months only) £2.11. 0. Over a four year period the average labour-cost involved in spraying an acre with a pressure-retaining knapsack at 50 gal/ac was about 25/-/ac per treatment (12/6 for spot-treatment). Excluding 1962, the average annual cost of weed control by herbicides (materials plus labour) was therefore about £24 per acre sprayed.

DISCUSSION

In 1962, three years after the start of this experiment, herbicide-treated plots were completely weed free and plant size and yield were as good as on cultivated plots. As the normal cropping life of a strawberry plantation is only three or four years, the results of this experiment indicate that it is possible under certain conditions to control weeds completely in established strawberries without manual or mechanical cultivation.

The symptoms of chlorpropham injury on the foliage in spring 1960 and the good growth that occurred later in the year suggest that this herbicide was directly responsible for the yield reduction in 1960. The variety Cambridge Vigour, is now known to be susceptible to chlorpropham during mild winters (Woodford 1960) and the use of the herbicide on this variety is not recommended in Northern Ireland (Anon 1961a). That the yield reduction was due to chemical injury and not to harmful soil conditions resulting from the absence of cultivation is supported by the satisfactory yield and growth obtained from herbicide-treated plants in 1961 and 1962. If soil erosion, lack of aeration or other harmful soil effect had been responsible for the lower yield in 1960, a reduction would also have been expected in subsequent years. Recent trials confirmed that simazine may be used effectively as an autumn and winter herbicide in strawberries (Anon 1961b, Anon 1962) and in 1961 and 1962 further use of chlorpropham was unnecessary.

Although there is a deeply entrenched belief among many growers in the need to maintain a surface tilth, there was no evidence in this experiment that the hard surface crust that occurred on unmulched herbicide-treated plots for three years had any adverse effect on the crop. The increased run-off and soil erosion from these plots clearly indicates, however, that under soil conditions at Loughgall, a mulch is a necessary adjunct to any system of non-cultivation on sloping ground.

Visual observations showed that both mulches used in this experiment effectively inhibited erosion and minimised the formation of a surface crust but neither had any significant effect on plant yield or crop vigour. The increased danger of frost damage on straw mulched plots in well known (Rogers, 1943) and a mulch of well rotted farmyard manure, which is less likely than straw to reduce air temperature (Robinson, 1962a), is considered to be more suitable.

No recent information is available in Northern Ireland on the annual cost of controlling weeds and runners in strawberry plantations by cultivation but it is undoubtedly more than £24/ac, and is generally considered to be around £50 - £60/ac. Costings studies carried out in south west Scotland in 1959 and 1960 showed that the average annual cost of cultivation in fruiting plantations was approximately £68/ac (Roberts, 1961). In the U.S.A. annual weeding costs may amount to £70 - £100/ac (Laverton, 1962) and to £150/ac in New Zealand (Porter, 1959). It seems therefore that a system of weed control based entirely on a herbicide programme may have a considerable economic advantage over traditional methods even where the addition of a mulch of organic matter is necessary to prevent erosion on sloping ground.

In 1962, the cost of the spray programme was greatly reduced because few weed seeds germinated on herbicide-treated plots. As suggested by Roberts (1962) this was probably partly due to the exhaustion of the population of non-dormant weed seeds in the germinating zone and partly to the enforcement of dormancy following compaction of the surface soil.

Newly planted strawberries are known to be susceptible to injury from 2,4-DES and simazine (Woodford, 1960). Moreover, it has been observed that slight spray wetting with diquat and paraquat has little effect on large plants but may be lethal to small ones. It does not seem possible, therefore, to introduce a system of non-cultivation in strawberries immediately after planting but, until safer herbicides become available, a short initial period of cultivation appears to be necessary. Even in established plantations the control of weeds by herbicides without crop injury is less easily obtained than in taller-growing bush and cane fruits. Not only are directed applications more difficult to apply, but strawberries appear to be inherently more susceptible than blackcurrants, gooseberries and raspberries to many herbicides, for example simazine, chlorpropham and dalapon.

Nevertheless, provided doses are applied accurately and at the right time, the complete elimination of cultivation using existing herbicides appears to be possible in varieties, such as Cambridge Vigour, which show fair tolerance to simazine. Experiments in progress at Loughgall suggest that a useful programme consists of simazine applied at about 1 lb/ac in July and again in December. These treatments usually control germinating weeds only, and other herbicides, applied as a spot-treatment or carefully directed spray, will be necessary if weeds become established. In this respect, paraquat and diquat appear to be most useful and 2,4-D may also be satisfactory for overall application at certain periods.

As this experiment has been in progress for three years, the normal cropping life of a strawberry plantation, it is concluded that a system of weed control based entirely on herbicides is a promising new cultural practice for this crop. While it is not yet known how suitable the system would be on other soil types, it may possibly be useful under a wide range of conditions, provided the surface of soil liable to compaction is protected by a mulch.

Acknowledgements

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REFERENCES

ANONYMOUS (1961a) The cultivation of strawberries. Leaflet No 68 Min of Ag N.I.

(1961b) Results of trials with herbicides in 1960. Mimeo. Report Horticultural Centre, Loughgall.

(1962) Results of trials with herbicides in 1961. Mimeo. Report Horticultural Centre, Loughgall.

ELLIOTT, J.C., BOYLE, P.J., ROBINSON, D.W. and HOLMES, G.D. (1962) Crop situations where cultivation for weed control may be eliminated by use of herbicides. Brit Weed Control Council. Symposium No 2. Crop production in a weed-free environment.

LAVERTON, S. (1962) Agricultural chemicals their value and safety. Assoc of Brit Manf of Agric Chem.

PLANT PROTECTION LTD (1962) Private communication.

PORTER, L.S. (1959) Weed control in berry fruits. Proc 12th New Zealand Weed Control Conf 106-111.

ROBERTS, C.W. (1961) The strawberry crop, 1959 and 1960. Outlays and returns on some market gardens in south west Scotland. The West of Scotland Agricultural College. Economics Department Report No.72.

ROBERTS, H.A. (1962) The problem of weed seeds in the soil. Brit Weed Control Council. Symposium No 2. Crop production in a weed-free environment.

ROBINSON, D.W. (1958) The chemical control of grass in fruit plantations. Res Exp Rec Min Ag N.I. 7, 72-78.

(1962) Investigations on the elimination of cultivation in bush fruit crops. Proc XVIth Internat Hort Cong Brussels 1962.

ROGERS, W.S. (1943) Strawberries, Straw and Frost. Fruitgrower 95, 393.

WOODFORD, E.K. (ed) (1960) Weed Control Handbook. British Weed Control Council. Blackwell Scientific Publications, Ltd. Oxford.

Research report

PROGRESS REPORT ON STRAWBERRY HERBICIDE EXPERIMENTS

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Summary: A replicated trial planted with the strawberry varieties Cambridge Vigour and Talisman has shown some evidence of crop reduction following annual treatments with 2.0 lb/ac simazine, 10 lb/ac neburon or 12 lb/ac dimethyl 2,3,5,6-tetrachloroterephthalate for two years, although all the plants have appeared normal. Only simazine has eliminated the need for spring hoeing before strawing. The trial is being continued.

INTRODUCTION

Preliminary work in Scotland in 1959 (Sutherland and Stephens 1960) showed that neither 1.5 nor 3.0 lb/ac simazine applied in March to established plants of Talisman and Redgauntlet strawberries reduced yields in the year of application. A new trial, described in this paper, was established to test the use of simazine over the greater part of the life of a strawberry plantation.

METHODS AND MATERIALS

The experiment was planted in March 1960 with the varieties Cambridge Vigour and Talisman, at planting distances of 3 ft between the rows and 18 in between the plants in the rows. Conventional cultivations were adopted until early in 1961, when the chemical treatments were applied for the first time on 22 February. It was decided that subsequent applications of the treatments would be split equally between autumn and spring, and the first two half doses were applied on 9 September 1961 and 22 February 1962. The treatments were simazine 2 lb/ac (split dose 1 lb/ac), neburon 10 lb/ac (split dose 5 lb/ac) and dimethyl-2,3,5,6-tetrachloroterephthalate ("Dacthal") 12 lb/ac (split dose 6 lb/ac).

Each treatment was replicated four times and the plots were arranged in randomized blocks on each variety. The plots consisted of two rows 18 ft long separated from the next plot by a single guard row of the same variety. The plants were maintained as single plants by de-runnering. All the sprays were applied at a volume rate of 30 gal/ac over the whole plot width, with an Oxford Precision Sprayer, applying the spray equally to bare soil surface and to the strawberry foliage. Each treatment was managed separately, and shallow surface cultivations for weed control were carried out as required.

RESULTS

Weed Control. Only simazine provided a sufficient control of weeds in 1961 to be a practicable alternative to hoeing. Neither neburon nor dimethyl-2,3,5,6-detrachloroterephthalate, even at the high rates used, achieved much more than a temporary check to the growth of annual weeds, but neburon was rather the more effective of the two. Weeds were again well controlled by simazine in 1962, and hand hoeing was not required on the plots of this treatment until after harvest.

Effect on Yield and Vigour of the Crop. No visible differences were detected between the plants under any of the treatments. However, the crop yields for 1961 and 1962 given on Table I show some evidence that simazine and neburon, and perhaps also dimethyl-2,3,5,6-tetrachloroterephthalate, reduced productivity.

TABLE I. YIELDS OF FRUIT IN CWT/AC

Treatment (lb/ac)	Cambridge Vigour			Talisman		
	1961	1962	Total	1961	1962	Total
control	40.0	52.2	92.2	62.6	139.4	202.0
simazine 2	32.1	45.0	77.1	47.9	118.5	166.4
neburon 10	31.0	39.2	70.2	54.0	113.2	167.2
"Dacthal" 12	40.0	43.6	83.6	65.2	131.5	196.7
Sig Diff ($\underline{P}$ = 0.05)	7.4	6.2	10.9	12.6	17.3	21.4

DISCUSSION

Strawberries are a notoriously dirty crop, needing a considerable amount of hand cleaning, and a herbicide is required that will reduce or eliminate this costly operation without endangering the crop. The only herbicide so far tested at Mylnefield that controls weeds in strawberries for more than a few weeks without obvious damage to the plants is simazine, and this material is now being widely used in commercial plantations in Scotland. Even if it could be demonstrated beyond doubt that the yield of strawberries is reduced by the use of low rates of simazine, it might still be profitable to use the material as an alternative to expensive and sometimes unobtainable hand labour. More work is required to determine the safest times, rates and methods of applying simazine in this crop, or to find a safer alternative material.

ACKNOWLEDGMENTS

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REFERENCES

SUTHERLAND, J.P. and STEPHENS, R.J. (1960). Effects of some chemical weed-killers on a raspberry cane nursery: a progress report. Proc 5th Brit Weed Control Conf, 351-6.

Research report

CHEMICAL POST-HARVEST DESICCATION OF STRAWBERRIES

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Summary: Increased yields of fruit sometimes follow the post-harvest removal of strawberry foliage by cutting or burning in the previous year. Various chemical desiccants were sprayed on the foliage to see if similar yield increases could be obtained through this method. Those materials which achieved substantial destruction of the leaves also caused a reduction in yield in the following season, although in some cases there was no visible decrease in plant vigour. The results presented suggest that the lower yields were caused by a reduction in the number of crowns per plant rather than by any direct inhibition of flower initiation.

INTRODUCTION

Increased fruit yields are known to occur as a result of the post-harvest removal of the foliage of strawberries by cutting or burning (Wilson and Rogers, 1954; Guttridge et al 1961). In the varieties Talisman and Redgauntlet this has been shown to be due to an increase in the number of fruit trusses formed per plant. Various types of mechanical cutter have been successfully used for defoliation on large acreages, but expensive hand work is still required on smaller areas. A trial was therefore designed to see whether chemical desiccation of the green leaves would equally well lead to an increase in the number of flower trusses, and a consequent increase in yield, without damage to the crowns of the plants.

Defoliant chemicals which rely on leaf abcission for their effect would be of little use for this purpose since strawberry petioles do not form an abcission layer, and therefore only chemicals capable of desiccating green leaves were used in this trial. It is not know how much reduction in leaf area is necessary to achieve an increase in yield, but this is being investigated.

METHODS AND MATERIALS

The experiment was planted on 19-20 April 1960, and the first sprays were applied in August of the following year, after the picking of the first crop. The individual plots were each two rows wide and 24 yd long, with single guard plants at the end of the row. Each plot was divided into two 12 yd sub-plots, planted with either Talisman or Redgauntlet. The following nine treatments were applied, each to three replicates arranged in randomized blocks:

1. No defoliation;
2. Mechanical defoliation with small "Hayter" machine;
3. Ammonium sulphate, 1 cwt/ac in 90 gal of spray, + 1 per cent "Shellestol";
4. Dinoseb in oil ("Stemmex D") 1.8 lb/ac in 45 gal of spray;
5. Cresylic acids formulation ("Crestol") 8.0 gal/ac in 45 gal of spray;
6. Sodium monochloracetate 20 lb/ac in 45 gal of spray;

7. PCP 9.6 lb/ac in 45 gal of spray;
8. Diquat at 1.0 lb/ac in 45 gal of spray, + 0.5 per cent "Lissapol";
9. Diquat at 2.0 lb/ac in 45 gal of spray, + 0.5 per cent "Lissapol";

The chemicals were applied on 12 August and the mechanical defoliation was done two days later. Records were made of the degree of scorch of the parent plants and runners by the treatments, and of the vigour of regrowth throughout. Six weeks after spraying, the entire experiment was cleared of runners and straw and cleaned by hand hoeing. After growth had ceased in December 1961, approximately 20 crowns per treatment taken at random from each variety were dissected. The inflorescences present were recorded and expressed as a percentage of the number of crowns per sample.

In June 1962 the emerged inflorescences were counted on 30 plants per treatment, and later the yield of both sound and damaged fruit was recorded.

EXPERIMENTAL RESULTS

Observations on foliage. The plants which were cut mechanically each produced a flush of about 15 new leaves within three weeks of treatment, whereas the uncut plants made little new growth during this period. The effects of the chemical treatments on the old leaves and on regrowth are summarized in Table I, which shows that the best kill of old leaves was obtained with sodium monochloracetate and that the most satisfactory regrowth followed the use of

TABLE I. DEGREE OF LEAF KILL AND PERCENTAGE PLANT CASUALTIES

Treatment	Estimated per cent leaf area killed after one week	Regrowth in 3 weeks (new leaves per plant)	Per cent of plants dead one year after spraying	
			Talisman	Redgauntlet
1. No defoliation	0	-	0	1.4
2. Mechanical defoliation	100	15+	0.7	0.7
3. Ammonium sulphate	0	-	0.7	2.1
4. Dinoseb in oil	50	10-12	2.1	5.6
5. Cresylic acids	0	-	0	4.2
6. Sodium monochloracetate	90	8-10	0.7	12.6
7. PCP	65	6	0.7	6.9
8. Diquat 1 lb/ac	40	6-8	1.4	22.9
9. Diquat 2 lb/ac	80	6	6.3	21.5

dinoseb. The plants treated with diquat failed to recover, and either died or remained severely stunted until the 1962 picking season. None of the other chemical treatments caused permanent visible injury. The regrowth of the plants sprayed with PCP remained yellow and chlorotic for two months but subsequent growth appeared to be normal.

Effect on flowering. The figures for flower truss initiation in Table II are based on the mean numbers of inflorescences initiated per crown as counted in December. None of the chemicals had a direct inhibitory effect on flower initiation and there are indications that ammonium sulphate, cresylic acids and PCP may have promoted flower initiation. The apparent flower promoting effect of diquat on Talisman is a special case, however, which resulted from severe growth retardation causing summer-initiated inflorescences to be retained in the bud.

In June 1962 the number of inflorescences per plant was recorded, and it was apparent that dinoseb, sodium monochloracetate, PCP and diquat had reduced the number of flower trusses, particularly in Redgauntlet. The mechanically defoliated plants produced slightly more inflorescences than the intact controls.

Effect on yield. The yield data show that the use of dinoseb, sodium monochloracetate, PCP and diquat significantly reduced the cropping of the plants. Cresylic acids and ammonium sulphate had no effect on yield. Mechanical defoliation increased yield in both varieties, but the difference was significant in Talisman only.

TABLE II. PERCENTAGE INFLORESCENCE INITIATION, NUMBER OF EMERGED INFLORESCENCES PER PLANT, AND TOTAL FRUIT YIELDS (SOUND AND DAMAGED FRUIT). T = TALISMAN, R = REDGAUNTLET.

Treatment	Per cent inflorescence initiation* (Dec. 1961)		No. of emerged inflorescences per plant+ (June 1962)		Total yield of fruit in cwt/ac (1962)	
	T	R	T	R	T	R
1. Control (intact)	105	145	19.6	14.6	140	156
2. Mechanical defoliation	122	125	21.3	15.9	157	167
3. Ammonium sulphate	121	170	18.7	14.6	138	154
4. Dinoseb + oil	118	147	16.9	11.5	117	108
5. Cresylic acids	100	170	16.6	15.2	133	148
6. Sodium monochloracetate	119	159	15.5	7.0	100	58
7. PCP	122	170	13.8	8.5	108	85
8. Diquat (low rate)	100	144	8.4	4.6	56	22
9. Diquat (high rate)	132	115	3.9	2.9	22	22
Significant difference ($P = 0.05$)					13	23

* 100 is equivalent to one inflorescence per crown bud.
\+ mean of 30 plants per treatment.

DISCUSSION

Plant habit played an important part in the degree of damage to the crowns. Talisman with a continuous canopy of leaves suffered less crown damage than Redgauntlet with a more open growth habit, which enables the spray to reach the crowns easily. At the rates used, diquat caused less foliage desiccation than dinoseb, sodium monochloracetate, or PCP, yet considerable permanent damage to the crowns occurred in both varieties. This suggests that desiccants with any systemic action would be unsuitable for post-harvest defoliation of strawberry plants.

During the autumn of 1962 satisfactory flower initiation took place in the intact plants, and therefore it was impossible to estimate the degree to which the chemicals could replace mowing in stimulating flower initiation.

Counts of the numbers of trusses reaching flowering in June, however, show that the chemical treatments which gave a 40 per cent or greater reduction in leaf area also reduced the number of trusses. Presumably this was due to a decrease in the number of crowns produced, since the dissections of individual crowns revealed no inhibition of flowering. Mechanical defoliation, on the other hand, slightly increased the number of inflorescences produced.

None of the chemicals, at the rates used in this trial, proved to be a suitable alternative to mechanical removal of the leaves. However, in a year in which the differences between mechanically defoliated and intact plants were greater than they were in the year 1961-62 chemically desiccated plants might outyield intact plants. Nevertheless, chemical desiccation would not be a practical alternative to mechanical defoliation unless a chemical treatment could be devised that avoided crown damage.

Acknowledgments

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REFERENCES

GUTTRIDGE, C.G., ANDERSON, M.M., THOMPSON, P.A. and WOOD, C.A. (1961). Post-harvest defoliation of strawberry plantations: J hort Sci 36 93-101.

WILSON, D.J. and ROGERS, W.S. (1954). Trials of burning and mowing strawberry plants after cropping. J. hort Sci 29 21-6.

Presentation by Dr. G. W. Ivens of preceding six papers.

There are as many papers on strawberries at this conference as at the previous five conferences put together and it may be significant that this coincides with the development of interest in the uses of simazine on this crop. With previous materials, such as 2,4-DES, chlorpropham and dinoseb, a number of applications had to be made during the year and, even so, the treatments were rarely effective enough to eliminate the need for handweeding. In Goodway and Heath's paper it is shown that, even with the most effective combination of the older chemical (chlorpropham in November and 2,4-DES both before and after harvest), three or four mechanical cultivations were needed annually to keep the plots up to a reasonably clean standard. An interesting point in this paper is that chlorpropham has caused no injury to Talisman at doses up to 2 lb/ac under the very mild winter conditions of Cornwall which are considered those most likely to favour injury.

Three of the other papers are primarily concerned with evaluating simazine. Holloway shows this chemical to be promising in runner bed of three varieties when applied in early June. A dose of 0.5 lb/ac gave good control of weeds through the runnering period while 1 lb/ac tended to increase rather than decrease the number of runner produced. In the paper by Ivens no injury was recorded on Cambridge Favourite from a dose of 1 lb/ac applied after harvest or in autumn, but in spring there was more chance of causing damage, especially when spring treatment followed an autumn application to newly planted runners. Simazine was considerably more effective on weeds than 2,4-DES but, in a mild wet winter was no more effective than chlorpropham on a weed stand consisting largely of Poa annua, Stellaria and Cerastium spp. This paper also presents observations on varietal differences in susceptibility to simazine and preliminary results with possible alternatives to simazine for use at times when this chemical is dangerous. CIBA 1983 appears to be one of the most promising of these. Neburon and "Dacthal" are reported unpromising in Stephens' paper as neither gave adequate control of weeds, but two applications of simazine at a dose of 1 lb/ac in September and February gave very good weed control so that little hand hoeing was required. Treatment at both dates caused a 15-20 per cent yield reduction which other work suggests is likely to be the result of the February treatment.

The work reported by Robinson takes weed control in strawberries a stage further. By using a schedule of herbicide treatments consisting mainly of 2,4-DES in spring and simazine in summer or early winter he has shown that the crop can be grown successfully for several years without cultivation. Control of excess runners in this trial was achieved by directed spraying with diquat or paraquat. Under non-cultivation conditions the soil became crusted and there was a tendency for surface wash to occur but this could be presented by mulching with farm-yard manure or straw. In the final year of Robinson's trial very few weeds germinated so that little herbicide treatment was required and the average annual cost of the herbicide treatments was less than the cost of the alternative schedule of cultivations.

The paper by Stephens and Mason is not directly concerned with control of weeds but suggests another possible use for herbicides in the management of the crop, namely the use of a foliage desiccant after harvest to stimulate flower truss initiation. A range of chemicals was tested including dinoseb, PCP, sodium monochloroacetate and diquat but none has so far proved a satisfactory alternative to mechanical removal of leaves.

The principal point brought out by this group of papers is that the weed problem in established strawberries is much nearer solution than it was at the time of the last Weed Control Conference but that a safe treatment for use in spring or on newly planted beds has still to be developed. Where strawberries are grown under systems of cropping for several years herbicides can now be employed to replace much of the hand labour previously required for hoeing. With the newer system of cropping maiden plants for one year only the herbicide position is, as yet, less satisfactory.

Discussion on preceding eight papers

Mr. Caseley Mr. Holloway emphasized the importance of root distribution and protection by the soil. At Long Ashton plants have been grown in sand culture where these factors have been removed. In our experiments we applied atrazine at 6 lb/ac to apple (M II) and quince A rootstocks and symptoms occurred in 2 weeks on the quince and in 5 weeks on the M II. With simazine at the same dose quince was injured but there was no effect on apple. Different varieties of blackcurrant respond differently to the triazines and soil protection seems to be an important factor with this crop. In sand culture trials monuron and diuron caused more injury to the majority of fruit crops than equivalent doses of simazine.

Dr. K. Holly Is there any information available as to whether all portions of the root systems of the fruit plants described are equally effective as absorbing organs? In particular, when new roots grow into a soil zone not previously exploited such as the surface layer on cessation of cultivation do they attain immediately their full capability for taking up materials from that soil?

Mr. Holloway We do not have much information on how soon newly formed roots can take up herbicides or even nutrients, but the new roots formed in surface layers of soil develop normal root hairs. We have a new root laboratory at East Malling, with provision for applying treatments to the roots, and hope eventually to obtain this type of information.

Mr. F. A. Roach Our experience, both from experiments and commercial use, has shown the value of leaving the soil undisturbed after applying simazine. If small patches of weed become established later, paraquat can be very useful applied as a spot treatment. In the very wet autumn of 1960 simazine applied in strawberries was relatively ineffective and possibly this was due to it being washed down below the level of weed seed germination.

Miss H. M. Hughes What were the varieties of gooseberry on which Dr. Robinson worked? Blackcurrant varieties shed the outer bud scales at different times depending on their earliness in starting growth. We have also used paraquat on raspberries at Efford but have had damage.

Dr. D. W. Robinson We have done trials on quite a number of gooseberry varieties: Amber, Careless, Crown Bob, Leveller, Lancashire Lad, White Smith, Whinham's Industry, and White Lion. At this time of the year all these eight varieties have buds tightly enclosed in bud scales. They must be examined before spraying though and spraying should not be carried out if there are any green tips showing. Blackcurrant varieties do differ in the closeness of the bud but with all of them there is some chlorophyll showing during the winter. Here again we have tested paraquat on a number of varieties and have found little difference, damage occurring at doses down to 0.5 lb/ac. With raspberries in Northern Ireland we only get injury following the use of excessive doses of 4 lb/ac. Even with this dose applied in March or April there is only temporary chlorosis.

Dr. G. W. Ivens We have sprayed blackcurrant cuttings growing in pots in the dormant season. We used diquat and paraquat and even when the buds had no green showing they were very badly damaged by 1 lb/ac.

Dr. S. H. Crowdy I would like to ask Dr. Robinson if there was a difference between the symptoms of paraquat and diquat on strawberries after these chemicals had been used to control runners.

Dr. D. W. Robinson We have found no real difference between diquat and paraquat as far as actual appearance of the symptoms is concerned. It is very difficult finding symptoms with diquat and even with paraquat we had to look hard for them.

Research report

A PROGRESS REPORT ON TRIALS WITH SOIL-APPLIED HERBICIDES IN SOFT FRUIT CROPS

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Summary: Blackcurrants, gooseberries and raspberries showed greater tolerance to simazine than to atrazine and diuron. In raspberries, repeated annual application of simazine at 2 and 4 lb/ac for five years had no adverse effect; atrazine and diuron applied in March at 4 lb/ac for three and two years respectively caused slight temporary leaf injury but crop yield was not affected. Repeated annual application of simazine and atrazine at 2 and 4 lb/ac for three years caused no injury to blackcurrants. Gooseberries were unharmed by four applications of simazine and atrazine at 2 lb/ac during a three year period. It is concluded that, under conditions at Loughgall, simazine is the most suitable of the three herbicides for blackcurrants, gooseberries and raspberries, but atrazine may be preferable where the soil is dry or where weed seedlings are already established. Diuron may be useful occasionally in gooseberries and raspberries where susceptible weeds are prevalent.

INTRODUCTION

At the 5th British Weed Control Conference a report was given of trials at Loughgall with soil-applied herbicides in soft fruits (Robinson, 1960). It was concluded that simazine at 2 lb/ac was safe in established raspberries and that this treatment was also promising in gooseberries and blackcurrants. Atrazine also showed promise for weed control in these crops. This work was continued and expanded in 1961 and 1962 and trials were started with other soil-applied herbicides, particularly diuron.

METHODS AND MATERIALS

The same methods were adopted as in 1959 and 1960 (Robinson, 1960) except where stated otherwise. A logarithmic sprayer, made by modifying an Oxford Precision sprayer as described by Sweetman (1959), was used in Trials A and B. The other trials were laid out in randomised blocks. The unit plot for raspberries was a row 24 ft long with rows 6 ft apart. In 1959, the spray application in gooseberries (Trial F) was confined to an area of 1 sq yd at the base of each bush but in 1960 and 1961 the entire surface area (36 sq yd per plot) was treated.

Trial A

The object of this trial was to compare the tolerance of three soft fruit crops to simazine, atrazine and diuron. On 3 March 1961, one-year-old plants of blackcurrants (variety Baldwin), gooseberries (Careless) and raspberries (Lloyd George) and unrooted blackcurrant cuttings (Baldwin) were planted in three plots each 7 yd long. Each crop was planted in a single row, running along the length of the plot, and spaced 1 ft from adjacent rows; the plants and cuttings were set at 1 ft spacings in the row. The crops were planted and the ground firmed in accordance with normal practice, the lowest roots of the young plants being about 6 in deep. The blackcurrant cuttings were about 1 ft long and were inserted 9 in deep. On 8 March 1961, simazine, atrazine and diuron were applied to single plots with the logarithmic sprayer. All herbicides were applied at a peak dose of 4.8 lb/ac. On 19 March 1962, the herbicides were reapplied on the same plots at a peak dose of 9.6 lb/ac.

Trial B

This trial was conducted to obtain information on the response of young fruit crops when their root system was in contact with simazine, atrazine and diuron incorporated in the soil. By this means it was hoped to gain further information on the significance of herbicide retention near the soil surface and to obtain an indication of possible consequences of cultivation and other factors which would tend to move the herbicides downwards.

Materials, plot size and date of spraying were the same as in Trial A in 1961, but the treatments were applied and the ground rotary-hoed to a depth of 6 in before planting. Three runs were made with the rotary hoe over each plot from the lower concentration end, all parts of the machine in contact with the soil being cleaned after each run to avoid contamination. Three rotavations were considered sufficient to mix the herbicides thoroughly with the top 6 in of soil (Anon. 1961). The rotary hoe was well fitted with shields and there was little displacement of soil along the length of the plot.

On the same day as spraying and rotary hoeing, young plants of blackcurrants, gooseberries and raspberries and unrooted blackcurrant cuttings were planted using the same varieties, age of plants and planting distances as in Trial A.

RESULTS

The effect of the treatments on crop growth is shown in Tables I and II (Trial A) and in Table III (Trial B).

TABLE I SUSCEPTIBILITY OF RECENTLY PLANTED FRUIT CROPS TO SIMAZINE, ATRAZINE, AND DIURON AT DOSES RANGING FROM 0.5 TO 4.8 LB/AC (TRIAL A).

Herbicide applied 3. 3. 61.	Effect on crops - 26.6.61 (doses in lb/ac)	
	Blackcurrants (cuttings)	Blackcurrants (1-year-old)
Simazine	None	None
Atrazine	Checked by 4.5 - 4.8 lb	Checked by 4.5 - 4.8 lb
Diuron	Checked by 3.0 - 4.8 lb	Checked by 3.0 - 4.8 lb
	Gooseberries (1-year-old)	Raspberries (1-year-old)
Simazine	None	None
Atrazine	None	Checked by 2.8 - 4.8 lb
Diuron	None	None

TABLE II SUSCEPTIBILITY OF FRUIT CROPS TO SIMAZINE, ATRAZINE AND DIURON APPLIED AT DOSES RANGING FROM 1.0 - 9.6 LB/AC 12 MONTHS AFTER PLANTING (TRIAL A).

Herbicide applied 19.3.62	Effect on crops - 20.6.62 (doses in lb/ac)			
	Blackcurrants (1-year-old)	Blackcurrants (2-year-old)	Gooseberries (2-year-old)	Raspberries (2-year-old)
Simazine	Slight stunting and leaf necrosis, 8.5 - 9.6 lb	Slight stunting and leaf necrosis, 8-5 - 9.6 lb	None	Slight stunting and leaf necrosis, 5.6 - 9.6 lb
Atrazine	Killed by 7.5 - 9.6 lb Stunting and leaf necrosis, 5.6 - 7.5 lb	Stunting and leaf necrosis, 5.6 - 9.6 lb	None	Killed by 7.0 - 9.6 lb Severe stunting and leaf necrosis, 4.0 - 7.0 lb. Slight leaf necrosis, 3.0 - 4.0 lb
Diuron	Killed or severely stunted with leaf necrosis 3.6 - 9.6 lb	Killed or severely stunted with leaf necrosis, 3.6 - 9.6 lb	None	Killed by 8.4 - 9.6 lb Severe stunting and leaf necrosis, 5.6 - 8.4 lb Slight leaf necrosis, 3.6 - 5.6 lb

TABLE III SUSCEPTIBILITY OF FRUIT CROPS TO PRE-PLANTING APPLICATION OF SIMAZINE, ATRAZINE AND DIURON AT DOSES RANGING FROM 0.5 TO 4.8 LB/AC INCORPORATED IN TOP 6 IN OF SOIL (TRIAL B)

Herbicide applied 3.3.61	Effect on crops - 26.6.61 (doses in lb/ac)	
	Blackcurrants (cuttings)	Blackcurrants (1-year-old)
Simazine	Slightly checked by 4.4 - 4.8 lb	Slightly checked by 4.4 - 4.8 lb
Atrazine	Checked by 2.8 - 4.8 lb	Checked by 2.8 - 4.8 lb
Diuron	Checked by 1.8 - 4.8 lb	Checked by 1.8 - 4.8 lb
	Gooseberries (1-year-old)	Raspberries (1-year-old)
Simazine	None	None
Atrazine	Checked by 4.4 - 4.8 lb	Checked by 1.8 - 4.8 lb
Diuron	Checked by 4.4 - 4.8 lb	Checked by 4.4 - 4.8 lb

Long-term cropping trials

Preliminary results have already been presented of the long-term trials started in 1958 and 1959 to compare the effect of simazine and other soil-applied herbicides in fruiting plantations of raspberries, blackcurrants and gooseberries (6). As the main object of these trials (C, D, E, F and G) was to obtain information on the effect of the herbicides on the crop plants, weeds were suppressed on all plots by cultivation whenever necessary. Control plots were hoed four to six times each year and sprayed plots were hoed lightly where necessary on the same dates although they were often almost weed-free.

Raspberries

Trial C

In the first of these trials on raspberries, simazine at 1, 2 and 4 lb/ac and 2,4-DES at 6 lb/ac were applied to the same plots each spring from 1958 to 1962. Throughout the five year period there was no significant difference ($P = 0.05$) in crop yield (Table IV) or cane vigour.

TABLE IV EFFECT OF ANNUAL APPLICATION OF SIMAZINE AND 2,4-DES ON YIELD OF RASPBERRIES (FOUR REPLICATES)

Treatment lb/ac 16.6.58 25.5.59 26.4.60 17.3.61 14.3.62	Yield - cwt/ac					
	1958	1959	1960	1961	1962	Total 1958-1962
Simazine 1	11.9	112.3	44.8	37.8	76.1	282.9
2	12.2	118.5	51.0	33.2	78.6	293.5
4	12.7	103.7	50.5	37.8	77.2	281.9
2,4-DES 6	12.2	106.6	45.6	39.1	84.0	287.5
Hoed	11.9	113.1	47.5	32.7	75.6	280.8

Trial D

In another trial on raspberries no crop reduction was caused by repeated applications in March of simazine at 4 lb/ac for three years or of diuron at 4 lb/ac for two years. Slight injury occurred each season on young suckers in atrazine- and diuron-treated plots but the damage was temporary and differences in cane vigour between treatments at the end of each year were not significant.

Trial E.

The object of this trial was to determine if the absence of injury on plots sprayed with simazine in the previous trials was due to the fact that treatments had been confined to a band only 3 ft wide containing the cane row. In this trial, simazine was applied annually at 4 lb/ac to bands 1.5, 3 and

6 ft wide and at 16 and 8 lb/ac to bands 1.5 and 3 ft wide respectively with the cane row at the centre (Robinson 1960). Dates of spraying and crop yield are shown in Table V. Throughout the four year period, none of the treatments had any significant effect on the crop.

TABLE V EFFECT ON RASPBERRIES OF ANNUAL APPLICATION OF SIMAZINE APPLIED TO DIFFERENT BAND WIDTHS (FOUR REPLICATES)

Total width of band sprayed ft (cane row) (in centre)	Simazine-lb 28.4.59 20.4.60 24.3.61 14.3.62		Yield - cwt/ac				
	Per acre of ground sprayed	Per acre of crop	1959	1960	1961	1962	Total 1959 - 1962
0	-	-	99.1	46.4	31.6	89.6	266.7
1.5	4	1	102.6	44.5	34.3	81.5	262.9
3.0	4	2	101.0	44.3	27.3	79.9	252.5
6.0	4	4	101.2	45.4	30.8	85.9	263.3
1.5	16	4	103.7	48.9	32.9	86.9	272.4
3.0	8	4	98.0	45.6	27.5	93.7	264.8

Gooseberries

Trial F

The long-term trial started in 1959 (Robinson 1960) to test the effect of repeated applications of simazine and atrazine on gooseberries, was continued. Both herbicides were applied on 30 September at 2 lb/ac and were re-applied to the same plots whenever their effect seemed to have disappeared, as judged by the development of sensitive weeds such as Senecio vulgaris and Stellaria media. The effect of both herbicides seemed to disappear at approximately the same time and treatments were reapplied in July 1960, April 1961 and March 1962. Since the start of the experiment until the present time neither herbicide has had any adverse effect on crop yield or bush vigour (Table VI).

TABLE VI EFFECT OF REPEATED APPLICATIONS OF SIMAZINE AND ATRAZINE ON YIELD AND GROWTH OF GOOSEBERRIES (FOUR REPLICATES)

Treatment lb/ac 30.9.59 30.7.60 30.4.61 19.3.62	Yield cwt/lb			Circumference of bush ft September		
	1960	1961	1962	1960	1961	1962
Simazine 2	92.4	66.6	95.7	15.1	16.6	17.6
Atrazine 2	90.4	61.9	93.0	15.2	16.7	17.2
Hoed	87.2	57.4	91.8	14.6	15.7	16.6

Blackcurrants

Trial G

A preliminary account has already been given of the long-term trial comparing the effect of repeated applications of simazine and atrazine on blackcurrants (Robinson 1960). Treatments were first applied on 27 July 1959 and were repeated on the same plots at approximately yearly intervals. During the three-year period, crop yield was, in general, better on the sprayed plots than on the cultivated control, although the differences were not significant (P=0.05) (Table VII). A greater amount of one-year-old wood was also recorded each year on sprayed plots and compared with the cultivated control the increase was significant in 1960 where atrazine was used at 4 lb/ac.

TABLE VII EFFECT OF REPEATED APPLICATIONS OF SIMAZINE AND ATRAZINE ON YIELD AND VIGOUR OF BLACKCURRANTS (EIGHT REPLICATES)

Treatment lb/ac 27.7.59 1.9.60 1.8.61 1.9.62	Crop yield cwt/ac			One year old wood ft/bush		
	1960	1961	1962	1960	1961	1962
Simazine 2	86.7	48.6	115.3	65.8	142.7	151.7
" 4	85.6	47.5	115.8	75.1	143.8	154.7
Atrazine 2	91.5	44.8	105.3	75.4	150.0	139.4
" 4	79.9	47.8	101.5	76.4	142.7	153.8
Simazine 1 +Atrazine 1	78.3	49.1	100.4	73.9	152.3	161.9
Hoed	78.8	47.3	96.6	59.2	133.0	126.8

Significant difference (P = 0.05) 16.4 N.S. N.S.

DISCUSSION

The results of the trials reported in this paper give further confirmation of the good tolerance shown by gooseberries, blackcurrants and raspberries to simazine. In Trials, C, D, E, F and G, annual application of simazine at 2 or 4 lb/ac for three to five years caused no yield reduction in any crop. In Trial A, although application was made only five days after planting, no damage occurred following a dose several times greater than that known to be necessary for the control of many common weed species at the germinating stage (Woodford 1960). Moreover, in 1961, the blackcurrants and gooseberries were younger than plants normally used for establishing commercial plantations and would therefore be expected to be more susceptible to injury.

The data in Tables I, II and III show that atrazine and diuron are more phytotoxic than simazine to blackcurrants and raspberries, and this result with raspberries is confirmed in Trial D. Compared with diuron, atrazine caused more damage to raspberries in Trials A and B, but was less injurious to blackcurrants.

Although the value of atrazine and diuron to the fruitgrower is overshadowed by the outstanding properties of simazine, the results of the above trials, along with others conducted on uncropped ground, suggest that both these herbicides may be more suitable than simazine in certain circumstances. In Trial A, atrazine caused no damage to gooseberries at a dose of 9.6 lb/ac but damaged blackcurrants and raspberries at 5.6 and 3 lb/ac respectively. Good control of germinating weeds, however, is often obtained with a dose of 0.75 to 1.5 lb/ac. The results of Trials A and B along with those from Trials C, D, F and G suggest that under conditions similar to those at Loughgall, the margin of safety is sufficient to permit its use on established crops, provided the treatments can be applied accurately.

In a number of trials atrazine has been found to be slightly more effective than simazine against some common weed species. The results of one trial, in which these herbicides were compared with diuron and linuron using the logarithmic sprayer, is summarised in Table V111.

TABLE VIII EFFECT OF FOUR SOIL-APPLIED HERBICIDES ON WEEDS IN THE SEEDLING OR YOUNG PLANT STAGE. SPRAYED 11.9.61 ASSESSED 10.11.61

Herbicide	Dose* in lb/ac giving complete control of				
	Senecio vulgaris	Veronica persica	Cardamine hirsuta	Poa annua	Ranunculus repens
	3 in.high+	3 in.high; stems 2-8 in.long	2 in.wide	(seedling)	2 in. wide
Simazine	1.0	<0.5	1.2	0.6	2.4
Atrazine	0.7	<0.5	0.9	<0.5	1.6
Diuron	3.0	>4.0	<0.5	<0.5	0.5
Linuron	1.4	1.8	0.5	0.6	0.8

* average of three replicates

\+ stage of weed on date of spraying

Little difference between simazine and atrazine was observed in long-term control of weeds. Because of its greater activity it seems that atrazine might be used at slightly lower doses than simazine (for example, 0.75 - 1.5 instead of 1 - 2 lb/ac) resulting in an economic advantage. The use of lower doses would also decrease the risk of crop injury with atrazine. In addition, this herbicide being more soluble than simazine (70 ppm.and 3.5 ppm.respectively in water at 25°C) gives better results under dry soil conditions or where weeds are already established (Anon 1959). For the same reason, it penetrates more deeply into the soil and has been found more useful than simazine against some perennial weeds (Pecheur et al 1961). Atrazine may also be preferable in plantations where a permanent mulch is used in conjunction with a system of non-cultivation as it would be expected to wash through the mulch more readily than simazine.

Atrazine is known to be more liable than simazine to damage crops by foliar absorption (Anon 1959). While directed applications with this herbicide would seem advisable during the period of active growth, small-scale trials have not revealed any injury following overhead application at doses of 1 and 2 lb/ac on gooseberries, blackcurrants and raspberries after growth had stopped in the autumn.

The advantage of using a rotation of herbicides is well known for preventing the increase of tolerant species and reducing the risk of build-up of toxic residues. Results obtained with diuron in 1961 and 1962 suggest that under conditions at Loughgall this herbicide may be suitable at 2 to 3 lb/ac as an occasional alternative to simazine in gooseberries and also possibly in raspberries. Gooseberries, in particular, appear to tolerate herbicidal doses of diuron and this was confirmed in a trial in which established bushes showed no damage following the use of diuron at doses up to 9.6 lb/ac. Raspberries appear to be more susceptible, but there has been no evidence of injury to established plants following the use of doses less than 3.6 lb/ac.

The effectiveness of diuron depends to a large extent on the weed species present. Where tolerant species such as Senecio vulgaris and Veronica persica (Table VIII) are common, results are likely to be disappointing. However, where the occurrence of these species is negligible, which is frequently the case where simazine has been applied, it seems that occasional treatment with diuron might be used with advantage to prevent simazine- tolerant weeds, such as Ranunculus repens, from becoming prevalent. On the other hand the continued use of diuron is likely to result in a rapid build-up of tolerant weeds as has occurred with monuron (Roberts, 1958).

In 1961 more damage was caused to blackcurrants, gooseberries and raspberries in Trial B where atrazine and diuron were incorporated in the top 6 in. than in Trial A where surface application had been used. Simazine also caused more injury to blackcurrants when incorporated. In Trial A, application was made five days after planting, whereas in Trial B, spraying preceded planting by about five hours. Assuming that the difference in planting time had no marked effect on the results, a comparison of the data obtained in the two trials gives further indication that retention of the herbicides at the soil surface may partly account for the tolerance shown by fruit crops to these relatively insoluble compounds. Although atrazine is more soluble than simazine, and might be expected to penetrate into soil more quickly, incorporation into the top 6 in. increased the degree of injury on all three crops. It appears, therefore, that with this herbicide also, penetration into the soil was slow under the conditions of this trial.

These results suggest that, if a treatment with a low margin of safety has been applied, it would be inadvisable to carry out cultivation, such as rotary hoeing, unless necessary for weed control. It seems likely that cultivation would increase the risk of injury on bush and cane fruits by working the herbicide downwards.

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REFERENCES

ANONYMOUS (1959) Atrazine Information issued by J.R. Geigy S.A.(Basle)

" (1961) Rotavator pictorial February 1961

PECHEUR J and SCHMITLIN, B. (1961) Desherbage des vergers 1[er] Confr Com franc Mauv. Herbes (Columa)

ROBERTS, H.A. (1958) Annual weed control in established asparagus with monuron. Proc 4th British Weed Control Conf 119-122

ROBINSON, D.W. (1960) Experiments with simazine and other herbicides in soft fruit crops. Proc 5th British Weed Control Conf 357-366

SWEETMAN, I.C. (1959) A simple conversion of a standard precision sprayer for logarithmic spraying. Proc 12th New Zealand Weed Control Conf 1959 11 - 16

WOODFORD E.K. (Ed) (1960) Weed Control Handbook. British Weed Control Council Blackwell Scientific Publications. Oxford.

Research Report

EXPERIMENTS WITH 2,6-DICHLOROBENZONTRILE

(DICHLOBENIL) * IN TOP AND SOFT FRUIT

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Summary: Over a period of three years, a series of field experiments was carried out with wettable powder and granular formulations of 2,6-dichlorobenzontrile (dichlobenil) in top and soft fruit. Persistence and phytotoxicity of the chemical were greatly increased by incorporation into the soil by rainfall, overhead irrigation or cultivation after treatment. The majority of perennial weeds were controlled by 4-6 lb/ac of the wettable powder formulation rotavated after spraying;higher doses were required when harrows or discs were used. Granules gave good control of perennial weeds without incorporation when the vegetative growth was sufficiently dense to reduce loss by volatilization. Surface applications at 6 lb/ac to clean soil gave good control of most annual weeds, although persistence was short in the absence of incorporation. Top fruit exhibited remarkable tolerance to dichlobenil, the yield of apples being unaffected by 16 lb/ac incorporated annually for 3 consecutive years. Pears, plums, cherries, gooseberries and blackcurrants were unaffected by 8 lb/ac incorporated. Raspberries appeared to be rather more sensitive and there were two cases of slight crop damage, although yields were not affected.

INTRODUCTION

The biological properties and herbicidal activity of dichlobenil were described by Barnsley (1960) and subsequently by Barnsley and Rosher (1961) and by Massini (1961). Early trials indicated that at rates up to 8 lb/ac active ingredient the chemical gave good control of a wide spectrum of annual and perennial weeds without any reduction in the yields of gooseberries or black-currants, In addition, it was reported that apples, plums and various other 'woody' crops appeared to tolerate upwards of 4 lb/ac.

Owing to its low water-solubility and high vapour-pressure, dichlobenil is a highly volatile compound and its persistence in the soil is greatly influenced by climatic conditions such as rain and temperature. When applied to the soil surface, the wettable powder formulation volatilises and is lost unless carried into the soil by rain or overhead irrigation or incorporated by cultivations, and it was reported by Barnsley that cultivations carried out soon after spraying substantially decreased the rate of loss.

The aim of the field trials described in this paper was to determine the dose of dichlobenil granular and wettable powder formulations needed to obtain long-term weed control without damage to soft and top fruit, both with and without incorporation. The chemical enters mainly through the roots, inhibiting the growth of buds on stolons, rhizomes and tubers, and it will,

*Dichlobenil has been approved by the B.S.I. as the common name for this chemical.

therefore, control many perennial weeds. Control of perennials is one of the main problems in fruit crops and particular attention has been paid to this aspect in the series of field trials presented here.

METHODS AND MATERIALS

The field trials were conducted from 1960 to 1962 at Woodstock Agricultural Research Centre, Sittingbourne, Kent, and on 15 commercial fruit farms situated in Essex, Berkshire, Surrey and Kent. The trials covered a wide range of soil types and the majority of the treatments were applied in the early spring before active growth had started.

All application rates are given in terms of active ingredient per acre. Spray treatments were applied with an Oxford Precision Sprayer in a volume of 100-200 gal/ac of water using a 50 per cent wettable powder. A 2.5 per cent granular formulation was mixed with dry sand before being broadcast by hand to facilitate even distribution. Applications in blackcurrants and gooseberries were made in bands 3 ft wide on either side of the row with two bushes per plot. Treatments to raspberries were applied in a similar manner with the cane row in the centre, the plots being 5 yd long. An area of 4 sq yd was treated round the base of mature top fruit trees and 2 sq yd around young fruit.

Except where indicated to the contrary, incorporation was carried out by means of a rake or Dutch hoe to simulate the action of light harrows. Other treatments were applied to the soil surface and not incorporated. Weed control and crop damage were generally assessed visually by three assessors scoring the plots independently and the results are expressed as means of these estimates.

RESULTS

(i) Control of Weeds

Treatments applied to stands of weeds without incorporation. Dichlobenil granules at 6 and 9 lb/ac gave variable control of perennial weeds. Where the vegetation was sufficiently thick to give a good ground cover, the granules penetrated the foliage and volatilization of the chemical appeared to be reduced by the leaf canopy with the result that control was generally satisfactory. Dense stands of Convolvulus arvensis, one of the most resistant species, and Aegopodium podagraria were well controlled in this manner for a period of about 6 months. Granular applications to grassy swards, including Agropyron and Agrostis spp., did not give consistently good control, possibly because of the absence of a sufficiently dense leaf canopy. However, a mixed stand of perennial weeds, in which grasses predominated, was satisfactorily controlled beneath mature plum trees, presumably because the dense canopy of the trees afforded sufficient shade to permit the establishment of a blanket of vapour.

The wettable powder applied to established weeds at doses up to 10 lb/ac did not give satisfactory control of either annual or perennial species as the chemical was retained on the foliage where it could not be absorbed. Apparently for the same reason, poor results were obtained where the spray was applied to a partially rotted straw mulch, although there were no weeds present at the time of application.

Dichlobenil wettable powder at 9 lb plus amino-triazole 2 lb and ammonium thiocyanate 1.85 lb/ac applied to a mixed stand of perennial weeds gave good control for a period of 6 weeks, but after 3 months Agropyron repens and Urtica dioica had started to regenerate.. Application of the granular formulation at 6 lb/ac followed by paraquat at 2 lb/ac gave better results so that 3 months later top growth of Agropyron repens and other perennial weeds were dead and there was no sign of regeneration.

Treatments applied to clean soil without incorporation. In the absence of mechanical incorporation, weed control was variable, depending upon the temperature and rainfall following application. In the early spring, surface applications did not give satisfactory control of perennials although there was some check to growth at about 8 lb/ac, especially when rain occurred shortly after treatment. In the majority of trials, many annual species were well controlled, however, and the susceptibility of a number of species is summarised in Table I. At equivalent doses the granular formulation was slightly more effective than the wettable powder.

TABLE I. DOSES, AS SURFACE APPLICATIONS, REQUIRED TO CONTROL ANNUAL WEEDS.

Dose of dichlobenil	Species of annual weeds controlled	Approx duration of weed control
2 lb/ac	Chrysanthemum segetum, Anthemis cotula, Matricaria inodora, Alopecurus myosuroides.	2 months
4 lb/ac	Chenopodium album, Capsella bursa-pastoris, Veronica chamaedrys Anagallis arvensis, Urtica urens Senecio vulgaria, Atriplex patula, Polygonum persicaria	2 months
6 lb/ac	Galium aparine, Stellaria media, Ranunculus arvensis, Lithospermum arvense, Galeopsis tetrahit, Polygonum aviculare.	3 months
8 lb/ac	Most other species with the possible exception of Fumaria officinalis.	4 months

Treatments were applied to an experiment in the autumn and in the spring. The weeds were a mixed stand of annuals and the plots were irrigated immediately after spraying to carry the chemical into the soil. It is evident from the results shown in Table II that treatment in spring was more effective than autumn.

TABLE II A COMPARISON OF ANNUAL WEED CONTROL FROM AUTUMN AND SPRING APPLICATIONS OF DICHLOBENIL

Dose of dichlobenil	Time of Application	Estimated per cent reduction of weed cover	Mean
1 lb/ac	Autumn	25	63
2 lb/ac	"	69	
4 lb a/c	"	95	
1 lb/ac	Spring	46	82
2 lb/ac	"	100	
4 lb/ac	"	99	

<u>The effect of incorporation</u>. In the absence of adequate rainfall soon after treatment, application to the soil surface gave rather variable control of annual weeds and was unsatisfactory against perennials. To obtain more consistent results it was found necessary to incorporate the chemical into the soil. In the majority of the trials the plots were raked by hand to simulate the action of a harrow. A dose of 3 lb/ac raked into the top inch of soil within 2-3 hours of treatment generally gave good control of most annual weeds. Perennials required larger amounts. At 6 and 9 lb/ac incorporated, spray treatments severely checked the growth of <u>Agropyron repens</u>, <u>Agrostis spp</u>. and <u>Cirsium arvense</u> but <u>Convolvulus arvensis</u>, <u>Rumex spp</u>. and <u>Ranunculus repens</u> proved rather more resistant.

In order to study the effects of various methods of mechanical incorporation on perennial weeds, two randomised block experiments were carried out on cereal stubbles containing a weed flora dominated by <u>Agropyron repens</u> and <u>Agrostis gigantea</u>. Treatments were applied in the autumn of 1961 and the results assessed 4 months later. The results are shown in Table III.

TABLE III COMPARISON OF DIFFERENT METHODS OF INCORPORATION OF DICHLOBENIL ON CONTROL OF <u>AGROPYRON REPENS</u> AND <u>AGROSTIS GIGANTEA</u> .

Treatment	Estimated per cent control
Wettable powder formulation 5 lb/ac	
Rotavated to a depth of 2-3 in.	80
Ploughed to a depth of 5 in.	42
Disced once	30
Harrowed once	20
Dalapon 10.2 lb/ac ploughed after 3 weeks	85
Control 1 - untreated	0
Control 2 - rotavated to a depth of 3 in.	25

Owing to compaction of the soil in the stubbles after harvest, penetration with the discs and harrows was poor, incorporation of the chemical was thus inadequate and weed control was poor. Incorporation by rotary cultivation, however, gave effective control of perennial grasses and this finding was confirmed in other trials. Whilst rotavation undoubtedly gave the most consistent results under all soil conditions, it was found that good control of perennials could be obtained with harrows or discs provided the topsoil was in a loose, friable state so that the chemical could be thoroughly incorporated to a depth of approximately one inch. However the dose required to achieve similar effects to rotary cultivation was slightly higher where harrows or discs were used.

In 1960 a non-replicated experiment in blackcurrants was started to compare the difference between surface and incorporated applications of dichlobenil for the control of annual weeds, incorporation being achieved by rotary cultivation. The treatments were applied in the spring and repeated annually for 3 consecutive years. Estimates of the per cent reduction in weed cover each year are given in Table lV, and show that incorporation of the wettable powder by rotavating the soil immediately after spraying improved weed control by 27 per cent.

TABLE IV EFFECTS OF DICHLOBENIL ON ANNUAL WEEDS IN BLACKCURRANTS IN THREE SUCCESSIVE YEARS.

Dose of dichlobenil	Cultural Treatment	Estimated per cent reduction in weed cover			
		1960	1961	1962	Mean
2 lb/ac spray	On surface	42	15	-	
4 lb/ac "		83	25	45	46
8 lb/ac "		89	60	85	
2 lb/ac spray	Incorporated	61	25	74	
4 lb/ac "		81	70	90	73
8 lb/ac "		92	80	100	
2 lb/ac granules	On surface	73	25	30	
4 lb/ac "		85	30	65	49
8 lb/ac "		94	55	90	

(ii) Effects on crops.

Apples. In the Spring of 1960, an experiment was started to determine the effect upon yield of dwarf pyramid apples of different doses of dichlobenil wettable powder, the treatment being repeated annually. After spraying, the plots were irrigated to ensure thorough incorporation. The plots were treated with doses of 0, 4, 8 and 16 lb/ac applied round the base of the trees, and contained the varieties Sunset, Wanderer, Rival, King Edward VII, Charles Ross, Warners King, John Standish and Jonathon. There were large differences in yield between the various varieties, but none of the treatments had a statistically significant effect on yield, nor was there any effect upon the time of fruit maturation.

TABLE V EFFECT OF DICHLOBENIL ON DWARF PYRAMID APPLIES

Dose of dichlobenil	Total weight of crops as per cent of controls		Numbers of apples per cent of controls	
	1960	1961	1960	1961
4 lb/ac	129	113	139	108
8 lb/ac	105	117	107	113
16 lb/ac	86	144	156	108
Sig Diff(P = 0.05)	N.S.	N.S.	N.S.	N.S.

In other field trials carried out during 1961 and 1962, many different varieties of young and established apple trees were treated at doses up to 9 lb/ac incorporated. In no case was there any visible sign of crop damage or effect upon fruiting.

<u>Pears, Plums and Cherries</u>. Several non-replicated trials were carried out on each of these crops at doses up to 9 lb/ac incorporated and there was no evidence of crop injury either to newly planted or established trees.

<u>Blackcurrants</u>. In a replicated experiment on mature blackcurrants 3 doses of dichlobenil were applied in autumn 1961 and spring 1962 and incorporated into the soil by rotary cultivation. Table VI gives the mean yields obtained with the different doses and shows that there was a significant increase in yield with the two higher doses. There was no appreciable difference between the effects of autumn and spring treatment.

TABLE VI EFFECT OF DICHLOBENIL ON BLACKCURRANTS

Dose	Mean yields as per cent of control
Dichlobenil 2 lb/ac	105
" 4 lb/ac	118
" 8 lb/ac	133
Sig Diff (P = 0.05)	12

The controls were hand weeded late in the season when the weeds were about to flower and, consequently, yields were in all probability depressed owing to competition for moisture in a dry year.

Another, non-replicated trial with plots containing 6 bushes, was started in 1960. Various dichlobenil treatments were applied in the early spring after clean weeding and repeated annually for 3 consecutive years. The incorporation of the wettable powder was carried out by rotavating the plots immediately after spraying. The results of this trial are given in Table VII and it should be noted that bushes grown for 3 years in soil treated with 8 lb/ac showed no sign of yield reduction. Time of maturation of the fruit was also unaffected.

TABLE VII EFFECT OF ANNUAL APPLICATIONS OF DICHLOBENIL ON BLACKCURRANTS

Dose of dichlobenil	Yield as per cent of controls		
	1960	1961	1962
2 lb/ac spray on surface	104	91	-
4 " " " "	72	92	87
8 " " " "	100	87	109
2 " " incorporated	100	92	-
4 " " "	100	107	80
8 " " "	84	100	112
2 lb/ac Granules on surface	104	118	-
4 lb/ac " " "	76	107	85
8 lb/ac " " "	76	118	130

Gooseberries During the last three years, 8 non-replicated field trials were carried out on different varieties of newly planted and established gooseberries at doses up to 8 lb/ac incorporated by raking. Visual observations showed no ill effects upon the bushes, even though in one trial the roots of the gooseberry bushes were exposed where the soil had been removed due to bad hoeing in previous years.

Raspberries. A factorial experiment with four replicates was started on established raspberries in 1961. Three doses were applied in the autumn and the following spring and the chemical was incorporated into the soil by irrigation. As shown by the yields given in Table VIII, there were no significant differences between treatments.

TABLE VIII EFFECT OF DICHLOBENIL ON THE YIELD OF RASPBERRIES

Dose of dichlobenil	Time of application	Yield as per cent of controls
1 lb/ac spray	Autumn	94
2 lb/ac "	"	101
4 " "	"	95
1 " "	Spring	115
2 " "	"	86
4 " "	"	103
Sig Diff (P = 0.05)		N.S.

Several other non-replicated field trials were carried out on raspberries in 1960 and 1962. Two instances of slight crop damage were observed; the first with doses above 2 lb/ac on light sandy soil where no incorporation of the chemical had been carried out. The effect consisted of slight chlorosis of the leaves and retardation of sucker growth. In another trial, the fruiting canes were slightly retarded in growth with a dose of 6 lb/ac raked into the soil surface.

DISCUSSION

The series of field trials reported in this paper indicates that dichlobenil is a promising herbicide for use in bush and top fruit and that its effectiveness can be considerably increased by rainfall, overhead irrigation or mechanical incorporation after treatment.

In most of the top fruit orchards of this country, it is common practice to keep the land clean weeded for at least 3 years after planting out, subsequently 'grassing-down'. The use of implements in such arable orchards presents no problems and dichlobenil can be incorporated without difficulty except close to the trunks of the trees. The most efficient method of incorporation is by means of a rotary cultivator. Objections to this implement may be raised on the grounds that it is likely to destroy the surface feeding roots, but the depth of cultivation need be no more than 2 in. and this is unlikely to cause any more damage to the roots than other implements used for mechanical weed control. At 4-6 lb/ac, dichlobenil rotavated into the soil within a few hours of spraying, will control most annual weeds and many perennials including Agropyron and Agrostis spp. and Cirsium arvense. When the topsoil is in a loose friable condition, other implements, such as harrows, discs or cultivators may be used to incorporate the chemical, but two 'passes' may be necessary to achieve thorough mixing and an increased dose of 6-9 lb/ac appears necessary to obtain results equal to rotary cultivation.

In gooseberries and blackcurrants, the problem of incorporation is different in that it is frequently impossible to cultivate between the bushes in the rows. Surface application of 6 lb/ac controls the majority of annuals but will not kill perennials. In such crops improved results are obtained where overhead irrigation can be applied after spraying. Between the rows the chemical can be mechanically incorporated in the usual way. Surface application of the wettable powder formulation at 6 lb/ac without incorporation gives variable results, dependent upon temperature and rainfall after spraying. Early spring treatments on clean land when air temperatures are low and rainfall imminent are, therefore, likely to be the most successful. At equivalent doses, the granular formulation is slightly more effective and on clean soil, without incorporation, will give longer control of annual weeds than the wettable powder.

Dichlobenil enters the plants predominantly through the roots. Sprays applied to existing stands of weeds are ineffective in the absence of incorporation as the compound is held on the foliage where it cannot be absorbed. On the other hand, granules penetrate the foliage and become available for uptake by the roots and, where the foliage is sufficiently dense to reduce loss by volatilization good control of mixed stands of annual and perennial weeds can be achieved. Even Convolvulus arvensis, one of the most resistant species, has been killed in this manner. The granular formulation, therefore, offers the possibility of controlling weed growth close to the trunks of fruit trees where it is not possible to obtain incorporation by cultivating. Control of this growth is necessary in order to reduce the possibility of damage by collar rot, dock sawfly and field mice.

Top fruit show a high degree of tolerance to dichlobenil. In an experiment on dwarf pyramid apples, 16 lb/ac repeated annually for 3 years and incorporated by irrigation did not reduce yields. Single applications to pears, plums and cherries at doses up to 9 lb/ac also caused no visible damage.

Blackcurrants tolerated 8 lb/ac, incorporated, with no reduction in yield, and gooseberries showed no ill effects with the same dose. With raspberries, although yield was not affected in one experiment, the growth of fruiting canes and suckers was slightly retarded in two others and further work is necessary before recommendations can be made for the use of dichlobenil in this crop.

It is concluded from this series of field trials that dichlobenil is a promising herbicide for use in top and bush fruit, although the need for incorporation to ensure long-term weed control may be a considerable disadvantage in some situations.

Acknowledgments

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REFERENCES

BARNSLEY, G.E. (1960) Proc 5th British Weed Control Conf 597-616

BARNSLEY, G.E. and ROSHER, P.H. (1961) Weed Research 1 147-158

MASSINI, P. (1961) Weed Research 1 142-146

Research Report

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

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Summary: Further results from two statistically designed raspberry herbicide experiments previously reported upon by Wood, Sutherland and Stephens (1960) suggest that neither the vigour of the plants nor the fruit yields have been affected by repeated annual doses of the herbicides used. In a new trial first chemically treated in 1961, annual applications of simazine (1.5 lb), monuron (3.0 lb), and diuron (3.0 lb), and an annual alternation of simazine (1.5 lb) and monuron (3.0 lb), have each given adequate commercial weed control without, so far, reducing or increasing plant vigour or fruit yields in comparison with hand cultivation. The oldest of the three experiments has now been concluded. A screening trial of available herbicides has suggested that atrazine is worthy of further trial as an alternative to better-established materials.

INTRODUCTION

The need for safe and effective herbicides in raspberry fruiting plantations was discussed by Wood, Sutherland and Stephens (1960), who gave preliminary results of two field-scale herbicide experiments. Of the four experiments described here, two are those first reported by Wood et al (1960) and two have not previously been described. All are established at Mylnefield on medium loam soil not severely infested with perennial weeds but having an abundant flora of annuals, consisting mainly of Chenopodium album, Stellaria media, Senecio vulgaris, Poa annua, Fumaria officinalis, Viola tricolor, Veronica hederifolia, V. persica, Polygonum aviculare and P. convolvulus.

METHODS AND MATERIALS

Experiment A, which was planted in spring 1956 with the variety Norfolk Giant received the following chemical treatments annually in March or April from 1958 to 1961 inclusive: TCA/dinoseb-amine mixture, propham/2,4-DES mixture and propham/fenuron mixture. The doses are given in Table I. The experimental layout and plantation management were as described by Wood et al. (1960) until the 1961 crop had been recorded, after which the experiment was discontinued.

Experiment B, was planted in the spring of 1959 to compare four herbicide treatments against a mechanical cultivation treatment in which the hoeing along the rows for the control of weeds and unwanted suckers is done with Dutch hoes instead of with draw hoes. Dutch hoes are also used for sucker control in the herbicide plots, and the alleyways throughout the experiment are rotary cultivated for weed and sucker control two or three times a year, whenever this is required in the control plots. The design is of six randomized blocks, with each unit plot consisting of a pair of recorded rows of the variety Lloyd George, 10 yards long, separated from the next plot by a single guard row. The chemicals applied are simazine, monuron, propham/2,4-DES mixture and 2,4-DES/ fenuron mixture at the rates shown in Table III. The sprays are applied overall from one guard row to the next, in March or April of each year.

Management of the control plots aims in the normal way to prevent weed growth from competing with the young replacement canes growing from the stools, but in 1959 these plots were neglected and the young canes which were to fruit in the following year became stunted. This was reflected in the 1960 crop.

Experiment C, which was planted in February 1960 with the variety Malling Jewel, is similar in layout to Experiment B, differing from it in having only four replicates and the following treatments:- simazine, monuron, diuron and simazine alternating with monuron. Doses are given in Table VI. This experiment was cleaned by hand hoeing in the rows and rotavation in the alleyways until the first spraying in 1961. The chemical treatments were applied on 14 April 1961 and 22 March 1962, and will be applied annually in the spring for the duration of the experiment. In each case the plots were sprayed overall, from one guard row to the next. As in Experiment B, weeds and unwanted suckers growing in the rows are controlled by Dutch hoeing and the alleyways are rotavated three or more times a year to control suckers and weeds.

Experiment D, planted in February 1961 with the variety Malling Jewel, was designed as a screening trial to compare against the better-known herbicides a number of relatively new materials not previously tested in raspberries at Mylnefield. The treatments were applied on 29 March 1961 and there were two replicates of each treatment (except of prometryne, of which there was only sufficient material available for single plots). All the chemicals were left on the surface - not raked or cultivated in - and the plots were left undisturbed until they became dirty with seedling weeds, when they were rotavated as necessary.

The sprays in Experiments A, B, C and D were applied with an Oxford Precision Sprayer, at a volume rate of 30/gal ac. The granular materials in Experiment D were applied by hand from a cardboard container with small holes at one end.

RESULTS

Experiment A. Table I shows the total fruit yields recorded in 1958, 1959 and 1960 followed by the yields obtained in 1961. The first three recorded crops were discussed by Wood *et al* (1960), who showed that the TCA/dinoseb plots had regularly produced significantly less fruit than any of the other treatments. In 1961, however, none of the fruit yields differed significantly, possibly because of the reduction in the dose of TCA in 1960 and 1961 from 18.6 to 10.0 lb. The numbers and lengths of new canes on a sample number of stools in each plot were recorded in the winter 1960/61 and the differences between treatments were not found to be significant. The trends established in earlier years continued, and although none of the treatments eliminated the need for hoeing to control weeds in early summer, all reduced the numbers of annual weeds present.

TABLE I EXPERIMENT A: FRUIT YIELDS IN CWT/AC

Treatment	1958-60	1961	Total
TCA 18.6* dinoseb-amine 2.8 lb/ac	163.4	82.3	254.7
propham 5.0 lb + 2,4-DES 3.6 lb/ac	217.4	84.5	301.9
propham 5.0 lb + fenuron 0.5 lb/ac	210.9	90.4	301.3
2,4-DES 4.6 lb + fenuron 0.5 lb/ac	199.4	84.4	283.8
Control	202.1	82.8	284.9
Sig. diff. (P = 0.05	-	10.9	-

*10.0 lb in 1960 and 1961

Experiment B. The yield and cane growth data from Experiment B are shown in Table II. By 1961 the control plots had recovered from the severe weed competition suffered during 1959, and fruit yields did not differ significantly between the treatments. However, in 1962 the crop under the propham + 2,4-DES treatment was significantly lower than under the other chemical treatments as shown in Table II.

TABLE II EXPERIMENT B: FRUIT YIELDS AND PRODUCTION OF NEW CANES

Treatment	Fruit yields in cwt/ac				Number of new canes per plot		
	1959 + 1960	1961	1962	TOTAL	1959/60	1960/61	1961/62
simazine 2.5 lb/ac	50.0	87.3	69.1	198.4	48.5	108.0	122.5
monuron 3.5 lb/ac	42.0	87.0	68.4	198.2	45.0	98.3	116.8
propham 4.0 lb + 2,4-DES 4.6 lb/ac	48.6	72.5	55.4	189.4	45.3	112.1	119.3
2,4-DES 4.6 lb + fenuron 0.5 lb/ac	46.2	85.9	70.6	202.7	43.5	114.8	126.1
control	22.1	88.6	61.6	186.1	24.7	101.5	107.8
Sig. Diff (P = 0.o5)	9.4	NS	11.2	NS	7.4	NS	NS

Counts made in the winters 1960/61 and 1961/62 of new stool canes available for tying-in, and of unwanted canes removed when "stooling up", are shown in Tables II and III. None of the recorded differences in number or length of new stool canes after the winter 1959/60 were significant; but both numbers and weights of unwanted suckers show some difference, although these were smaller in 1961/62 than in the previous year.

TABLE III EXPERIMENT B: SUCKERS REMOVED PER PLOT WHEN "STOOLING UP"

Treatment	Winter 190/61		Winter 1961/62	
	Number	Weight (lb)	Number	Weight (lb)
simzine 2.5 lb/ac	182	12.4	266	15.6
monuron 3.5 lb/ac	162	8.7	242	13.5
propham + 2,4-DES	160	8.4	289	16.9
2,4-DES + fenuron	149	7.5	215	11.6
control	115	5.0	246	13.8
Sig diff (P = 0.05)	22	2.1	25	4.8

It was shown by Wood et al that in 1959 and 1960 all four treatments reduced the weed populations in the spring and early summer, but that only the simazine and monuron kept the plots substantially clean throughout the season. This continued to be so in 1961 and 1962, and the annual weed growth on the monuron and simazine plots is now negligible, though still slightly the greater on the monuron plots. Again as previously reported, the shallow rotavation carried out in the alleyways of all plots did not eliminate the weedkilling effect of either simazine or monuron: the residual action of the other, less successful treatments was largely lost each year by the time the alleyways were first cultivated, and after cultivation these plots became just as weedy as the control plots.

Experiment C. Average yields per plot for this experiment in 1961 and 1962 are shown in Table IV. Neither the individual year figures nor the totals differed among themselves significantly.

TABLE IV EXPERIMENT C: FRUIT YIELDS IN CWT/AC

Treatment	1961	1962	1961 + 1962
(a) simazine 1.5 lb/ac	30.9	69.6	100.5
(b) monuron 3.0 lb/ac	25.4	67.4	92.8
(c) diuron 3.0 lb/ac	26.6	65.2	91.8
(d) simazine/monuron in alternate years	29.9	69.4	99.3
(e) control	30.9	57.9	88.8
No difference signifant at P = 0.05			

The difference in cane growth between the treatments were very small, and although the difference in the quantities of suckers removed at stooling up were larger, none of the recorded differences were significant. During the first year of treatment none of the herbicides gave adequate control of weeds, and all the plots treated with simazine, monuron or diuron had approximately 50 per cent cover of weeds by late summer. Weed control during 1962 was more successful, and all the treatments gave an adequate commercial control of annual species. For the first month after application monuron was slightly superior to the other treatments, but later, when the simazine plots remained clean, Senecio vulgaris and Veronica spp. survived under monuron.

Experiment D. **Weed counts obtained by throwing a 6 in x 6 in. quadrat ten times in each plot nearly six weeks after the application of the treatment are shown in Table V. During the summer the wettable powder formulations of simazine, atrazine, prometryne, diuron, monuron and fenuron all kept the ground substantially clean, but by September the prometryne plots were becoming dirty and weeds later became established on all plots except those treated with atrazine at 4 lb or simazine at 4 lb or 6 lb. The plots which received these last three treatments were the only ones which remained weed free for twelve months after spraying.**

TABLE V. EXPERIMENT D. WEED COUNTS PER SQ FT ON 8/5/61

Herbicide	Dose	Count
Dichlobenil (wettable powder)	2 lb	19
" " "	4 lb	5
" (granular)	2 lb	43
" "	4 lb	19
Simazine (wettable powder)	2 lb	1
" " "	4 lb	1
" (granular)	2 lb	20
" "	4 lb	6
Atrazine (wettable powder)	2 lb	1
" " "	4 lb	0
" (granular)	2 lb	74
" "	4 lb	79
Prometryne (wettable powder)	2 lb	0
" " "	4 lb	0
" " "	6 lb	0
Diuron (wettable powder)	4 lb	2
Monuron (wettable powder)	4 lb	2
Fenuron (wettable powder)	4 lb	7
Control		58
Control		59
Simazine (wettable powder)	6 lb	0

No permanent injury to the raspberry plants was detected, although temporary damage to the young spawn in spring 1962 was noted under several of the treatments. Growth in 1962 was apparently normal under all treatments.

DISCUSSION

These results substantiate the preliminary finding by Wood et al (1960) and other workers, that simazine is a safe and effective herbicide for annual weed control in raspberry fruiting plantations. None of the results reported suggest that any reductions in yield or vigour are likely to be caused by the annual, overall application of low rates of simazine or monuron, and diuron and atrazine may well be suitable alternative products. Commercially, however, simazine is at present the most commonly used material.

In practice, overall treatments are often replaced by band spraying along the rows, whereby only about half as much material is applied to each acre of raspberries. Weeds and suckers in the alleyways are then controlled by occasional cultivation. As the weediness of the plantation becomes reduced following the use of simazine, so the rate of application of the herbicide can probably be reduced, making the treatment even safer for the crop.

Except in experiment B in 1959/60 - when there had been neglect of cleaning on the control plots - the use of herbicides did not lead to the recording of significantly larger numbers of new stool canes (potential canes for fruiting in the following year) at the end of the growing season: but in general there were more sucker canes to be removed than under the normally-cultivated control treatments. This was probably due in part to a less thorough hoeing-down of suckers on the plots where there were fewer weeds to remove, but it is also likely that the raspberries suckered more freely on plots where there was less disturbance of the soil by cultivation.

The screening trial of newer materials did not suggest that there exists at present any other herbicide as useful as simazine for the control of annual weeds in raspberries - except, perhaps, the related but more soluble atrazine. More work, however, would be required to demonstrate the long-term safety of this material.

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REFERENCES

WOOD, C.A., SUTHERLAND, J.P., and STEPHENS, R.J. (1960). Effects of the use of herbicides on the growth, cropping and weed flora of raspberry plantations: a progress report. Proc 5th Brit Weed Control Confr 373-9.

Research report

HERBICIDES IN KENYA COFFEE 1962.

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Summary: Herbicides can be valuable aids to good coffee management, but are unlikely entirely to replace mechanical and hand weeding. Pre-weed-emergence herbicides should be applied very early in a wet season but not before the onset of the rains. At one site diuron alone and with paraquat gave excellent weed control for three months, but under high rainfall conditions none of the triazine or urea derivatives tested checked grasses for more than a month, although all were effective against most dicotyledon species.

INTRODUCTION

It has been shown repeatedly that weed growth should not be permitted in coffee plantations, (Pereira and Jones, 1954, Jones and Wallis, in press) and that the ground should be partially covered with a layer of mulch (Jones et al 1960). In a four year yield recorded trial it was found that chemical control was as beneficial to the coffee productivity as tillage with hand or mechanical implements (Wallis, 1958). 2,4-D or MCPA at doses of 1-1½ lb/ac with dalapon at up to 7 lb/ac can be used in coffee, but at these doses herbicides are more expensive than combinations of mechanical and hand weeding (Wallis, 1961). It appears very unlikely that chemical methods will entirely replace cultivation for controlling weed in coffee, but herbicides should have a useful place in an integrated programme of coffee management. The control of perennial grasses is a particular case for the use of herbicides in coffee (Wallis, 1960). Two other applications for chemical weed control are to prevent weeds growing through the mulch and to control weeds in the rows of coffee trees where the ground is inaccessible to mechanical implements; these problems have been studied since November 1959, using mainly pre-weed-emergence herbicides, and results from trials in 1960 and 1961 have already been published (Wallis, 1962).

METHODS AND MATERIALS

All treatments were applied with an Oxford Precision Sprayer using 00 jets at a spacing of 13½ in., a pressure of 40 psi and 5 pints of spray were applied to each plot. Trial 1 was on the Coffee Research Station near Ruiru, at an altitude of 5275 ft where the mean annual rainfall is about 40 in. The coffee was spaced at 9 ft x 9 ft and, at the time of spraying, about 10 ft tall. Trial 2 was on a Coffee Research Sub-station near Koru at an altitude of 5000 ft where the mean annual rainfall is about 60 in. The coffee was planted in 1960 at 10 ft x 7 ft and at the time of spraying was about 5 ft tall.

In Trial 1 there were three replications of the thirty four treatments listed in Table I and all but three were applied early in April just as weed seedlings were beginning to germinate. Treatments 17, 25 and 34 were delayed as the chemicals were not available earlier. When these late treatments were applied, the weeds were already 9 - 12 in. tall, though still very immature.

In Trial 2 two replications of the twentyeight treatments listed in Table II were applied early in May. There had been 15 in. of rain in April and the ground was partially waterlogged at the time the treatments were applied.

TABLE I. TRIAL I. HERBICIDE TREATMENTS AT THE COFFEE RESEARCH STATION, RUIRU, APPLIED 9 - 11 APRIL, 1962. (Individual Plot size 12ft x 45ft, 3 replications applied at 50 gal/ac.)

Treatment	Dose per acre. formulation	Dose per acre. lb. active	Treatment	Dose per acre. Unit formulation	Dose per acre. lb. active
(1) Control	-	-	(18) CMU) BiPC)	9.9 pt	2.04 1.42
2 Simazine	3.9 lb	1.95	19 Monuron	3.7 lb	2.96
3 Simazine Amitrole	3.9 lb 2.0 "	1.95 1.00	(20) Neburon	5.9 lb	2.95
4 Simazine	5.9 lb	2.95	21 Diuron	3.7 lb	2.96
5 Atrazine	3.9 lb	1.95	22 Diuron Paraquat	3.7 lb 1.6 pt	2.96 0.91
6 Atrazine Amitrole	3.9 lb 2.0 "	1.95 1.00	23 Diuron Paraquat	3.7 lb 3.0 pt	2.96 1.71
(7) Atrazine	5.9 lb	2.95	24 Linuron	5.9 lb	2.95
(8) Prometon	5.9 lb	2.95	25 Linuron* Diuron	2.0 lb 3.7 "	1.00 2.96
9 Prometon	9.8 lb	4.90	26 Diuron Paraquat	3.7 lb 4.0 pt	2.96 2.25
(10) Prometryne	2.0 lb	1.00	27 FW 734+	6.7 pt	2.01
11 Prometryne	3.9 lb	1.95	28 FW 734+	13.2 pt	3.96
12 Prometryne	5.9 lb	2.95	29 FW 734+	19.9 pt	5.97
(13) Amitrole	6.7 pt	1.77	30 Paraquat	1.4 pt	0.80
(14) Amitrole) Dalapon) Monuron)	3.7 lb	0.89 1.37 0.74	31 Paraquat	2.8 pt	1.59
15 Amitrole) Dalapon)	3.7 lb	1.18 1.81	(32) Dichlorprop	4.0 pt	2.00
(16) Amitrole	5.9 lb	2.95	(33) 2,4-DES	3.9 lb	3.51
(17) Fenac*	13.2 pt	2.97	(34) Atraton*	3.9 lb	1.95

\+ 3,4-dichloropropionanilide

* Treatments not applied until 27 April, 1962.

() Treatments not significantly different from 'control' in Table III

TABLE II. TRIAL 2. HERBICIDE TREATMENTS AT THE COFFEE RESEARCH SUB-STATION, KORU. APPLIED 1 - 2 MAY, 1962. (Individual Plot size 10ft x 42ft; 2 replications applied at 65 gallons per acre.)

Treatment	Dose per acre. formulation	Dose per acre. lb. active	Treatment	Dose per acre. Unit formulation	Dose per acre. lb. active
1 Control	-	-	(15) Atraton	2.0 lb	1.00
2 Monuron	4.0 lb	3.20	16 Atraton Paraquat	2.0 lb 1.5 pt	1.00 0.68
3 Monuron	2.0 lb	1.60	17 Prometon	5.0 lb	2.50
4 Monuron Paraquat	2.0 lb 1.5 pt	1.60 0.68	(18) Prometon	3.0 lb	1.50
5 Diuron	4.0 lb	3.20	19 Prometon Paraquat	3.0 lb 1.5 pt	1.50 0.68
6 Diuron	2.0 lb	1.60	20 Prometryne	5.0 lb	2.50
7 Diuron Paraquat	2.0 lb 1.5 pt	1.60 0.68	(21) Prometryne	3.0 lb	1.50
(8) Simazine	4.0 lb	2.00	22 Prometryne Paraquat	3.0 lb 1.5 pt	1.50 0.68
(9) Simazine	2.0 lb	1.00	23 Dalapon 2,4-D	5.0 lb 2.5 pt	3.70 1.00
(10) Simazine Paraquat	2.0 lb 1.5 pt	1.00 0.68	24 Dalapon 2,4-D	3.0 lb 3.8 pt	2.22 1.50
(11) Atrazine	4.0 lb	2.00	25 Dalapon 2,4-D	3.0 lb 2.5 pt	2.22 1.00
(12) Atrazine	2.0 lb	1.00	26 Amitrole 2,4-D	5.0 lb 2.5 pt	2.50 1.00
13 Atrazine Paraquat	2.0 lb 1.5 pt	1.00 0.68	27 Amitrole 2,4-D	3.0 lb 3.8 pt	1.50 1.50
14 Atraton	4.0 lb	2.00	28 Amitrole 2,4-D	3.0 lb 2.5 pt	1.50 1.00

( ) Treatments discarded as ineffective 5 June, 1962.