *Stellaria media* and *Senecio vulgaris*, were killed in the germinating stage by 1 lb/ac.

The effect of repeated applications of a weedkiller is of great importance in fruit crops, especially where residual herbicides are used. However, there was no evidence of any growth-check or crop reduction where simazine was applied annually on raspberries at doses up to 4 lb/ac for three years. Moreover, the results of the experiment in which simazine was applied to different band widths for two years suggest that the tolerance of this crop does not depend on applications to narrow bands which leave much of the root absorbing zone unsprayed.

The absence of serious damage on recently-planted raspberry canes where simazine at 8 lb/ac was sprayed on the soil surface and the occurrence of severe injury where the same dose was placed 3 or 6 in. deep suggests that the crop may owe part of its tolerance to the retention of the herbicide near the soil surface. This possibility is supported by glasshouse tests in which soil samples lifted from plots sprayed with simazine were seeded with a sensitive test crop (*Lolium perenne*). These tests, carried out one and three months after application at 4 lb/ac on the soil surface, failed to detect the herbicide at depths more than 2 in. from the surface. The results of field trials were confirmed by pot experiments in which young raspberry plants, raised from root cuttings, were grown in mixtures of soil and simazine. These experiments also indicated that, even if the entire root system of the raspberry was in contact with simazine treated soil, there is a considerable margin between the concentration necessary to kill germinating weeds and that liable to damage the crop plant. Although no damage occurred in the experiment on different band widths, following application at 8 lb and 16 lb/ac, treatment at 8 lb/ac on the soil surface caused slight injury in the experiment where different placement depths were tested. In this case, however, the raspberries had been planted immediately prior to application and probably would be more susceptible to injury than established plants. Atrazine also gave very promising results on raspberries both in preliminary trials and in the experiment reported in this paper. It is more soluble than simazine and the risk of crop injury is possibly greater. Slight temporary injury occurred in young canes where atrazine was applied at 4 lb/ac in February, but recovery was complete and plant vigour and yield were not affected. Amino triazole damaged raspberries at low doses and does not appear to be a satisfactory herbicide for use in this crop. 2,4-DES caused no damage after repeated annual applications of 6 lb/ac for three years, but weed control was much less effective and less consistent than was obtained with simazine at 2 lb/ac.

No injury with simazine and atrazine was evident in the experiments on blackcurrants and gooseberries and the results with both herbicides in these crops are very encouraging. The greater growth of blackcurrants on plots sprayed in July 1959 is probably due to the excellent control of weeds. Although the ground had been hoed twice since spraying, the effect of the herbicides was still evident in May 1960, especially where the higher doses were used. In the gooseberry experiment, application of either herbicide reduced the time required for hand-hoeing around the base of the bushes by about 70 per cent. On an acreage basis the cost of hand-hoeing the unsprayed area on 1st June and 27th July is £9. 10. 0. and the corresponding figure for the simazine treatment is £2. 15. 0. Only one quarter of the total area was hand-hoed or sprayed, the remainder being cultivated mechanically. Only ½ lb of simazine/ac of crop would therefore be needed to spray around the base of the bushes at 2 lb/ac and this treatment, supplemented by hand-hoeing, would be considerably cheaper than hand-hoeing alone.

If the accumulation of a residual herbicide in the soil is to be avoided, the dose used annually in a perennial crop must not exceed the amount that will disappear in a year. More information is obviously needed on the persistance of simazine and atrazine in different soil types and under different climatic conditions before recommendations for annual applications can be made. Work at Oxford on two soil types suggests that simazine at 2 lb/ac will disappear in less than a year, except under very dry conditions (Holly 1960). This dose appears to be safe on raspberries and there was no indication in the limited trials conducted on gooseberries and blackcurrants to suggest that it might have any adverse effect on these crops. In view of the tolerance shown by raspberries to successive annual application of 4 lb/ac for three years and 8 lb/ac for two years, these doses may also be safe, but information on the persistence of such amounts would be needed before their safety for annual applications could be assumed.

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A PROGRESS REPORT OF TRIALS WITH SIMAZINE AND MONURON ON SOME FRUIT PLANTS

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Summary: Persistent herbicides have especial promise for use in perennial crops. Simazine at 2½ and 5 lb/ac and monuron at 5 and 10 lb/ac have been applied for two seasons to black currants and raspberries and for one season to a range of apples and pears at East Malling Research Station, Kent. The plants treated with simazine all appear perfectly normal and have shown no effects on vigour or yield. Monuron at the higher dose has proved too damaging for repeated use on the soft fruit crops whilst at the lower dose also it has adversely affected their growth or cropping. It is concluded from these preliminary results that simazine is very promising for use in fruit crops.

INTRODUCTION

Whilst some herbicides have been of use for particular weed problems which are of importance in fruit growing, it was only with the development of very persistent total weedkillers (initially for weed control on industrial sites and waste ground) that it became feasible to take advantage of the perennial nature of fruit crops by using herbicides which would give a long period of weed control. It would be possible to examine the effects of chemicals on the crop plants when used at rates expected to control an established stand of weeds, with possible residual effects for several years, or to use rates expected to control weeds for not more than twelve months, when applied to clean ground. For the present investigation the latter approach was chosen.

The two herbicides selected for trial are simazine and monuron. Simazine is one of a group of triazine derivatives which were described at the Third British Weed Control Conference (Gysin and Knusli, 1957). There are many reports of the use of simazine under apple trees. In Germany no harmful effects were found from autumn applications of 4 kg/ha on 2 or 4 year old apples (Karnatz, 1959), whilst rates of up to 10 kg/ha were reported to be promising (Loewel and Mohs, 1958). From Belgium it is reported that 1 kg/ha applied in the spring after planting and again the following year did not harm the apple trees, whilst growth was checked by 2½ kg/ha (Detroux et al., 1957). It is also reported that in a one year trial pear trees were not injured by 5 kg/ha (Dermine, 1959). In black currants 5 kg/ha was found to be promising (Karnatz, 1959), although the same author reports damage to black currants elsewhere, whilst in raspberries 4 kg/ha (Slaats et al., 1959) and two annual applications of 5 kg/ha (Gast, 1958) gave no injury.

Monuron was discovered in U.S.A. (Bucha and Todd, 1951). In a range of experiments on a total of 150 apple trees for up to 4 years no damage was seen from 5 or 10 lb/ac (Holm et al., 1959), and there is another report of 8 lb/ac having no effect on apples (Schubert and Amato, 1957). However, one year old trees have been damaged by 8 kg/ha (Detroux et al., 1957), whilst half this rate has injured older shallowly rooted trees (Jaivenos, 1958).

METHODS AND MATERIALS

The crops chosen for this work are raspberries, black currants, apples and pears. The raspberries used are a plot of the variety Norfolk Giant, planted in January 1957, and the herbicides were first applied in November 1958. The black currants are of the variety Westwick Choice, planted in 1956 and cut down so that they carried their first small crop in 1958, the treatments first being applied in November 1958. Both of these trials are laid out in randomised blocks, the unit plot for raspberries being a row 26 ft long, the rows being 7 ft 6 in. apart, and for black currants 4 bushes 5 ft apart, the distance between the rows being 8 ft. There are 7 replicates on the currants and 8 on the raspberries. The apples and pears are combined in one trial, having 6 replicates. The unit plot consists of one tree each of Worcester / M.VII, Cox / M.II, Cox / M.VII, Cox / M.IX and Conference / Quince A, planted in November 1958, and also Conference / Quince A planted in November 1959, the trees being 5 ft apart in rows 8 ft 6 in. apart. In all cases there are guard plants between plots in the same row, but no internal guard rows as the treatments are applied in a band 3 ft 6 in. wide.

The three trials are adjacent to one another on a deep, well drained, sandy loam of the Barming Series (Furneaux, 1954), at a height of about 150 ft above sea level. The pH is between 6.0 and 6.5. The alleys between the plots have been cultivated as required, whilst the treated strips have been hoed as soon as there was weed growth on the control plots, using shallow-acting horizontal bladed hoes to give a minimum of soil disturbance.

The herbicides applied are simazine as a 50 per cent wettable powder ('Weedex') and monuron as an 80 per cent wettable powder ('Telvar W'). Simazine is applied at 2½ and 5 lb/ac, monuron at 5 and 10 lb/ac, active ingredient, to weed-free ground in November. Applications have been made with a bucket pump delivering large droplets at a pressure of 50 psi, at 200 gal/ac.

RESULTS

On Westwick Choice black currants (Table I)

TABLE I. EFFECTS OF SIMAZINE AND MONURON ON BLACK CURRANTS

Treatment (lb/ac)	Shoot growth 1959 (mean/plot (cm))	Mean height/ bush (Aug. 1960 (cm))	Yield 1959 (lb/plot)	Yield 1960 (lb/plot)
Monuron 10	--x	--	4.2xxx	--
Monuron 5	6038	160	19.4xxx	8.4xxx
Simazine 5	7549	168	28.1	12.4
Simazine 2½	7983	165	26.1	12.0
Control	7394	162	25.9	12.6
S.D.	1331.8	N.S.	3.7	2.6

xxx - difference from control significant at 0.001 level
x - difference from control significant at 0.05 level

Monuron at 10 lb/ac killed 7 bushes during the summer after the first application, and the remainder showed severe leaf injury followed by death of shoots. The first symptom was marginal chlorosis. This gradually extended interveinally and was followed by necrosis and death of the leaves and then the shoots. At 5 lb/ac there was less extensive leaf injury, but the total shoot growth during 1959 was reduced. As a result of the severe damage caused by 10 lb/ac of monuron the yield was reduced by 84 per cent. 5 lb also gave a highly significant reduction. In the spring of 1960 approximately 70 per cent of the blossoms were killed by frost, resulting in an overall crop reduction of 55 per cent on the previous year, but there was again a highly significant reduction in yield. As an indication of growth in 1960 the heights of the bushes were measured in August and showed no significant differences. Because of the serious damage caused by monuron at 10 lb/ac this treatment was not repeated in November 1959. During 1960 the surviving bushes made reasonably good growth but showed leaf injury similar to that on bushes that received 5 lb/ac.

Simazine had no significant effect on the growth or yield of Westwick Choice. No symptoms of injury were seen on the leaves and the bushes appeared perfectly normal in every respect.

On Norfolk Giant raspberry (Table II)

TABLE II. EFFECTS OF SIMAZINE AND MONURON ON RASPBERRIES

Treatment (lb/ac)	No. of canes/plot 1959	No. of canes/plot 1960	Yield 1959 (lb) mean/plot x	Yield 1960 (lb) mean/plot x
Monuron 10	120	112 xxx	40.7 ≠	34.1 xxx
Monuron 5	134	157 xxx	43.0	58.8
Simazine 5	141	175	44.1	61.3
Simazine 2½	135	170	42.8	60.2
Control	142	178	45.7	60.7
S.D.	N.S.	20.2	3.3	5.9

xxx - difference significant at 0.001 level
≠ - difference nearly significant ($p < 0.1$)
x - adjusted according to 1958 yield

On the plots treated with 10 lb/ac monuron leaf injury was seen in May 1959, occurring on the leaves of the laterals on the fruiting cane but not on the new cane. The symptoms were similar to those described above on the black currants. There was a reduction in yield from this treatment which was nearly significant. The plots receiving 10 lb/ac monuron also produced the least number of canes during 1959, but the difference is not significant. During the following year there were very severe leaf symptoms on these plots, with highly significant reductions in the vigour of the canes and in the yield. In 1960 some leaf injury was seen on the plots receiving 5 lb of monuron, equivalent to that shown in the previous year by the plots receiving double the rate, when the 5 lb plots had shown no injury. The crop was not affected, but there was a reduction in the number of canes produced.

As with the black currants, the simazine treatments did not affect growth or cropping, the canes appearing perfectly normal in all respects.

On apples and pears

In the single season for which records are available leaf injury has been seen on only one tree, a 2 year old Conference pear which received 10 lb/ac monuron. The leaves of this tree showed very marked marginal chlorosis, but this did not extend interveinally. Shoot growth records are not yet available, but no differences are apparent and all other trees are growing normally.

On Weeds (Table III)

TABLE III. PERCENTAGE WEED COVER

Treatment lb/ac	Black currants June 1960	Black currants Sept. 1960	Raspberries June 1960	Raspberries Sept. 1960	Apples and pears June 1960	Apples and pears Sept. 1960
Monuron 10	(6)	(48)	0	0	0	0
Monuron 5	1	8	0	0	3	7
Simazine 5	1	3	0	0	3	3
Simazine 2½	3	3	0	0	3	5
Control	16	43	20	54	23	87

Note:- Convolvulus arvensis has been excluded from these figures.

Visual estimates of the percentage of the plot area covered by weeds have been recorded prior to each hoeing. During April 1959 there was much germination of Senecio vulgaris in the black currant trial amounting to 78 plants per square foot on the control plots. On the monuron plots the S. vulgaris continued to develop until hoed. During 1960 the monuron plots did not develop this great cover of groundsel even though the 10 lb/ac applications had not been repeated. Apart from this the 5 lb monuron and the simazine treatments all gave excellent weed control, except that during August each year Convolvulus arvensis developed on certain plots and appeared to be completely unaffected by simazine. The main weeds occurring on the control plots have been Capsella bursa-pastoris, Chenopodium album, Matricaria spp., Poa annua, Senecio vulgaris, Stellaria media, Veronica hederifolia, V. persica and Urtica urens.

DISCUSSION

Monuron at 10 lb/ac had such severe effects that this treatment had to be discontinued after one year on black currants and two years on raspberries; further, it is the only treatment to have shown any damage on the tree fruit, causing leaf injury to one pear tree. At 5 lb/ac monuron has given significant reductions in the growth and yield of black currants, whilst on raspberries it reduced the amount of new cane produced in 1960. Besides these adverse effects of monuron on the fruit plants, Senecio vulgaris, one of the most abundant annual weeds, showed considerable resistance to the herbicide even at 10 lb/ac. The increase in damage to the raspberries after the second application indicates that monuron may be accumulating in the soil, but bio-assays are necessary to confirm this.

It is, however, the results obtained with simazine that are of most interest. In no case has any effect on the growth or cropping been shown, although for the raspberries a difference in yield of 7 per cent (p 0.1) in 1959 and 10 per cent (p=0.001) in 1960 would have been significant.

A difference in yield of 14 per cent was significant (p=0.001) for the black currants in 1959, but in 1960 nearly three quarters of the blossoms were killed by frost, and a difference of 20 per cent was needed for significance at the same level in that year.

Thus monuron, even at the lower dose of 5 lb/ac has adversely affected black currants and raspberries, whilst at 10 lb some damage has been seen to a Conference pear during the first season after application. So far simazine, on the other hand, has had no adverse effects on any of these crops and appears to be an extremely promising herbicide for use in fruit crops. It must be emphasised that this preliminary report covers only two seasons for the small fruits and one for the top fruits. The experiments must clearly be continued for a number of years, and further investigations are needed on the persistence of simazine in the soil and of whether the crops are inherently resistant or whether the herbicide does not reach them in sufficient quantity to cause damage.

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EFFECTS OF THE USE OF HERBICIDES ON THE GROWTH, CROPPING AND WEED FLORA OF RASPBERRY PLANTATIONS: A PROGRESS REPORT

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Summary: Two statistically-designed field experiments with raspberries have received chemical weedkiller treatments in spring for three and two years respectively. Ine one, planted with the Norfolk Giant variety, the herbicides being used are mixtures of propham with 2,4-DES and with fenuron, of fenuron with 2,4-DES and of TCA with dinoseb. In the other, planted with Lloyd George, they are simazine, monuron and mixtures of 2,4-DES with propham and with fenuron. Fruit yields, cane growth and weed populations are recorded. The mixture of TCA (18.6 lb/ac in 1958 and 1959, reduced to 10 lb/ac in 1960) with dinoseb (2.8 lb/ac) has injured young stems and foliage in spring and depressed fruit yield and new cane production. Simazine (2.5 lb/ac) has apparently given good results but the increases of growth and yield associated with it are below significance level. Monuron (3.5 lb/ac) has given good weed control but caused some crop injury. These experiments remain in progress.

INTRODUCTION

Labour costs for soil cultivation are one of the larger items of expenditure in commercial raspberry growing, exceeded usually only by the cost of picking. Cultivations are necessary for the removal of surplus sucker canes as well as of weeds, and normally consist of hand-hoeing along the rows and harrowing and rotary cultivation of the alleyways. There is now an increasing interest, however, in the possible use of chemical herbicides, both to prevent the growth of annual weeds in clean plantations and to suppress perennial weeds where these are present.

This paper reports the progress of two field experiments in which chemical weedkillers are being used in combination with, and partly as substitutes for, normal mechanical cultivations. The objectives are to suppress weeds and reduce the amount of cultivation required, whilst at the same time measuring the effects of the treatments on the growth, yield and fruit quality of the crop. Both experiments will be continued for approximately the normal life of commercial plantations. Both are established at Mylnefield on medium loam land, largely free from perennial weeds but productive of a large flora of annuals, including *Chenopodium album*, *Stellaria media*, *Senecio vulgaris*, *Poa annua*, *Fumaria officinalis*, *Viola tricolor*, *Veronica hederifolia*, *V. persica*, *Polygonum aviculare* and *P. convolvulus*.

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METHODS AND MATERIALS

In experiment A, chemical weedkillers were first applied in spring 1958 to a 2-year-old plantation of the variety Norfolk Giant in which six former experimental treatments (dates of lifting of planting material from the nursery) were no longer of significant effect. The new treatments, arranged orthogonally in relation to the former ones within a 6 x 6 latin square design, were as follows:

(a) TCA (18.6 lb) + dinoseb-amine (2.8 lb)

(b) Propham (5.0 lb) + 2,4-DES (3.6 lb)

(c) Propham (5.0 lb) + fenuron (0.5 lb)

(d) 2,4-DES (3.6 lb) + fenuron (0.5 lb)

(e) Control (normal cultivation)

The unit plots are single rows 10 yd long, containing 12 stools, and the distance between the rows is 6 ft. In the new design the control treatment is allocated to 12 plots and each of the others to 6.

In 1958 the weedkillers were applied (already mixed) under dry, sunny conditions on 13 May, shortly after the completion of spring cultivations. They were sprayed in bands 3 ft wide alongside the rows, so that the whole soil surface between adjacent sprayed plots was treated. The control plots had to be hoed in mid-June. In 1959 the same treatments were applied on 9 April, again to freshly-cultivated, clean ground. All plots except those of treatment (a) were hoed on 16 June, and the appropriate mixtures were re-applied to those of (b), (c) and (d) on 20 June. The sprays this time were confined to bands 2 ft wide along each side of the rows. In 1960 the entire plantation was sprayed on 4 March with 8 per cent tar oil winter wash to destroy overwintered weeds, and treatments (a) - (d) (with the TCA in treatment (a) reduced to 10 lb) were then re-applied on 22 April after light cultivation. The sprays this time were confined to bands only 15 in. wide alongside the rows. Hand-hoeing between the stools was done on the control plots on 10 May and throughout the experiment on 23 May and 1 July, the May hoeing being mainly for sucker removal. The alleyways were rotavated with those of other plantations in the same field.

Experiment B was specially planted in spring 1959 to compare four herbicide treatments with a mechanical cultivation system in which the hoeing along the rows is done as far as possible with Dutch hoes, instead of the usual draw hoes. The variety is Lloyd George. The design is of six randomised blocks, with unit plots consisting of pairs of recorded rows 10 yd long, alternating with single guard rows. Multiple-row plots of this kind are preferable for herbicide work to single-row plots as used in experiment A. The treatments are:

(a) Simazine (2.5 lb)

(b) Monuron (3.5 lb)

(c) Propham (4.0 lb) + 2,4-DES (4.6 lb)

(d) 2,4-DES (4.6 lb) + fenuron (0.5 lb)

These were applied to the entire plot surfaces (i.e. from the inward-facing side of one guard row to that of the next) on 10 April 1959, nine days after planting, and were re-applied on 1 April 1960.

In both experiments the herbicides were applied by Oxford Precision Sprayer in volumes of liquid equivalent to 30 gal/ac.

RESULTS

Experiment A

Yield. Table I shows the fruit yields of experiment A from 1958 to 1960. The TCA/dinoseb plots have given the poorest crop each year, and their present total yield is significantly below that of any other treatment. The differences in total yield between the other treatments are not significant.

TABLE I. EXPERIMENT A: FRUIT YIELDS IN CWT/AC.

Treatment	1958	1959	1960	Total
(a) TCA + dinoseb	33.7	44.2	85.5	163.4
(b) Propham + 2,4-DES	50.0	61.6	105.4	217.0
(c) Propham + fenuron	41.8	66.8	102.3	210.9
(d) 2,4-DES + fenuron	43.0	60.1	96.3	199.4
(e) Control	49.8	53.8	98.5	202.1
Sig. diff. (P = 0.05) between treatment (e) and any other treatment				20.5
" " " " treatments (a), (b), (c) and (d)				23.7

Cane growth. After routine stooling-up in autumn, when the remaining sucker canes are removed together with any broken, weak, severely diseased or badly misplaced new stool canes, the procedure is to count and measure the sound new stool canes available in each plot. These are then thinned to an average of not more than 7 per stool subject to a maximum of 8 on any stool. The canes left are next laced to the wires and tipped, usually at a height of 5 ft, and the proportion of canes reaching this height is recorded.

Table II shows the numbers of canes present before and after thinning during the winters from 1957/58 onwards. In 1957/58, before the application of herbicides, the differences in average cane number between the five sets of plots were not significant. By 1958/59 the TCA/dinoseb plots had the fewest canes, although

TABLE II. EXPERIMENT A: NUMBERS OF NEW CANES PRESENT PER PLOT

	1957/58		1958/59		1959/60	
	Before thinning	After thinning	Before thinning	After thinning	Before thinning	After thinning
(a) TCA + dinoseb	39.2	38.7	41.0	37.2	58.8	49.7
(b) Propham + 2,4-DES	42.5	41.3	46.8	43.0	74.2	63.2
(c) Propham + fenuron	37.8	37.0	50.3	46.7	70.0	60.3
(d) 2,4-DES + fenuron	36.5	35.3	49.7	44.8	64.5	57.5
(e) Control	41.9	40.0	44.6	40.3	67.3	75.9
Sig. diff. (P = 0.05) between treatment (e) and any other treatment			8.9	7.6	11.6	8.1
Sig. diff. (P = 0.05) between treatments (a), (b), (c) and (d)			10.2	8.7	13.4	9.3

they differed significantly in average number only from the propham/fenuron plots, and then only after thinning. In 1959/60, however, the TCA/dinoseb plots before thinning had significantly fewer canes than those of one other treatment (2,4-DES/propham), and after thinning they had significantly fewer than those of three other treatments. The measurements of the canes, not yet analysed, suggest that the TCA/dinoseb treatment also caused a slight reduction in average cane length. When applied each spring this mixture caused scorching, distortion and death of many emerging young canes and of some of the lowermost laterals of the fruiting canes.

Weed Counts. Counts of total weed seedlings were taken in 1958 on 5 June and 4 July, by throwing eight and ten 6-in. quadrats/plot respectively, and on 9 June 1959 by throwing five quadrats. The results, summarised in Table III, show that all four chemical treatments largely reduced the weed population, especially in 1959, but not to the extent of eliminating the spring weed problem completely. The second count in 1958 was made because it seemed at the time of the June count that many seedlings present on the propham/2,4-DES and propham/fenuron plots would die, and this in fact happened. The figures shown have not been analysed statistically. The weeds on the herbicide-treated plots included most of the species present on the controls, and it is not possible from these data alone to point to any clear selective effects of the individual treatments. In 1960, when no weed count was taken, the degree of control resembled that of 1959.

TABLE III. EXPERIMENT A: NUMBERS OF WEED SEEDLINGS PER SQUARE FOOT OF SOIL SURFACE

Treatment	5/6/58	4/7/58	9/6/59
TCA + dinoseb	54.3	63.7	4.1
Propham + 2,4-DES	67.0	38.5	8.3
Propham + fenuron	150.6	80.3	6.3
2,4-DES + fenuron	80.0	80.6	8.9
Control	239.6	*No count	66.9

* Plots hoed in mid-June.

Experiment B

Yield. Fruit yields for the first two years of experiment B are included in Table IV. The main feature is the poor performance of the control plots, caused by their having been allowed to become heavily weed-infested in spring 1959 as a contrast to the herbicide-treated plots, which remained clean. The plots of the five treatments are now being managed independently, each set being hoed for sucker and weed control when necessary and a record kept of all cultivations; but the control plots may take some time to recover from their check. The simazine plots, highest in yield so far, have shown good growth and no chemical injury, while the monuron plots, the lowest in yield of the chemical treatments, have shown some leaf chlorosis: but none of the cropping differences associated with the chemical treatments have yet reached significance level.

TABLE IV. EXPERIMENT B: FRUIT YIELDS AND CANE GROWTH

Treatment	Fruit yield (cwt/ac)			New Canes in 1959/60	
	1959	1960	Total	Av no./plot	Av length (in)
(a) Simazine	3.0	47.0	50.0	48.5	42.2
(b) Monuron	2.5	39.6	42.1	45.0	41.3
(c) Propham + 2,4-DES	2.8	45.8	48.6	45.3	42.6
(d) Fenuron + 2,4-DES	2.8	43.4	46.2	43.5	40.6
(e) Control	1.4	20.7	22.1	24.7	32.2
Sig. diffs. (P = 0.05)			9.4	7.4	

Cane growth. Table IV also gives the numbers and average lengths of the new canes present in the winter of 1959/60. Since thinning was unnecessary, these were the numbers of canes tied-in for fruiting in 1960, and as the plantation was only a year old they were left at full length and arched-over on a single wire. There is obviously a close parallel between these figures and the data for yield.

Weed Counts. Table V gives counts of total weeds taken on arbitrarily selected dates in 1959 and 1960. All four herbicide treatments markedly reduced the weed population, but the effects of simazine and monuron were outstanding. In 1959 the four treatments gave adequate weed control up to 20 June, when all the rows of the experiment were hoed and the alleyways lightly rotavated because of the weed growth on the control plots and the general need for destruction of sucker canes. Much less time was required to hoe the treated rows, however, than the controls. A striking effect afterwards was that the simazine and monuron plots continued to remain clean, even after a second rotary cultivation on 20 August. In late November their weed cover was still estimated at below 5 per cent, and consisted mainly of young seedlings. The propham/2,4-DES and fenuron/2,4-DES mixtures showed no evidence of residual action after cultivation.

TABLE V. EXPERIMENT B: NUMBERS OF WEED SEEDLINGS PER SQUARE FOOT OF SOIL SURFACE ON DATES IN 1959 AND 1960

Treatment	16 June 1959		11 May 1960	
	No. of seedlings	Main species	No. of seedlings	Main species
Simazine	1.9	*Viola* spp.(38) *Polygonum* spp.(19)	1.5	*Viola* spp.(35) *Polygonum* spp.(30)
Monuron	2.9	*Viola* spp.(38) *Fumaria officinalis* (18) *Polygonum* spp.(10)	1.1	*Viola* spp.(40) *Fumaria officinalis* (20) *Veronica* spp.(20)
Propham + 2,4-DES	4.9	*Chenopodium album* (36) *Fumaria officinalis* (11)	13.2	*Chenopodium album* (44) *Stellaria media* (16) *Viola* spp.(11)
Fenuron + 2,4-DES	6.1	*Chenopodium album* (34) *Stellaria media* (23)	9.5	*Stellaria media* (44) *Chenopodium album* (16)
Control	49.8	*Chenopodium album* (38) *Stellaria media* (16) *Poa annua* (12)	51.7	*Stellaria media* (36) *Chenopodium album* (28)

(The figures in brackets show the approximate percentage incidence of the main species.)

DISCUSSION

These results strongly suggest that some of the chemical weedkillers now available will prove useful in raspberry growing. Chemical weed control could not only ease the task of cleaning large acreages for annual weeds two or three times in spring and early summer, but could prevent the unchecked growth of weeds that usually occurs in late summer and autumn, when mechanical cleaning is impracticable.

Some confirmation of the results with simazine is already coming forward from growers, and if this herbicide proves successful in long-term use it should become a valuable asset. The results with monuron seem at present less satisfactory in that some crop injury has occurred, but with a perennial plant like the raspberry the possible doses and times of application of any weedkiller leave considerable room for manoeuvre. Of the mixtures tried, none has so far given such good weed control as simazine or monuron. That of TCA and dinoseb has caused severe damage, attributed to the TCA component. Propham/2,4-DES mixtures appear to be safe, and if used under suitable conditions will usually control Stellaria media, Senecio vulgaris, Poa annua, Capsella bursa-pastoris and some other annuals: but this combination of herbicides is unlikely to be as successful in raspberry fruiting plantations as in cane nurseries (Wood and Sutherland, 1960), where it is aided by the dense shade of the cane crop. Even if some such weedkiller as simazine should prove outstandingly successful, however, there may still be reason to vary the herbicide programme from time to time, in which case some of the mixtures now on trial may be useful.

The use of long-term trials yielding reliable quantitative data appears to be the only sound way of assessing the usefulness and safety of herbicides for such a crop as raspberries. Plantation performance varies from year to year under the influence of a large number of factors often difficult to evaluate, and short-term herbicide trials of an "observational" nature may therefore easily produce false conclusions. The present experiments will be more fully reported later.

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EFFECTS OF SOME CHEMICAL WEEDKILLERS ON A RASPBERRY CANE NURSERY: A PROGRESS REPORT

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Summary. After preliminary trials of herbicides in raspberry cane nurseries between 1955 and 1958, monuron, simazine and a 2,4-DES/propham mixture were chosen for inclusion in a longer-term trial planted in 1958. No hand cultivation has so far been required in this trial following spring applications of simazine at 2 lb or 3 lb/ac, and very little following the use of monuron at 3 lb. Lower doses of monuron and simazine, and the mixture of 2,4-DES (3.6 lb) with propham (5.0 lb) have not eliminated the need for cultivations. Higher yields of cane, of better quality, have been harvested from the plots on which herbicides have effectively replaced cultivations. A preliminary test on the persistence and movement of simazine and monuron in the soil is also reported.

INTRODUCTION

At the Fourth British Weed Control Conference, in 1958, the weed problem in raspberry cane nurseries (spawn beds) was described and a report was given on preliminary trials with chemical herbicides (Wood & Sutherland, 1960). It was shown that of various herbicides tested between 1955 and 1957, none used singly controlled a sufficiently wide range of weed species, and at least two, chlorpropham and TCA, caused injury to raspberry canes. Mixtures of herbicides were tried in 1957, but at safe doses none of the combinations used had a sufficiently long residual action to give the degree of weed control desired. Mixtures of 2,4-DES and propham were the most successful. A small trial early in spring 1958 tested diuron and monuron, each at 0.5 lb and 1 lb, and simazine at 1 lb and 2 lb. These showed promise, and monuron and simazine were chosen for a new trial, started later in the same spring, which is the subject of this report. A 2,4-DES/propham mixture was also included. This trial gave its first cane crop in autumn 1959 and will be re-cropped at least once more.

METHODS AND MATERIALS

Field procedure

The experimental nursery was planted in May 1958, with canes of the variety Malling Exploit, in four rows 6 ft apart and with the canes spaced at 3 ft in the rows. Unit plots 8 yd x 2 yd were marked out at right angles to the direction of the rows. The treatments, each applied to three plots chosen at random,

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were simazine at 1 lb, 2 lb and 3 lb; monuron at 1 lb, 2 lb and 3 lb; 2,4-DES (3.6 lb) + propham (5.0 lb) and control (hand cultivation). The herbicide treatments were applied each spring by Oxford Precision Sprayer. The treated plots afterwards received hand cultivation where this was necessary because of weed growth.

In 1958 the herbicides were applied on 16 June, each at a liquid volume rate of 40 gal/ac. The planted canes were then in leaf and the young canes a few inches high. The whole experiment was cultivated in late August, by which time the control plots had become badly weed-infested. In early March 1959, after the one-year-old stools had been dug out in accordance with normal practice (Wood, 1949), the whole area was sprayed with diquat (2 lb in 25 gal/ac) to destroy over-wintered weeds. Nevertheless, all the plots except those receiving simazine at 2 lb and 3 lb and monuron at 3 lb still required hoeing before the main treatments could be re-applied, and this probably destroyed some emerging young canes. The main treatments were re-applied on 19 March, again in 40 gal/ac. Weed growth afterwards developed fairly heavily on the 2,4-DES/propham, monuron 1 lb and control plots, but, owing to the risk of damage to young canes, hoeing was postponed until 19 June. All the plots were then hoed except those treated with simazine at 2 lb and 3 lb, which were clean. Weed control later in 1959 was aided by the shade of the cane crop. After the canes had been harvested the ground was cultivated early in 1960 for weed control and levelling, and the treatments were re-applied on 4 March at a volume rate of 30 gal/ac, without a prior diquat spray.

Testing for herbicide persistence

Introductory work to test for the persistence of simazine and monuron at various soil levels was started in August 1959, five months after the application of the sprays that year. Samples were taken from the control plots, the 2 lb and 3 lb monuron plots and all the simazine plots, and were drawn from three soil levels, namely 0 - 1 in., 1 - 3 in. and 3 - 6 in. The sample for any one depth on a given plot was made up from three random borings. Each sample was used to fill three 3½ in. pots, into which were sown, as test plants, swedes, Blenda oats and Arctic King lettuce.

RESULTS

Yield and quality of canes

The productivity of a cane nursery of any given variety of raspberry largely reflects the efficiency and care exercised in weed control. Not only do weeds compete with the crop, but cultivations for their control destroy emerging young canes. An ideal method of weed control would therefore be provided by a herbicide which, when sprayed on to the clean nursery in spring, kept the ground weed free for most of the growing season without injury to the crop.

Table I shows the numbers and grading of canes harvested from this trial in winter 1959/60. The marginal overlap between the plots is a large source of error, and a statistical analysis of these results has not yet been made. The figures, however, support the visual observation that cane growth was distinctly best on the 2 lb and 3 lb simazine plots and good also on the 1 lb simazine and 3 3 lb monuron plots. Not only were there more canes from the better treatments, but the canes were larger. Also as reflected in the figures, growth on the monuron plots was never quite as good as on those treated with simazine, but this may have been a result of severe chlorosis caused to the mother stools sprayed with monuron when in full leaf in June 1958. Spraying with any suitable residual herbicide would normally be done earlier. The simazine and 2,4-DES/propham sprays also caused slight leaf chlorosis in 1958, but none of the treatments did so when applied at correct times in 1959 and 1960. Visual differences between car growth on the monuron and simazine plots have been less obvious in 1960.

TABLE I. AVERAGE YIELDS OF CANE PER PLOT, WINTER 1959/60

Treatment	No. of canes	per cent 1st grade	per cent 2nd grade
Simazine 1 lb	147	73	27
" 2 "	181	78	22
" 3 "	170	74	26
Monuron 1 "	87	62	38
" 2 "	79	70	30
" 3 "	104	76	24
2,4-DES (3.6 lb)/propham (5 lb)	109	58	42
Control	93	50	50

Samples of canes dug from all the treatments in 1959 were heeled-in for observation in 1960. All came normally into growth.

Weed counts

Weed counts made on single dates in 1958, 1959 and 1960 are given in Table II. All the chemical treatments, but least those of simazine at 1 lb and monuron at 1 lb and 2 lb, gave good weed control following the initial applications in 1958. Thereafter the simazine treatments, particularly the two higher rates, became clearly the best and the 1 lb monuron and 2,4-DES/propham treatments the poorest.

TABLE II. COUNTS OF TOTAL WEEDS PER SQUARE FOOT ON DATES IN 1958, 1959 & 1960

(Based on ten 6 in. quadrats per plot in 1958 and eight in 1959 and 1960.)

Treatment	Weeds/sq ft on 17.7.1958	1.6.1959		26.5.1960	
		No. of species	Weeds/ sq ft	No. of species	Weeds/ sq ft
Simazine 1 lb	12	7	4	9	12
" 2 lb	6	3	0.5	1	1
" 3 lb	3	1	0.2	2	0.7
Monuron 1 lb	24	8	68	9	644
" 2 lb	14	9	46	9	49
" 3 lb	8	5	14	7	29
2,4-DES 3.6 lb + Propham 5 lb	9	12	47	14	586
Control	72	13	160	15	644

N.B. In the 1959 and 1960 records a miscellaneous group of less common weeds has been counted as a single species.

The 1958 count was on total weeds only, but in the later counts the most frequent species or groups of closely allied species were recorded separately. The number of these in 1959 was 12, plus a "miscellaneous" group of less common weeds, and in 1960 it was 13 plus a miscellaneous group. For simplicity, the miscellaneous group for each year has been included in Table II as a single species.

The simazine and highest-dose monuron treatments clearly reduced both the numbers of species present and the numbers of individual weeds. In 1959 their effects persisted until the next time of spraying, in spring 1960, whilst none of the other treatments gave more than a temporary control of weed growth. Similar differences have been apparent in 1960, except that the plots with poor weed control have become increasingly dirty because of the inherent difficulty in cleaning cane nurseries by ordinary methods of cultivation.

Table III lists the weed species which have so far proved regularly persistent under the three most effective treatments.

TABLE III. WEED SPECIES PERSISTENT ON SIMAZINE AND MONURON-TREATED PLOTS

Treatment	1959	1960
Simazine 2 lb and 3 lb	Vicia hirsuta Polygonum aviculare " convolvulus	Vicia hirsuta
Monuron 3 lb	Veronica persica Fumaria officinalis Polygonum aviculare " convolvulus	Veronica persica Fumaria officinalis Senecio vulgaris

Herbicide persistence

Table IV shows the results of the 1959 test for herbicide persistence and movement in the soil. At five months after spraying there was no evidence of the presence of seriously toxic quantities of monuron or simazine below the top inch of soil. The results from the 2 lb simazine plots, which gave slight evidence of a downward movement of herbicide, could have been due to accidental mixing of samples. The rainfall during the five months was 8.31 in, compared with the average for the same period of 10.4 in. Weeds germinated freely in the soil from the control plots and from below the 1 in. level on other plots.

TABLE IV. RESULTS OF HERBICIDE PERSISTENCE TEST, 1959

		Control	Sim 1 lb	Sim 1 lb	Sim 3 lb	Mon 2 lb	Mon 3 lb
Top ten	Swedes	+	xx	xxx	xxx	xxx	xxx
	Lettuce	+	xx	xxx	xxx	xxx	xxx
	Oats	+	xx	xxx	xxx	xxx	xxx
1 in.–3 in.	Swedes	+	+	x	+	+	+
	Lettuce	+	+	x	+	+	+
	Oats	+	+	x	+	+	+
3 in.–6 in.	Swedes	+	+	+	+	+	+
	Lettuce	+	+	+	+	+	+
	Oats	+	+	+	+	+	+

Key to behaviour of test plants:

+ Normal
x Some stunting
xx Severe stunting
xxx Death

DISCUSSION

These results show that simazine and monuron have so far been the most successful herbicides tested as weedkillers in raspberry cane nurseries. As in other work with raspberries, monuron has caused some temporary crop injury, but this danger may well be overcome by modifications in doses and times of use. A mixture of 2,4-DES and propham was less successful, but this and other mixtures may be useful as alternative treatments, especially on soils where the weed population has already been well reduced.

The test made in 1959 on herbicide persistence and movement in the soil showed that simazine and monuron, applied at low doses, can persist for at least five months in the top inch layer of soil in quantities lethal to seedlings of swede, oat and lettuce. There was no certain evidence of movement to a lower depth within that period.

Acknowledgments

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EXPERIMENTS WITH DALAPON IN SOFT FRUIT CROPS

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Summary. In 1959 and 1960, serious damage occurred on fruiting canes of Lloyd George raspberries where dalapon had been applied at 3.7 lb/ac during the previous autumn. Doses of 3.7 and 7.4 lb/ac caused no injury on several varieties when applied during the winter, however, and three successive annual treatments in December had no adverse effect on two varieties. In blackcurrants, repeated annual treatments since 1957 at 7.4 lb/ac during the growing season caused no injury to the variety Davison's Eight. Other varieties also tolerated this treatment but, in one experiment, a single application of 14.8 lb/ac in September slightly reduced growth in the following year. No injury was evident on well-established gooseberries following application at 7.4 lb/ac between September and March. It is concluded that in these crops, dalapon at 3.7 lb/ac during the winter is useful for the control of Poa annua and some other grasses. In raspberries this treatment only appears safe between mid-November and mid-January but with blackcurrants and gooseberries much more latitude in timing and dose seems possible.

INTRODUCTION

Published reports on the use of dalapon in raspberries record variable results. Injury has been caused in some trials, (Neilson, 1955; Davison et al, 1955; Wilson, 1957; Dodge & Snyder, 1958; Anon, 1959; Robinson 1960 b; Wood and Sutherland, 1960), but not in others (Carlson, 1955, 1955 a, b; White, 1958; Anon, 1958 c; Cartwright, 1958; Montgomery, 1959; Robinson, 1960 b).

Results on blackcurrants have been more consistent. In W. Ontario, no injury was caused by 6 lb of commercial product per acre (Neilson, 1955) and, in a trial in the U.S.A., resistance was fair to good (Anon, 1958 d). No injury was recorded on blackcurrants in Northern Ireland (Anon, 1957 a; Robinson 1958, 1960), and in trials carried out by the N.A.A.S, 6 and 8 lb/ac applied after harvest had no adverse effect (Anon, 1958 a). In Tasmania, rates of 10 to 20 lb/ac in the spring or autumn are recommended for control of all grasses in this crop (Anon, 1957 b).

Little information is available in the literature on the use of dalapon on gooseberries. In Canada no injury was caused by 6 lb/ac of commercial product (Neilson, 1955) nor in Northern Ireland by January and May application of 3.75 lb/ac, although slight injury appeared where double this rate was used in February and more severe damage was caused by 15 and 30 lb/ac (Robinson, 1960 a). The damage was temporary, however, even at the highest rate. In Lincolnshire, 5 lb/ac caused no damage in December, but bushes up to three years old were damaged by a late April application. (Anon, 1958 b).

On account of the prevalence of Poa annua in Northern Ireland and its susceptibility to dalapon, further trials were conducted in 1959 and 1960 in raspberry, blackcurrant and gooseberry plantations.

METHODS AND MATERIALS

In most of the experiments, the methods used were similar to those described in the previous paper, but in gooseberries and blackcurrants, treatments were applied as a directed spray to the entire area, except where stated otherwise.

The terminology, adopted by Wood and Robertson (1957) to describe the types of laterals and inflorescences produced on raspberries, has been used in this paper. The data on lateral formation in raspberries, presented in table I, are based on all cropping nodes on 30 canes selected at random from each plot.

RESULTS

Raspberries

Trials were conducted between 1958 and 1960 to obtain information on the response of raspberries to dalapon* applied at different times of the year.

In the first trial, single plots of the variety Lloyd George, planted in February 1957, were sprayed at 3.7 lb/ac during the first week of each month from October 1958 until April 1959. No obvious phytotoxic effects occurred following application between December and February, but treatments applied earlier or later than this period caused some injury. The type of damage resulting from application in the autumn differed from that caused by treatment in the spring. On plots treated in October or early November fruiting laterals appearing in April were reduced in size and bore small berries which crumbled easily. Damage was more severe towards the tops of the canes and in many cases where the fruiting lateral from the main or primary bud at a node was stunted or killed, a short lateral had been produced from the secondary bud immediately below the main one.

March and April applications caused no obvious injury to the fruiting canes but checked the emergence and growth of young spawn. This injury was only temporary, however, and later growth was normal.

A similar unreplicated trial on Lloyd George was conducted the following year. Dalapon at 3.7 lb/ac was applied at weekly or fortnightly intervals between 31st August and 9th November 1959 and between 5th February and 6th April, 1960. The symptoms of injury in spring 1960 were similar to those recorded the previous year. Table I shows that applications between 31st August and 19th October stunted the fruiting laterlls, and increased the number of nodes bearing both primary and secondary laterals. Although the number of inflorescences was increased by treatment during this period, the crop yield was markedly decreased because of reduction in the vigour of the fruiting laterals and also in the number of flowers produced per primary lateral. The fruit was also small and of poor quality. There was no obvious difference between treatments in the number of flowers on secondary laterals.

Plots sprayed on 3rd November 1959 or later, showed no obvious injury symptoms on fruiting canes. Where treatment had been applied on 28th March and 6th April, similar damage to that recorded in the previous year occurred on the young canes.

Commercial product - Dowpon containing 74 per cent a e of dalapon and a wetting agent.

A similar treatment applied between mid-September and mid-November 1959 caused no obvious injury to the raspberry varieties Malling Jewel, Malling Landmark, Malling Exploit and Seedling V. Length of fruiting lateral and number of berries per lateral were not affected and there was no apparent difference in crop yield or quality between sprayed and unsprayed plots.

The effect of applying dalapon at different times was also tested in a cropping experiment on the variety Lloyd George in 1959/60. A dose of 3.7 lb/ac was applied in December, February and April and compared with a hand-hoed control plot. Treatment in December and February caused no apparent injury, but application in April slightly retarded the emergence and growth of young canes. This check was only temporary, however, and at the end of the season, the number and height of canes on sprayed plots did not differ significantly from the control. None of the treatments caused any obvious injury on fruiting canes, but plots sprayed in April gave a significantly lower yield (P = 0.05) than the control (table II).

TABLE I. EFFECT OF TIME OF APPLICATION OF DALAPON ON LLOYD GEORGE RASPBERRIES

Date of application of dalapon 3.7 lb/ac	Fruiting canes - 1960					
	Percentage* of nodes furnished with:			Mean length of primary and secondary laterals ✝ cm	No. berries/ primary lateral✝	Yield/ plot of 4 yd row
	primary laterals	secondary laterals	primary + secondary laterals			
31/8/59	44.4	7.5	38.9	5.6	5.4	9.8
7/9/59	53.5	7.3	32.3	7.2	6.1	10.8
21/9/59	64.4	11.9	20.3	5.8	5.3	7.1
5/10/59	47.5	10.9	25.0	7.3	5.3	6.7
19/10/59	58.1	10.5	27.5	9.8	5.8	7.3
3/11/59	83.1	3.4	11.9	14.1	9.7	14.3
9/11/59	85.2	3.7	8.7	13.0	9.8	17.9
5/2/60	82.1	6.0	10.4	13.2	9.3	13.2
20/2/60	88.7	2.1	7.2	12.0	8.5	10.4
4/3/60	86.4	4.9	8.6	14.9	9.6	11.6
11/3/60	88.0	5.4	8.7	13.7	8.8	10.7
28/3/60	73.0	8.1	8.9	14.0	8.5	12.1
6/4/60	78.3	4.9	9.1	13.3	8.0	10.3
Untreated	87.8	5.5	8.0	13.0	9.1	15.7

* Nodes with tertiary laterals are omitted from this table.

✝ Data taken on 4th or 5th node from top of cane.

TABLE II. COMPARISON OF APPLICATION OF DALAPON AT 3.7 LB/AC ON RASPBERRIES AT DIFFERENT TIMES (THREE REPLICATES)

Date of application	Yield in lb/ plot of 8 yd row July 1960
1/12/59	40.5
4/2/60	45.6
7/4/60	35.2*
Untreated	43.8

S.E. of difference ±2.98

* Differs significantly from untreated plot at 5% level ($P = 0.05$)

In a trial started in December 1957, dalapon at 3.75 lb/ac was compared with a hand-hoed control on Malling Landmark and Malling Jewel. The sprayed plots were treated again at 7.4 lb/ac in December 1958 and also in December 1959. Treatments were replicated twice on each variety and all plots were hand-hoed whenever necessary during the course of the experiment. There was no indication that the repeated use of dalapon in mid-winter had any adverse effect on crop yield, as may be seen in table III. Cane measurements at the end of the third season showed no loss of vigour compared with hand-hoed control plots.

TABLE III. EFFECT OF REPEATED SPRAYS OF DALAPON ON RASPBERRIES

Variety	Year	Yield in lb/ plot of 6 row yd	
		) 30/12/57 Hand-hoed) 30/12/58) 30/12/59	) 3.75 lb/ac - 30/12/57 Dalapon) 7.4 lb/ac - 30/12/58) 7.4 lb/ac - 30/12/59
Malling Jewel	1958	27.7	28.5
	1959	27.4	28.1
	1960	20.3	23.2
Malling Landmark	1958	28.7	25.1
	1959	18.8	21.2
	1960	20.6	22.4

In tests on the effect of overall applications of certain herbicides on Lloyd George raspberries in January 1959 and February 1960, dalapon at 7.4 lb/ac caused severe damage. In the spring leaves on fruiting canes were stunted and chlorotic and some were killed. Fruiting laterals were less severely injured than the foliage but some terminal flower buds failed to open.

Blackcurrants

To test the tolerance of blackcurrants to dalapon, a dose of 14.8 lb/ac was applied to an area of 100 sq ft around single bushes of Boskoop Giant each month from October 1958 till April 1959. A similar area was treated around Cotswold Cross bushes each month from August 1959 till March 1960. On each spraying date a similar bush was sprayed overall at a rate equivalent to 3.7 lb/ac in 100 gal of water/ac. Ground applications caused no apparent injury to the vigour of the bushes and crop records showed no marked reduction in yield. Overall sprays had no obvious adverse effect except when applied after bud burst.

High doses of dalapon applied in the autumn and spring were compared with a hand-hoed control in 1959/60. Treatments were as shown in table IV and each was replicated four times on plots containing 4 nine-year-old bushes of each of the varieties Goliath, Wellington XXX and Seabrooks Black. No phytotoxic effects were observed on the foliage in autumn 1959 or during 1960 nor were crop yield or the amount of young growth significantly affected (table IV). In this experiement, however, the amount of new wood produced on each of the three varieties, following a single application of 14.8 lb/ac in September, was slightly less than on the hand-hoed control.

TABLE IV. EFFECT OF HIGH DOSES OF DALAPON ON BLACKCURRANTS (FOUR REPLICATES)

Dalapon, lb/ac per treatment	Times of application	Yield lb per plot of 12 bushes July 1960	One-year-old wood, ft per bush September 1960
0	-	68.9	119.6
7.4	29/9/59 and 24/3/60	76.1	122.6
14.8	29/9/59	60.3	104.5
14.8	24/3/60	67.0	114.1
7.4	29/9/59, 24/3/60 and 5/5/60	63.7	119.3
S.E. of difference		±8.5	±8.2

In a long-term experiment on the effect of the elimination of hand-hoeing around blackcurrants, dalapon has been used, along with simazine and other herbicides, to maintain plots of Davison's Eight in a weed-free condition since spring 1957. Four applications of dalapon at 7.4 lb/ac and one application at 3.7 lb/ac have been made in four years during the growing period without causing any check to growth. In 1960 crop yield on sprayed plots was higher than on hand-hoed plots, but the increase just failed to be significant ($p = 0.05$).

Gooseberries

The effect of autumn, winter and spring applications of dalapon was compared on gooseberries in 1959/1960. The bushes were eight years old and were planted

6 ft apart in each direction. Treatments were as follows:- 7.4 lb/ac in September; 7.4 lb in September plus 7.4 lb in March; 7.4 lb in November; 7.4 lb in March; 3.7 lb in September plus 3.7 lb in March plus 3.7 lb in May. These treatments were replicated twice on each of the six varieties, Amber, Careless Crown Bob, Lancashire Lad, White Lion and Whitesmith. No sign of injury occurred on the foliage in autumn 1959, and in 1960 there was no significant difference (P = 0.05) between treatments in growth or crop yield and no difference in reaction between varieties.

DISCUSSION

Dalapon is reported to be absorbed, translocated and accumulated in higher plants and to remain essentially non-metabolised for long periods (Crafts and Foy 1959). There was no evidence, however, to suggest that repeated applications in December for three years had any harmful effect on raspberries. Although in a number of experiments, directed sprays applied between late November and mid-January caused no damage, raspberries have been injured in varying degrees by treatment in the autumn or spring.

Application of herbicides is not normally practicable in established raspberries until after tying-in the canes in the winter. Dalapon, however, is often regarded as being particularly suitable for use in the autumn and, on some commercial holdings where the grass problem is severe or the cane growth sparse, autumn applications have been attempted. It is evident from the results in 1959 and 1960 that, in Northern Ireland, its use in the autumn will result in serious injury on the variety Lloyd George. The severe damage to the fruiting laterals in both years was caused by the use of a low dose (3.7 lb/ac) applied as a carefully directed application.

There was a marked difference between the severe injury obtained on plots sprayed in September and October and the absence of obvious damage when the spray was applied a few weeks later. Dalapon has been shown to be highly mobile in plants and tends to move to any region of high metabolic activity (Crafts and Foy 1959). In the raspberry, fruit-bud differentiation usually takes place between mid-September and early November (Mathers 1952) and in the variety Lloyd George, dalapon applied in the autumn appears to have been absorbed by the roots and moved to the fruit buds where active cell division was occurring. The situation, however, is complicated by varietal differences in susceptibility and plants of Malling Exploit, growing in the same field and sprayed on the same dates as Lloyd George were uninjured by autumn treatments.

Some injury was caused to fruit buds in Lloyd George when sprayed on 3rd November 1958 but not when treated on the same date in 1959. The crop became tolerant to dalapon between early November and early December in 1958 and between mid-October and early November in 1959. The weather in the summer and autumn 1958 was wet while that in 1959 was generally warm and dry and it is possible that the damage caused in November 1958 was due to the climatic conditions being favourable for late growth. In addition, 0.27 in. of rain fell about 12 hours after application on 3rd November 1958 and this would probably increase the chance of injury by quickly bringing the herbicide in contact with the root system of the crop.

Applications in March and April usually depressed cane emergence for a time but, where the raspberries were vigorous, good recovery occurred later in the season. Although injury to the fruiting laterals was not obvious, however, there

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to be very promising for runner inhibition in strawberries grown on this system Thompson (1960) has shown that it is also effective when used to give complete runner control of strawberries growing in rows as single plants and (1961) has suggested that, in fact, it may be more reliable when used for this purpose than in systems in which rooted runners are already present such as the 'matted row' and 'matted bed'.

In this paper a short description is given of the pattern of runner production during the summer, as this governs the choice of times of application of maleic hydrazide, and an experiment is described in which successful runner control was achieved in four varieties growing in the field, using two separate sprays of maleic hydrazide during the summer.

METHODS, MATERIALS AND RESULTS

Pattern of runner production in field

Young plants of the varieties Talisman, Redgauntlet, Cambridge Favourite and Cambridge Vigour were planted in the field in April. During the summer runners were removed from 120 plants of each variety on the following dates; 26th June, 14th July, 10th August and 27th August. Table I shows, for each variety, the rate of primary runner production, that is runners growing directly from the parent plant, expressed as the mean daily production of runners for every 100 plants between each removal date.

TABLE I. MEAN RUNNER PRODUCTION PER 100 PLANTS BETWEEN SUCCESSIVE DATES DURING THE SUMMER

Variety	Mean daily production between given dates			
	16-26 June	26 June-14 July	14 July-10 August	10-27 August
Redgauntlet	17	18.3	29	38
Talisman	28	25.0	53	71
Vigour	3	13	19	22
Favourite	13	11	20	35

It is clear that the peak rate was reached in the second half of August, just before primary runner production ceased early in September. This is to be expected as the plants produce new branch crowns during the summer and hence increase the effective rate of leaf production and the number of sites available for runner initiation.

Primary runners formed in late August, however, contribute relatively little to the mats of runners found in neglected strawberry plantations, and it is the early-formed runners, particularly those produced in early July, which it is most important to control. This is illustrated in Table II which shows the mean number of secondary runners produced from the first seven primary runners emerging from six plants of Talisman growing in the field, and counted on 15th August. Out of a mean total of 56 runners/plant, 30 are derived from the first two primary runners.

It is quite clear that one cannot equate the large numbers of relatively unimportant primary runners produced in late August with the few produced during July, and that for effective control it is the latter which it is most important

THE USE OF MALEIC HYDRAZIDE FOR THE CONTROL OF RUNNERS IN STRAWBERRY PLANTATIONS

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Summary: Maleic hydrazide as the triethanolamine salt was used to control runner production in four varieties of strawberry; Talisman, Redgauntlet, Cambridge Vigour and Cambridge Favourite. Records of primary runner production in the field showed that runners emerging during July gave rise to large numbers of secondary runners, and it was necessary to inhibit these, rather than the runners formed in the second half of August for successful control. Maleic hydrazide was applied on 23rd June at 0.1, 0.15 or 0.2 per cent. The plants were resprayed when healthy young runners were again seen emerging. Successful runner control was achieved with all treatments in the varieties Talisman, Cambridge Vigour and Cambridge Favourite. In Redgauntlet a few plots of all treatments were only marginally controlled. Comparison of the height of treated with untreated plants in the following spring showed a slight reduction in the treated series. The crop from treated plants of Talisman and Redgauntlet was approximately equivalent to that taken from control plants from which all runners had been removed at intervals by hand. In Cambridge Vigour and especially Cambridge Favourite the crop was reduced. It is believed that the latter result may have been due to poor establishment of the plants at the time of treatment.

INTRODUCTION

All commercial strawberry varieties grown in Britain produce stolons in long days during the summer. Although cultural systems such as those known as the 'matted bed' and the 'matted row' have been devised to take advantage of these runners the simplest and most easily managed system is to remove all runners and grow the plants in rows as individual units. With the leafy, vigorous varieties now being widely grown this latter system is almost essential for the successful control of grey mould (*Botrytis cinerea*).

In the North it is difficult to obtain sufficient early-formed runners in time for autumn planting, and it is more usual to establish plantations in the spring, to deblossom in their maiden year, and to take the first crop in the following year, fifteen months after planting. Runners formed during this period act as weeds in the sense that they compete with the parent plants for water and nutrients, and their presence, if allowed to grow unchecked, not only greatly reduces the cropping capacity of the plantation but impedes routine cultural operations.

A variety of chemicals have been tried for runner control in the past (Carlson 1953, Denisen 1955) but of these only maleic hydrazide has proved to give a reasonable level of runner inhibition without severely damaging the parent plant. Denisen (1950) first reported maleic hydrazide as a possible means of controlling runner production in strawberries grown in matted beds. Since then further publications by Denisen (1956) and Hitz (1959) have shown this substance to control. This means that the first spray application must be applied sufficiently early to inhibit the development of early runners. Moreover there is no need to risk interfering with flower initiation by applying maleic hydrazide later than mid-August, since a spray at this time will inhibit all but a few unimportant runners produced at the end of the season.

TABLE II. NUMBERS OF SECONDARY RUNNERS PRODUCED BY SUCCESSIVE PRIMARY RUNNERS OF THE VARIETY TALISMAN (RECORDED 15TH AUGUST 1960)

	Mean no. of secondary runners		
Primary runners	Rooted	Unrooted	Total
1st	3	13	17
2nd	3	9	13
3rd	1	6	8
4th	1	4	6
5th	0.8	4	5.8
6th	0.3	2	3.3
7th	0.1	2	3.1
		Total	56.2

Application of maleic hydrazide in the field

The following four varieties were planted in April 1959 in the field; Talisman, Redgauntlet, Cambridge Favourite and Cambridge Vigour. They were allowed to grow on until the first runners started to appear towards the end of June when the first treatments were applied. All plants, except for the control, were sprayed on 23rd June with maleic hydrazide as the diethanolamine salt at a rate equivalent to 0.1, 0.15 or 0.2 per cent of active ingredient. The plants were then resprayed when actively growing young runners were again found emerging. In the case of plants treated at 0.1 and 0.15 per cent the sprays were repeated on 22nd July at the same levels as on the first occasion. It was not found necessary to respray plants sprayed on the first occasion at 0.2 per cent until 13th August when they were resprayed at 0.1 per cent. At this time it was also considered necessary to spray Redgauntlet plants, previously twice treated at 0.1 per cent for a third time.

A further control set of plants was left unsprayed. Runners growing from these plants were removed and counted at intervals through the season so that the plants remained free of established runners. The experiment was divided into four blocks with all treatments represented at random in each block in plots of thirty plants to give a total of 120 plants per treatment.

The sprays were applied with an Oxford Precision Sprayer at a rate equivalent to 60 gal/ac. Only the parent plants were sprayed, and on occasions when runners were present between the rows these were not deliberately sprayed.

During the summer records were made of the appearance of the plants and the degree of runner inhibition. In the following year measurements were made of plant height to assess vigour, the number of inflorescences, and the weight of crop produced. The results of these observations are summarised in tables III, IV and V.

Effect of treatment on growth and vigour

Until a fortnight after treatment few effects were discerned, by this time the first signs of runner inhibition were apparent and some of the younger leaves of plants treated at 0.2 per cent were chlorotic. When the appearance of the plants was recorded one month after treatment it was found that treatment at 0.1 per cent had had no visible effect on plant growth; at 0.15 per cent a large proportion of the plants showed some degree of chlorosis of the young leaves, and at 0.2 per cent some stunting was also evident in all varieties except Redgauntlet. One month later on 11th August all the treated plants, even those sprayed a second time, were a normal green colour. In the following spring records of the height of the plants were made by measuring the distance from the ground to the apex of the dome formed by the leaves, see Table III. As can be seen treatment at all levels slightly depressed vigour in comparison to the control plants.

TABLE III. RECORDS OF PLANT HEIGHT (IN CM) OF FOUR VARIETIES OF STRAWBERRIES MEASURED IN THE SPRING AFTER TREATMENT THE PREVIOUS SUMMER WITH MALEIC HYDRAZIDE.

Variety	Concentration (per cent) and dates of spray			Control
	0.1 23.6 0.1 22.7 0.1 13.8*	0.15 23.6 0.15 22.7	0.2 23.6 0.1 13.8	
Redgauntlet	10.9	10.8	10.7	11.8
Talisman	10.4	10.9	10.5	11.7
Cam. Vigour	11.5	11.8	11.8	12.4
Cam. Favourite	7.1	7.5	7.5	7.9

* Applied only to the variety Redgauntlet

Effect of treatment on runner inhibition

Records of runner growth were made on 21st July, 11th August and 6th October. The first two occasions were used as a guide to which treatments needed spraying for a second time. The records made on 6th October are shown in Table IV. Counts of the number of runners present give little idea of the appearance of a plantation, or the relative effectiveness of treatment. For this reason runner density was scored in the following way.

1 Primary runners absent or very small, no secondary runners.
2 Primary runners strongly inhibited, a very few poorly rooted secondary runners.
3 Primary runners not fully inhibited, small numbers (up to 3 per plant) rooted, with small chains of secondary runners.

4 Moderate numbers (up to ten per plant) of primary runners with small chains of secondary runners.
5 Primary and secondary runners both present in quantity, numbers slightly restricted by inhibition of some primary and secondary runners.
6 Few signs of effective inhibition.

In practice it is considered that, by this classification, any value less than '4', indicates an effective control of runner production since the runners present would be insufficient to impede cultivation. As Table IV shows the mean value for any variety never reached this level, and in fact inadequate control of runners only occurred in a few plots of the varieties Redgauntlet and Favourite. In Talisman and Cambridge Vigour runner control was consistently high in all the treatments and replications used.

TABLE IV. RECORDS MADE ON OCTOBER 6 OF DENSITY OF RUNNERS FROM FOUR VARIETIES OF STRAWBERRIES SPRAYED DURING THE SUMMER WITH MALEIC HYDRAZIDE

Variety	Concentration (per cent) and dates of spray			Control
	0.1 23.6 0.1 22.7 0.1 13.8*	0.15 23.6 0.15 22.7	0.2 23.6 0.1 13.8	
Redgauntlet	2.5	3.75	3.5	1.0
Talisman	1.75	2.5	2.25	1.0
Cam. Vigour	2.25	1.75	2.25	1.0
Cam. Favourite	3.5	2.25	2.0	1.0

* Applied only to the variety Redgauntlet.

Effect on flower initiation and cropping.

Counts were made of the number of fruit trusses per plant at the time of peak flowering in June 1960. The crop was picked at frequent intervals during July and early August and its weight recorded on a plot basis. The results for both records are shown in Table V.

TABLE V. NUMBER OF FLOWER TRUSSES PER PLANT AND WEIGHT OF FRUIT (OZ PER PLANT) FROM FOUR VARIETIES OF STRAWBERRIES AFTER TREATMENT WITH MALEIC HYDRAZIDE IN THE PREVIOUS YEAR

Variety	Concentration (per cent) and dates of spray			Control
	0.1 23.6 0.1 22.7 0.1 13.8*	0.15 23.6 0.15 22.7	0.2 23.6 0.1 13.8	
Redgauntlet				
No. of trusses	5.1	4.8	4.6	4.4
Crop picked ‡	16.9	15.6	15.6	13.7
Talisman				
No. of trusses	8.5	11.9	9.6	12.2
Crop picked ‡	23.2	26.1	24.4	26.9
Cam. Vigour				
No. of trusses	7.3	9.3	7.5	9.9
Crop picked ‡	19.4	25.4	22.4	25.7
Cam. Favourite				
No. of trusses	4.3	5.2	6.0	8.3
Crop picked ‡	11.9	13.0	16.1	21.1

‡ Sig diff 2.3 oz/plant

* Applied only to the variety Redgauntlet

The weight of crop picked always varied according to the number of trusses present and it is quite clear that any effects of maleic hydrazide on cropping was due to the influence on the number of flower trusses produced in the previous autumn, rather than to any carry over effect on the vigour of the plants. The effect of treatment on cropping depended largely on the variety. In Redgauntlet treatment increased the crop above the control value, although in only one case was this increase significant. At the other extreme it caused a severe reduction in crop at all levels in Cambridge Favourite, and a moderate reduction in two out of the three levels applied to Cambridge Vigour. Talisman showed slight reductions in yield, which reached a significant level in only one treatment (1000 ppm applied on 22nd June and 22nd July).

DISCUSSION

When assessing the results of this experiment it is essential to bear in mind the economic considerations which control the relationship between the attention given to a plantation and the possible gain in crop resulting from any additional expenditure on labour and materials.

Thus in a comparison of the yields obtained from plants treated with maleic hydrazide with that obtained from the controls, the latter value should be regarded as the maximum to be obtained by runner control since all primary