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SOME PRELIMINARY OBSERVATIONS ON THE ASSESSMENT OF WEED CONTROL IN ROW CROPS

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Summary

Graphically there is a linear relationship between weed stand and the time taken to remove the weeds. If hand weeding alone is considered the line passes through the origin: thus a given percentage reduction in the weed stand gives the same percentage reduction in the time taken to remove the weeds. If hoes are used in addition to hand weeding the time-stand relationship is still linear but does not pass through the origin. The implications of these observations are discussed.

Introduction

With a crop such as a cereal in which the rows are close together, the farmer is faced with the decision of whether to allow the weeds to remain in the crop and accept some loss of yield, or to spray with a selective herbicide. If the question of re-infection of the land by seed from the weed in the unsprayed crop is not considered, then the success of the spraying can be summed up as the extent to which the value of the increased yield exceeds the cost of the herbicide and its application. There is a considerable body of literature in which the yields of sprayed and unsprayed crops have been compared. The difference between the two varies widely according to the number of weeds present, the soil type and the weather during the growing season, but nevertheless relatively simple experiments can give results which enable immediate practical recommendations to be made to farmers.

The problem of assessing the economic benefit deriving from the use of herbicides in vegetable crops is somewhat different. In crops such as onion and beet, it is general practice to carry out mechanical cultivations between the rows and remove the weeds in the row by hand, the crop being kept as free from weeds as possible right through the growing season. Mechanical inter-row cultivation is a relatively cheap operation, and the main purpose of experimental work with herbicides in such crops is to find a means of eliminating hand labour which is becoming increasingly expensive and difficult to obtain. Therefore the best measure of the effect of a herbicide (i.e. that which gives the closest relationship with the economics of growing a commercial crop) is the time taken to hand weed the rows. This assessment has been used by various workers, but it has several disadvantages, deriving from the necessity to have fairly large plots and the variations in the method and speed of working between operators. The purpose of this report is to offer some observations on the relationship between the stand of weeds and the time taken to remove them from the rows.

Experimental results

In one experiment the natural variation in weed stand from plot to plot was used to give a range of higher weed densities. A range of lower densities was produced by the use of a pre-emergence herbicide on some of the plots. The whole experiment was mechanically inter-row cultivated on one date. The time taken to hand weed the rows was recorded on three subsequent dates, one third of the plots being weeded on each date. On the first two dates the weed and the crop were at a normal stage of growth for hand weeding whilst on the last date the crop had suffered considerably from the presence of the weeds. Figure 1 illustrates the relationship obtained between the weed stand per foot of row and the time taken to remove the weeds. The data for the first two dates appear to be adequately represented by one line. The solid lines represent data obtained by using only one worker and it will be seen that the difference between the first two dates and the last one is solely in the slope. The dotted line in Figure 1 is based on data obtained for a different worker on the last date. It will be seen therefore that the slope of the line depends upon the stage of growth of the weeds and the speed of the worker. In all three cases, however, the data are adequately described by straight lines passing through the origin. This has been confirmed by other evidence not here presented.

In another experiment on the weeding of onions following treatment with a pre-emergence herbicide, the workers were equipped with long-handled hoes. Two workers were employed, but as they did not differ appreciably in the rate at which they worked, the data have been combined and presented as a single line in Figure 2. Here, the line does not pass through the origin but cuts the weeding time axis at four seconds which represents the time taken to clean the row in the absence of weeds. It was observed that even though the ground had previously been mechanically cultivated, the workers tended to cultivate the inter-row and leave a tidy job. Workers timed on hoeing sixteen inch inter-rows (the spacing used in this experiment) averaged 4.15 and 3.55 seconds/ft of inter-row with Dutch hoes and swan-necked hoes respectively. These figures support the belief that the four seconds taken to clean 1 ft of row in the absence of weeds is entirely accounted for by this tendency to hoe the inter-row.

Discussion and conclusions

Figure 1 shows that for all practical purposes the relationship between weed stand and the time taken to remove the weeds by hand is linear and passes through the origin. This means that a given percentage reduction in the weed stand leads to the same percentage reduction in the time taken to remove the weeds by hand. This is true for any worker at any one stage of growth of the weeds. Figure 1 also shows that a stand of five weeds/1 ft of row took five seconds to remove on the first two dates. The same worker however took five seconds to remove just less than two weeds/1 ft of row on the last date when the weeds were bigger. This implies that a sixty % reduction in the weed stand can either be considered to give a sixty % saving in the labour required to remove the weeds by hand or to allow a three to four weeks delay in the timing of the weeding operation without any increase in the time taken to remove the weeds.

In the second experiment there is still a linear relationship between the weed stand and the time taken to remove the weeds. However, as the line does not pass through the origin it cannot be said simply that a given reduction in weed stand will lead to the same relative reduction in the weeding time. In

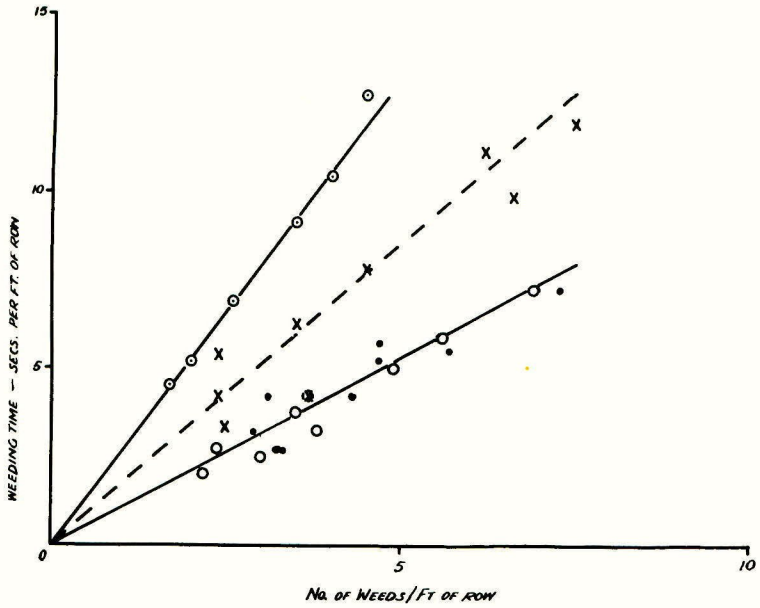

Figure 1. The relationship between weed stand and the time to remove the weeds by hand. . . . worker A 16/5/56; same line o worker A 25/5/56; x x worker A 13/6/56; X---X worker B 13/6/56.

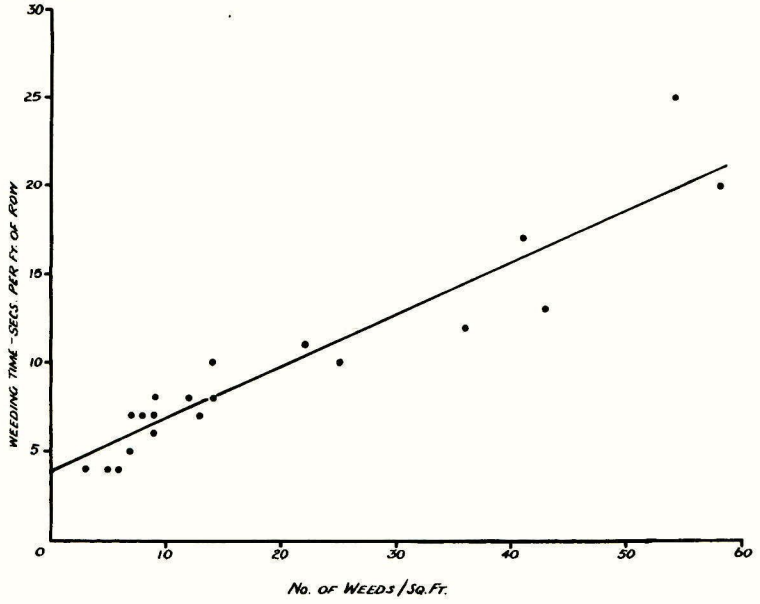

Figure 2. The relationship between weed stand and the time taken to remove the weeds when the workers are equipped with long-handled hoes.

this case it is necessary to know the origin and slope of the line before any conclusions can be drawn. There are indications that the origin is probably constant at about four seconds, hence a few points enabling the slope to be determined and the origin to be confirmed could be used to facilitate the interpolation of other data.

Petersen (1954) presented data on the time taken to remove weeds by hand and the weight of weed per unit length of row. Lines similar to those shown in Figure 1 adequately describe this relationship. It may be that when weight is used instead of weed number the slope of the line becomes independent of weed size and depends solely on the speed of the worker. Weed cover, which takes into account both size and number of plants, could probably be substituted for weight thus making the measurement both non-destructive and easy.

The points raised in this paper are being further investigated.

Reference

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APPLICATION OF PENTACHLOROPHENOL EMULSIONS FOR PRE-EMERGENCE WEED CONTROL

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An interesting paper dealing with the use of PCP oil emulsions for pre-emergence weed control in vegetable crops was presented at the conference in 1954 by Roberts (a). This paper dealt with the principles of contact pre-emergence weed control and reported the results of trials carried out by the National Vegetable Research Station at Wellesbourne. Further contributions on this subject have been made by Parker in his papers on weed control in sugar beet, which were based mainly on trials carried out by the Norfolk Agricultural Station, Sprowston (2 & 3), and also by Lloyd (4).

The principal object of this paper is to review the performance of a PCP 12% miscible oil product, following its extensive use by farmers and market gardeners during 1955 and 1956. The introduction to the market of this product was preceded by a programme of field trials, the results of which are summarised.

Trials programme

A trials programme was started in 1950, with the object of developing a suitable herbicide for contact pre-emergence weed control in sugar beet. Initial field trials were confined to the testing of an unfortified petroleum oil at rates of application ranging from 15 gal to 60 gal/ac. No injury to sugar beet seedlings resulted from application of this herbicide 1-2 days before emergence, even with the highest application rates. Broad leaved annual weeds and also annual grasses were well controlled down to a level of about 20 gal/ac on light soils and 30 gal/ac on organic fen soils, but at lower rates of application performance fell off sharply. It was considered that even these minimum application rates would be too costly to appeal to sugar beet growers and therefore work was put in hand to develop a product of equal efficiency and safety which would be cheaper and more convenient to handle than a bulky oil product.

Over a period of four years field trials were conducted to compare the following formulations:

Herbicide	Rate per acre
1. Petroleum oil/PCP	10-15 gal oil/2-5 lb PCP
2. Activated DNC suspension	6 lb DNC
3. DNC oil emulsion	2-6 lb DNC
4. Dinoseb ammonium salt	1-2 lb dinoseb
5. PCP 12% miscible oil	2-6 lb PCP

2, 3, 4 and 5 were applied at low, medium and high volume per acre.

The relative performance of these formulations may be summarised by saying that both the DNC preparations and also ammonium dinoseb while providing an adequate control of small seedling annual weeds at all rates of application, tended to damage sugar beet seedlings when applied shortly before emergence, particularly on light soils and at the higher rates of application where rain followed spraying. The petroleum oil fortified with PCP and the PCP miscible oil gave comparable performances, and the results of two typical trials are presented in Table 1. It was considered that the miscible oil formulation would prove more generally useful to farmers, taking into account cost, efficiency and convenience of application, and therefore this product was selected for marketing in 1955.

The performance of this PCP 12% miscible oil, in a wide range of conditions, has been closely watched during 1955 and 1956, when it has been applied to a considerable variety of arable and vegetable crops, besides sugar beet, and it has been possible to draw some useful conclusions from this experience.

Timing of applications

Although there are definite indications that PCP emulsions have some residual toxicity to annual weeds germinating near the soil surface shortly after spraying, the successful employment of the contact pre-emergence technique is dependent primarily upon the main emergence of annual weeds taking place before the crop appears above ground.

Even in the most favourable circumstances and with a slow germinating crop, the interval between weed and crop emergence is short, unless the seed bed is prepared in advance of sowing. Therefore, it is clearly essential to delay application of the weedkiller for as long as possible, consistent with safety to the crop.

With sugar beet, application two days before first emergence appears to be safe in all conditions, and indeed several cases have been observed when spraying has been deferred until the earliest seedlings are above ground, with no significantly detrimental effect on the final stand of plants or yield of beet. An example of the results of late application of a high rate of PCP emulsion is shown in Table 2. As a general indication of the latest reasonably safe time for application, it is suggested that one emerged seedling in 100 in. of row should be regarded as the limit, and then only in an emergency.

Experience with other crops indicates that two days before emergence is also an appropriate recommendation for spraying beans, peas, mangolds, fodder beet and potatoes. With small seeded shallow drilled crops such as kale, onions, leeks, carrots, parsley, parsnips and lettuce, an interval of 3-4 days between application and estimated emergence is suggested.

Opinions differ as to the best practical advice to give to a farmer on when he should spray. Recommendations sometimes take the form of a given period after drilling the crop, but the interval of time between drilling and crop emergence may vary by several weeks, according to soil, season, time of sowing and other conditions. Therefore, some more precise indication is needed if consistent results are to be obtained. Another recommendation which is sometimes made is to drill a quick germinating indicator crop, such as radish, with a slower germinating crop, and apply the weedkiller when the indicator crop emerges. The disadvantage of this method is that the relative germination times of the two crops are not constant, and if circumstances

prevent spraying, as they may well do, the indicator crop has to be subsequently cleaned out of the crop rows.

In view of the extreme importance of precise timing, and of deferring spraying until the latest safe stage, there is little doubt that with sugar beet and similar crops and also large seed crops a random examination of the drills is the best method. A good indication of when beet seedlings will emerge in 2-3 days time is when the germinating seedlings have developed 0.5 in. root.

The practice of sowing in a stale seed bed with minimum soil disturbance is often recommended as a device for encouraging weed seeds to germinate in advance of the crop, and lengthening the period during which effective spraying may be carried out safely. This method is unpopular with sugar beet growers particularly, no doubt with justification, but is normally essential for effective contact pre-emergence applications to quick germinating crops such as lettuce, kale and other brassicae.

Rates of application

In deciding upon appropriate rates of application to recommend to the farmer it is necessary to strike a balance between the requirements of maximum weed control, minimum risk of crop damage, and cost.

A study of weed susceptibility to PCP emulsions indicates that whereas no common annual species is resistant at the early seedling stage, weeds such as Sinapis arvensis and Raphanus raphanistrum are usually more completely eliminated from a seed bed than Polygonum persicaria and Polygonum aviculare. This may be due partly to the greater retention of spray on the broad horizontal cotyledons of the cruciferous weeds, and partly to the fact that Polygonum persicaria and Polygonum aviculare frequently emerge over a longer period. Control of the latter species frequently improves with increasing rates of application, which suggests that residual action of PCP may be responsible. The control of grass weeds with normal rates of application is usually incomplete, and amounts to little more than a temporary check.

Conclusions which have been reached from trials and field observations are that 3 lb/ac of PCP in oil emulsion is the optimum rate of application for sugar beet on light and medium loam soils, where a fairly even germination of weeds is common. In these conditions no significant improvement in weed control has been apparent from higher rates of application. Greater differences between rates of application, in terms of weed control, but not in effect on crop, have been apparent with sugar beet on organic fen soils (Table 3). Compared with the mineral soil types, these tend to produce several flushes of annual weeds during the critical period between drilling and singling of sugar beet. Increasing the rate of PCP up to 5 lb/ac has the effect of reducing weed emergence for a longer period after spraying, thus facilitating early inter-row cultivations and singling. Here again, it seems that this effect must be attributed to some residual effect of the PCP emulsion on germinating weeds.

The same rate of application of 3 lb/ac PCP, with an increase to 5 lb with fen soils and where there is a predominance of Polygonum persicaria or Polygonum aviculare, has proved satisfactory with other crops, with certain reservations referred to under "Crop Susceptibility".

Volume of spraying

Comparisons of various dilutions of herbicides and volumes of application per acre point to the fact that high volume application of PCP emulsion for pre-emergence use is unnecessary, in contrast to post emergence spraying of sugar beet with nitrate of soda. Experience has suggested the advisability of increasing the volume in direct proportion to rate of application, and with a PCP 12% miscible oil a dilution rate of about 8% has been found to be most satisfactory. Thus, 2.5 gal (3 lb PCP) of this formulation should be applied in about 30 gal/ac of water and 4 gal (4.8 lb PCP) in about 50 gal of water. No advantages have been apparent from increasing the volume above 50 gal, but performance has been unreliable below 20 gal/ac of water, probably due to imperfect cover of weeds which present a very small surface at this early stage.

Crop susceptibility

With sugar beet, mangolds, fodder beet, beans, peas and potatoes, when spraying has been carried out before any crop seedlings emerge, no cases of injury sufficient to have any adverse effect on plant population after singling or on yield, have been reported or observed, with application rates up to the equivalent of 5 lb/ac of PCP. These results indicate that the crops mentioned may be sprayed pre-emergence with confidence, assuming strict observance of the recommendations.

Kale also seems to be a very suitable subject for treatment, where it is drilled in a stale seed bed.

Onions (main crop), leeks, lettuce and carrots appear to be a little more susceptible to an early check, and although this effect is seldom more than temporary, it is considered advisable not to exceed 3 lb/ac PCP with these and other shallow drilled crops, and also to spray not less than three days before estimated emergence.

Application to spring (salad) onions is a doubtful proposition because any appreciable thinning of seedlings which may occur in light soils and wet weather is undesirable, and conditions in late summer and autumn, when the crop is in the seedling stage, are often not conducive to a quick recovery from any check to growth.

A crop which has shown definite susceptibility to pre-emergence applications of PCP emulsions has been red beet, damage being associated with a combination of light soil and heavy rain between application and emergence. Injury is presumably caused by washing down of PCP into contact with the germinating crop.

Pre-emergence weed control in bulb crops

This review has so far been confined to a consideration of pre-emergence use of PCP emulsions for arable and vegetable crops grown from seed. To complete the story, reference should be made to the suitability of this preparation for pre-emergence application to bulb crops. The fact that PCP is relatively non-toxic has appealed to many bulb growers and emulsion products have been tested fairly thoroughly during the past two or three years.

Rates of application as high as 16 lb/ac PCP have been used on narcissus and tulips, with no adverse effect on flowering or on the bulbs themselves,

and treatment in November has resulted in almost complete suppression of weeds until flowering time. Some growers may regard this high rate of application as rather costly and a more acceptable but still effective rate mgght be about 8 lb/ac PCP.

There are indications that similar applications are suitable for pre-emergence treatment of Iris and Anemones, but more evidence is required on safe dosage limits.

Conclusions

It is abundantly clear that there are strict limitations to the general employment of PCP emulsions as contact pre-emergence herbicides, even though a wide range of crops may be treated. Accepting the common reluctance of farmers and market gardeners to adopt the stale seed bed procedure, the essential conditions of substantial emergence of annual weeds in advance of the crop, are frequently not fulfilled. Even in favourable circumstances the time available for successful application is limited, and the intervention of rain at the critical stage will often prevent treatment. Likewise, in a prolonged spring drought early weed emergence may be insufficient to justify the expense of spraying.

The most promising conditions for worth while application of this herbicide would seem to be:-

1. Early sowings of sugar beet and other crops, when the longest interval between weed and crop emergence may be expected, and when there has been less opportunity to destroy weed seedlings by thorough seed bed preparation.

2. After a spell of cold weather when crop seedlings are emerging slowly.

3. On particularly weedy fields when there is a possibility of the crop being submerged by early weed growth.

4. When quick germinating weeds predominate.

The method is usually of less value on late sowings in good growing weather, when both crop and weeds emerge rapidly.

In spite of the shortcomings and limitations which have been noted, the use of PCP pre-emergence weedkillers is proving attractive and economic to an increasing number of farmers. Labour shortage and the greater use of mechanical thinners which need a clean braird for efficient operation, particularly in the rows, are largely responsible for this demand.

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Table 1

Comparison of oil/PCP and PCP miscible oil on sugar beet

Rate of Application	Weed Population as % control	
	Trial 1 (Mean)	Trial 2 (Mean)
Oil 15 gal/PCP 2 lb	34	54
Oil 10 gal/PCP 2 lb	54	70
Oil 10 gal/PCP 5 lb	46	53
PCP Miscible oil, PCP 6 lb	49	25
Control (hoed)	100	100

Trial 1: sprayed 12th April
weed count 22nd April

Trial 2: sprayed 1st May
weed count 22nd May

Sprayed when first seedlings emerging.

Principal weeds Chenopodium album, Polygonum persicaria and Polygonum aviculare.

Table 2

Comparison of rates of application of PCP miscible oil on sugar beet

Rate of Application per acre	Plant Counts per 100 in. drill	Weed Counts per square ft	Final plant population per chain
PCP 3.6 lb in 40 gal water	27	12	55
PCP 3.6 lb in 60 gal water	28	14	54
PCP 6 lb in 40 gal water	24	2	52
PCP 6 lb in 60 gal water	32	5	56
Control (hoed)	47	115	63

Crop drilled: 30th April (Taxigraine 8 lb/ac)
Sprayed: 12th May
Weed Counts: 18th May (average of 5 counts)
Soil: Light Fen

The crop was sprayed when 12 beet seedlings had emerged in 20 ft of row. The following morning, approximately 12 hours later, 30% of crop seedlings had emerged.

Principal weeds Chenopodium album, Stellaria media, Urtica urens Polygonum persicaria.

Table 3

Yields of Sugar Beet
Fen Soil

Treatment	Weed Population as % control	Yield of Sugar Beet % control	Yield Sugar per acre as % control
PCP Miscible oil 12 lb PCP	14	95.3	98.5
PCP Miscible oil 6 lb PCP	35	105.5	107.2
PCP Miscible oil 3.6 lb PCP	35	91.5	91.0
Control (hoed)	100	100	100

Application 1 day before crop emergence.

PRE-EMERGENCE WEED CONTROL IN ROW CROPS, AND THE IMPORTANCE OF RAINFALL

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Summary

In a preliminary trial in 1955 on sugar beet, monuron was the only one of four substances tested which showed promise as a residual pre-emergence herbicide. Weed control, except for established couch-grass, was good, but the beet were damaged.

Another trial in 1956, using only monuron, resulted in very poor weed control, especially of chickweed, although no crop damage occurred. The difference in results of these two trials was almost certainly due to the very different amounts of rain which fell within a few weeks of spraying on the two occasions. This dependence on rainfall may prove to be an insuperable problem so far as the pre-emergence broadcast use of monuron is concerned.

A preliminary trial with monuron for pre-emergence control in kale resulted in fair weed control and no kale damage at the lower concentration, and excellent control and severe damage at the higher. It was found possible to afford the crop considerable protection from the effects of the higher concentration by a form of inter-row spray placement. Such a technique might possibly be a solution to the difficulties associated with unpredictable rainfall variation.

Introduction

Monuron has been used in trials under British conditions as a pre-emergence herbicide for row crops since 1952, particularly by Woodford (1953) and Parker (1953, 1954). From these reports it seems likely that large-seeded crop plants and perennial weeds are most resistant, but the extent of weed control and of crop damage depend very largely on the rainfall following the application of monuron. In Parker's (1954) experiments, for example, the kill of beet, using 0.64 lb/ac varied from 0% to 91% under different weather conditions. However, where rain fell within six weeks of spraying, the amount was similar on all sites and no correlation between percentage kill and level of rainfall was attempted. Another factor affecting the action of monuron is the nature of the soil. Since much is already known about this subject under American conditions (e.g. Sherburne and Freed, 1954) and the effect of soil type can be allowed for before spraying, soil variation is less serious an economic hazard than rainfall differences.

It thus appears that two requirements for a successful residual pre-emergence treatment may govern the usefulness of monuron. First, for a given rainfall, there must be a margin of safety between the concentration of herbicide which provides effective weed control and that which is detrimental to the crop. Secondly, there must be sufficient selectivity, over and above the first requirement, to allow for safe yet efficient application of a chosen concentration under different weather conditions following spraying. Parker (1954) concluded that monuron probably was not sufficiently selective and his results are largely supported by the trials described below. More work is however required

to confirm this and, if it should prove to be the case, to ascertain whether it is possible artificially to increase this margin of safety.

The primary object of the present work was to add to existing knowledge of pre-emergence sprays for sugar beet and to extend the investigation to other row crops, particularly the brassicas. Similarity of soil type and, to some extent, of weed flora, on three experimental sites allowed the important effect of varying rainfall to be observed. On two trials the use under purely experimental conditions of an inter-row placement technique as a means of crop plant protection was investigated.

Experimental details and results

1. Pre-emergence weed control in sugar beet, 1955

In a preliminary trial in 1955, the use of TCA (sodium), PCP, CIPC and monuron as residual pre-emergence sprays for sugar beet was investigated. The trial took place on a light sandy loam (80% fine and coarse sand, 10% clay) low in organic matter. Thirty-two plots 4 x 3 yd were sprayed, using a hand syringe, at a volume of 150 gal/ac with varying concentrations.

Less than 0.1 in. of rain fell in the two weeks prior to drilling; subsequent rainfall was heavy, as is shown in Fig. 1. The field was drilled on April 25th and sprayed four days later.

Beet on all treatments appeared to germinate and grow normally for 17 to 20 days, after which treatment differences appeared. 80% monuron was the only herbicide to give effective weed control and even at 0.3 lb/ac gave good control of the important dicotyledons and annual monocotyledons. It was however very toxic to the beet, especially at the higher concentrations used. CIPC at 1 lb/ac controlled the few annual monocotyledons but TCA (sodium) 8 lb/ac and PCP at 2 lb/ac, separately or together, failed to control weeds and had no observable effect on the beet. Similar unsatisfactory control was obtained at the Norfolk Agricultural Station (1955) when PCP was employed as a residual pre-emergence spray.

The results for monuron are given in Table 1, together with the principal weeds occurring on control and treated plots. Throughout this report, the concentrations (or doses) are in terms of lb/ac of 80% monuron.

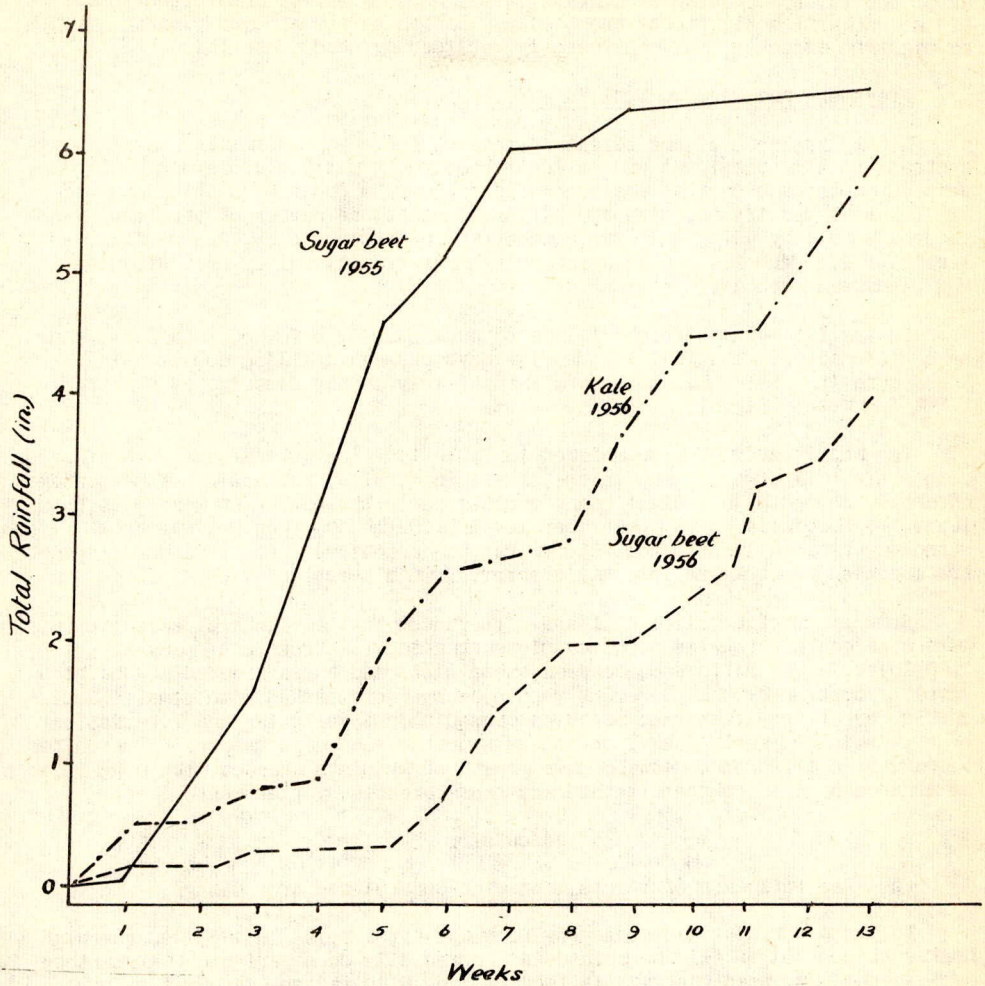
2. Pre-emergence weed control in sugar beet, 1956.

In the light of the experience gained from the 1955 trial, another experiment was carried out in 1956 under similar soil conditions.

80% monuron at 0.12, 0.30 and 0.75 lb/ac was sprayed by hand syringe as before, but each level was applied as a broadcast spray over the whole plot area and as an inter-row placement spray where the crop row was protected by a strip of absorbent paper 4.5 in. wide. Also included were no spray/no hoeing and no spray/hand hoeing plots, making a total of eight treatments randomized over four blocks with individual plots 4 x 3 yd.

In the two weeks before drilling on April 20th, 1.23 in. of rain fell. From then the rainfall was negligible for five weeks (Fig. 1), after which time the amount was considerable. Herbicide was applied four days after drilling.

FIGURE 1 CUMULATIVE RAINFALL FROM THE TIME OF SOWING



The important results are summarized in Table 1, but exclude the effect of placement spraying as it soon became evident that this method was not necessary to protect the beet under the conditions of this trial.

Weed counts were made after five weeks and thereafter control was recorded by estimation of percentage ground cover by weeds. At eight and eleven weeks, weed control was significant statistically for the two higher levels of herbicide, but was by no means sufficient to provide a satisfactorily clean crop,

while at the lowest level the weed population was not significantly less than that on the no spray/no hoeing plots.

Germination and growth of beet appeared normal until 6 - 8 weeks (i.e. after the first appreciable rainfall). Signs of toxicity then appeared but did not significantly reduce the beet population on the sprayed plots. Growth, as might be expected, was considerably retarded by weed competition.

3. Pre-emergence weed control in kale, 1956.

Little is known of the effect of monuron for weed control in brassicas, in contrast to its occasional use in sugar beet. It was therefore decided to lay down an experiment on the same plan as for the 1956 sugar beet trial and under similar soil conditions, with the difference that the number of treatments was reduced to six by using only two concentrations of monuron. Contrasting levels of 0.25 and 1.00 lb/ac were applied after drilling, by both broadcast and placement methods.

In the two weeks before drilling on June 5th, 0.38 in. of rain fell, and an additional 0.78 in. fell in the five days between drilling and spraying. After spraying, rainfall was moderate and fairly evenly distributed over the first few weeks (Fig. 1).

The main results are summarized in Table 1. Statistical analysis of weed counts after five weeks, and later, of weed control by estimation of percentage coverage, showed highly significant reductions in the number of weeds, at both levels of herbicide. At the higher level (1.00 lb/ac), control was to a standard of cleanliness acceptable in farming practice. At the lower concentration weed control was less satisfactory from a practical viewpoint.

Some areas of complete kill and differences in the vigour of kale growth were apparent after three weeks on plots treated with broadcast spray at 1.00 lb/ac. The difference between these plots and those treated at the high level of monuron by the placement method became more marked with time. Broadcast spray at the lower concentration caused slight yellowing and retardation of growth in the early stages but these symptoms soon disappeared. Thereafter there was no difference between kale growth on the plots treated with 0.25 lb/ac of monuron by the broadcast method and those treated by placement.

Discussion

(a) The influence of rainfall on weed control and crop damage.

The most striking fact emerging from the first trial in 1955 was the high degree of control of all the main weeds, especially corn marigold (Chrysanthemum segetum), mayweed (Matricaria inodora) and wild radish (Raphanus raphanistrum), obtained at the low concentration of 0.30 lb/ac of monuron, but this was in a season of heavy and uniform rainfall in the first two months after spraying. In contrast, negligible weed control was achieved in 1956 during unusually dry conditions in the first two months. This is an agreement with Parker's (1954) observations and stresses the importance of unpredictable weather variation. In these two experiments a low concentration of herbicide was as toxic in a wet season as one three or more times as great in a dry season. Therefore, to be sure of successful weed control with a monuron pre-emergence spray, a high concentration is indicated but this is likely to be impracticable since it is also probable that few crops are normally tolerant of

a concentration at least 3 to 6 times as great as would be required to control the weeds commonly found in it. In 1956 a concentration well above 0.75 lb/ac would have been necessary to achieve good weed control in beet, while 0.6 lb/ac in 1955, under wet conditions, reduced the stand of beet by one-third, and left many of the remaining plants stunted.

It is of interest that, judging only by the relatively few results in Table 1, rainfall can be regarded as a "dose", in the same way as can the concentration, i.e. lb/ac of monuron. A concentration - rainfall - response relationship which holds over a considerable range of the variables, can be established. This is illustrated in Fig. 2, where the logarithm of the products of concentration and rainfall are plotted against the probits of the respective percentage weed controls. Rainfall figures for the first three weeks after spraying have been used, since it is probably during this early period that moisture exerts its main effect on monuron toxicity. Weed control figures for six weeks after spraying are used in Fig. 2a. Comparison with the later weed control figures shows that the one anomalous result falls into line when these are used (Fig. 2b), but as would be expected, there is a somewhat greater scatter of points due to the gradually increasing contribution of other variable factors.

The method of probit analysis (Finney, 1952) is a tool frequently employed in insecticide studies, and the relationship noted here to some extent recalls the connexion between concentration and time well known in that field. The relationship could have a certain practical importance. From rainfall figures for the appropriate period of previous years, the mean (M) and its standard error, SE_M, can be found. From $M \pm ySE_M$, an estimate of the maximum and minimum rainfalls can be found for any level of probability. For example, if M=3 and SE_m=0.5, for 19 years in 20 (P=0.05; y=2) the rainfall would be within the range of 2 - 4 in. Hence a twofold difference in effectiveness of a given concentration would have to be allowed for. This rainfall-compensating factor would then have to be multiplied by a safe crop-weed selectivity factor to give the minimum selectivity requirement. Naturally, once in 20 years a higher rainfall than 4 in. or a lower one than 2 in. would be expected, and in this eventuality damage to crop or lack of weed control might occur. However, not only must the provisional nature of these observations be stressed, but it is also worth noting that it is not known whether a given amount of rain in one large downpour has the same effect as an equal amount in several showers.

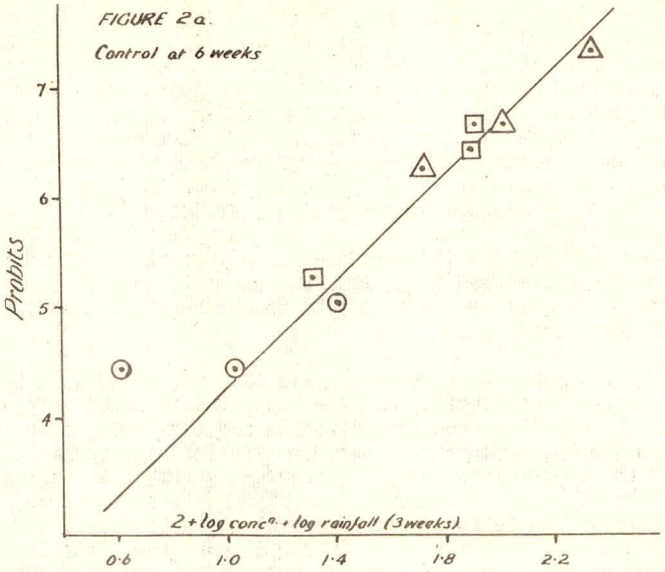
(b) Increased selectivity due to spray placement

The most serious drawback to the commercial use of monuron as a pre-emergence spray is its low selectivity. Apart from the development of urea derivatives which might possess greater selectivity, it is theoretically possible to achieve the same end by protecting the row crop by a placement technique. The use of the technique for certain general contact foliage sprays is well known for beet (e.g. Robbins, Crafts and Raynor, 1952) and Dallyn et al. (1955) report the necessity of directional application of monuron for weed control in onions. The low water solubility of monuron does, however, present a practical difficulty for low volume spraying at the time of drilling or soon after.

Whether or not a suitable placement spray machine can be developed, there is little doubt from the result of the kale trial in 1956 at Reading, that vital protection of the crop was achieved by placement between the rows. In particular, under the conditions of the trial, there was no indication of monuron

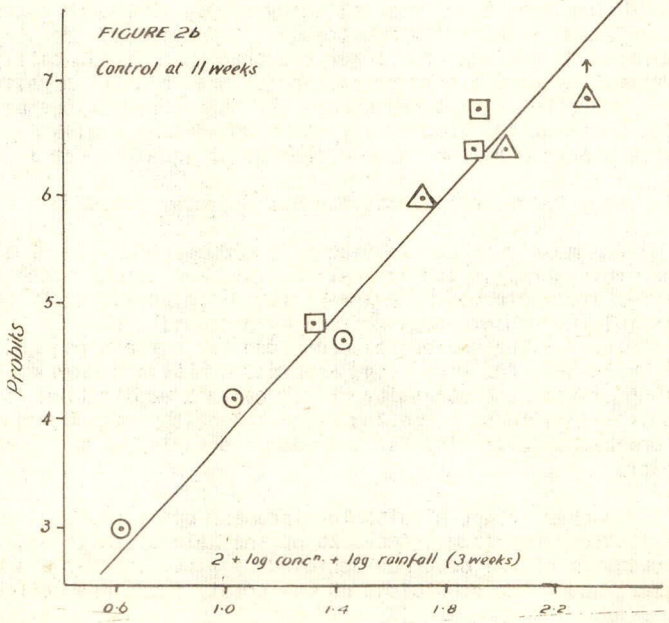
RELATIONSHIP OF WEED CONTROL (IN PROBITS)
TO LOG. (CONCENTRATION x RAINFALL)

FIGURE 2a.
Control at 6 weeks



△ Sugar beet 1955
⊙ Sugar beet 1956
□ Kale 1956

FIGURE 2b
Control at 11 weeks



△ Sugar beet 1955
⊙ Sugar beet 1956
□ Kale 1956

(47011)

being washed inwards to the rows of young kale seedlings in sufficient amounts to be toxic to them during the first few critical weeks. The trial has shown that a level of herbicide which is toxic to the crop when applied as a broadcast spray has little or no effect on the stand of kale, as measured by the number or height of the plants, when placed between the rows. More information is required, and the kale trial, which is still incomplete, must be regarded only as a preliminary one. Certain aspects of pre-emergence spray placement are at present being considered in more detail.

Conclusions

1. The amount of rain falling within 3 - 6 weeks of spraying markedly affects the toxicity of monuron to both weeds and crop. The damage done to both is greater under wet than dry conditions.

2. To achieve satisfactory weed control irrespective of the weather conditions after spraying, the higher concentration necessary for weed control under dry conditions would need to be applied.

3. However, in climates where the rainfall is very variable, wet conditions following the use of this higher concentration would result in high toxicity to the crop unless the selectivity of the monuron were sufficiently great. This in fact seems seldom to be the case.

4. Monuron does not therefore appear to be a safe material to use under British conditions unless the crop can be protected by some means.

5. Over a wide range of the independent variables, there appears to be a connexion between the degree of weed control on the one hand, and the product (monuron concentration x early rainfall) on the other.

Acknowledgments

It is a pleasure to record our thanks to Mr. R. Taylor, B.Sc., who was largely responsible for the 1955 sugar beet trial, and to Dr. J. Tinsley for advice on spray placement. We also wish to thank Miss E. Rolls and Mr. J. May for valuable technical assistance, and the Imperial Chemical Industries for providing the monuron.

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Table 1

Pre-emergence weed control with monuron from 6 to 12 weeks after spraying, and rainfall after 3 and 6 weeks

1	2		3	4			5	6	
Trial	Cumulative rainfall, in.		80% monuron lb/ac	% Control dicotyledons, relative to control = 0			Principal weeds	% Crop damage	
	3 weeks	6 weeks		by plant count 5-6 weeks	by % coverage method 8 weeks	by % coverage method 11 weeks		8 weeks	11-16 weeks
Sugar Beet, 1955.	1.68	5.15	0	0	-	0	Matricaria inodora, Chrysanthemum segetum, Stellaria media, Raphanus raphanistrum, Fumaria officinalis, Papaver rhoeas, Agropyron repens.	-	0
			0.30	89	-	82	S. media, R. raphanistrum, A. repens. Some P. rhoeas, Polygonum aviculare.	-	20
			0.60	95	-	92		-	36*
			1.20	99	-	97	---	-	90*
Kale 1956	0.79	2.60	0	0	0	0	Chenopodium album, Capsella bursa-pastoris, R.raphanistrum	0	0
			0.25	60	63	43		0	5
			1.00	92	90	92	As above	56*	69
			1.00**	95	87	96		7	0
Sugar Beet, 1956	0.34	0.72	0	0	0	0	S. media, R. raphanistrum, P. aviculare, C. album, M. inodora, Sonchus spp., annual grasses.	-	0
			0.12	30	8	2		-	0
			0.30	29	20	19	As above, fewer grasses.	-	0
			0.75	52	56	36		-	0

Note i. Column 4. % Control = $\frac{\text{number of weeds in control - number in sprayed plot}}{\text{number in control}} \times 100$

ii. * Many surviving plants retarded.

iii. ** By inter-row placement.

FARM TRIALS WITH 2,4-DES ALONE AND IN COMBINATION WITH OTHER HERBICIDES FOR THE CONTROL OF WEEDS IN HORTICULTURAL CROPS

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Sodium 2,4-dichlorophenoxyethyl sulphate (2,4-DES) has been widely reported in U.S.A. as an effective pre-emergence herbicide in perennial crops which had no damaging effects on crop plants from drift because the material was inactive until converted to the active state by decomposition in the soil. Some reports have indicated that variable and sometimes poor results were due to unfavourable soil conditions.

Because horticulture has gained virtually none of the benefits but suffered most of the disadvantages from the use of hormone weed-killers, especially from spray-drift, a compound like 2,4-DES appeared to have great interest and value to market-gardeners and nurserymen in the U.K.

An initial screening trial of 2,4-DES with other herbicides in a strawberry runner-bed gave very encouraging results and it was decided to follow with a large number of trials in other horticultural crops. Instead of attempting to carry-out detailed replicated trials on small plots, which had already been done many times in America, the aim in the trials referred to here was fairly large-scale single plot farm trials, using farm equipment, covering as many as possible types of soil, spray-gear, crops and localities.

It became evident during the trials that on certain soils 2,4-DES was being converted so slowly by soil bacteria to the active 2,4-D that the weed seeds were able to germinate and survive during an initial period after application; again in some localities the soil remained so wet that it was not possible to kill established chickweed and some other seedlings by hoeing before applying 2,4-DES. In such situations therefore, the addition of other compounds to 2,4-DES appeared to be necessary to achieve immediate killing powers against germinating weeds, established seedlings and odd pieces of older rooted chick-weed and groundsel. CIPC and fenuron were found to be very useful for this purpose and in situations where the crop was not exposed to a contact-killing spray a mixture of chlorxylenols was of value in destroying small weeds in the same way as that shown for pentachlorophenol, the flame-gun, or tractor paraffin, while leaving the 2,4-DES behind in the soil to prevent any further germination for some weeks.

The trials not only confirmed the American reports of the value of 2,4-DES in favourable soil conditions with an absence of hazard to nearly crops from spray drift, but also indicated the promise of further useful aids to weed control in horticultural crops from new combinations and formulations of herbicides.

Discussions and conclusions

Taking the results as a whole it appeared that 2,4-DES used alone tended to give unreliable pre-emergence weed control in the spring especially when the soil was dry, but weed control performance improved from June onwards and even earlier

in the year in the wetter south-west of U.K. The addition of CIPC, chlorxylenols or fenuron to 2,4-DES caused a marked improvement in weed control, although CIPC was not effective against seedlings of groundsel, which were, however killed by fenuron. The latter herbicide used as a very low concentrated emulsifiable liquid showed exceptionally good promise as an additive to 2,4-DES and in this low concentration should be safe to handle by farm labour, by eliminating to a large extent the possibility of making excessive and damaging dosages of fenuron.

If 2,4-DES were used alone in dry soil, at any period of the growing season, it was apparently essential, to cultivate or hoe thoroughly not longer than one day before spraying, and that not less than 5 or 6 lb/ac should be used per application. 2,4-DES used alone, or in combination with 2 or 4 lb CIPC or 0.5 lb fenuron, or two gal of a 20% chlorxylenol concentrate per acre showed itself to have considerable value for weed control, in several horticultural crops. It was, however, too toxic for use in lettuce, cauliflower, lavender, celery and leeks.

Spray drift from formulations of 2,4-DES alone or in combination with the other compounds caused no apparent damage to closely adjacent crops, including top and soft fruit. This was a feature of very great importance to market gardeners and farmers.

Recommendations

Certain recommendations can be made for the control of annual weeds by 2,4-DES. All formulations should be made in 100 gal/ac water or more. Fenuron, monuron, CIPC or chlorxylenol formulations can cause severe damage to crops if the recommended dosages are grossly exceeded i.e. doubled. Reasonably accurate dosage application should therefore, be ensured by measuring precisely the area traversed when spraying one or two gal of water through the actual nozzles of the actual sprayer to be used, immediately before operations begin on the crop.

Strawberry

Weed control sprays are most effective if begun before planting or during the late summer or autumn when the soil is wet and warm.

Spring-time sprays. 4 lb 2,4-DES plus 2 or 4 lb CIPC immediately following preparation of the soil, followed by planting a few days later; or 6 lb 2,4-DES in third week of May, following cultivation in established bed.

Summer sprays in runner beds. 6 lb 2,4-DES or 4 lb 2,4-DES plus 0.5 lb/ac fenuron, immediately after hoeing following deblossoming. Repeat 6 lb 2,4-DES alone in mid-August if necessary, following hoeing.

Summer sprays in fruiting beds 4 lb 2,4-DES plus 2 lb CIPC or 4 lb 2,4-DES plus 0.5 lb fenuron immediately after cleaning-up operations and cultivation after harvest. The CIPC formulation has an advantage in that it reduces excessive runner formation although giving a temporary check to the plants.

Autumn sprays. As per spring-time procedure for new plantations or post-planting sprays of 6 lb 2,4-DES alone or 4 lb 2,4-DES plus 0.5 lb fenuron.

Gladiolus

4 lb 2,4-DES plus 2 or 4 lb CIPC or 4 lb CIPC plus 0.5 lb fenuron or 4 lb 2,4-DES plus 0.5 lb fenuron immediately following spring planting. In early July, hoe the soil and follow at once with 6 lb 2,4-DES or 4 lb 2,4-DES plus 2 lb CIPC.

Repeat July treatment in late August if necessary. July and later sprays should be directed to the soil and base of the plants.

Herbaceous perennials

Operations should definitely start in late summer or autumn. Immediately following thorough hoeing, apply 6 lb 2,4-DES, or 4 lb 2,4-DES plus 0.5 lb fenuron. If accurate directional sprays can be applied use 4 lb 2,4-DES plus 2 lb CIPC in the alleys only of low bushy plants or to the bases as well of plants on "legs".

Use 6 lb 2,4-DES immediately after hoeing perennials in late May and again in July/August.

Asparagus

Where perennial weeds are established use 2 lb fenuron or 2 lb monuron in mid or late May, as soon as all perennials have completely emerged.

All asparagus should be cut immediately before spraying. Only one spray per annum should be necessary or should be risked.

If only annual weeds are involved, any one of the following formulations may be used instead of the above immediately after the last earthing-up, 4 or 6 lb 2,4-DES plus 0.5 lb fenuron; 4 lb 2,4-DES plus 4 lb CIPC. Repeat if necessary after cutting has finished in late June and again in late summer.

Vegetables and salads

The following recommendations are made with the proviso that other varieties of peas should be checked for tolerance to 2,4-DES.

Broad beans, peas (Onward), runner beans, french beans, sweet corn, after complete emergence of the crop and formation of 2 rough leaves, cultivate or hoe and follow with 6 lb/ac 2,4-DES. If chickweed is very bad in overwintered broad beans, hoe and direct to the plant bases and soil a spray of 4 lb 2,4-DES plus 2 lb CIPC.

Lettuce, cauliflower, leeks and celery are damaged by 2,4-DES.

Acknowledgements

It is a pleasure to extend sincere thanks to all farmers and nurserymen who made such a generous provision of time, labour and machinery for the trials, and, in particular, to those very keen growers like Mr. Ian Ford of Reginald Ford Ltd., Cardiff and Mr. G. T. Duncan of John Waterer, Sons & Crisp, Twyford, Berks., who suffered voluntarily no little loss of crop in the somewhat ruthless efforts to evaluate quickly the possibilities of weed control in different crops.

Editor's Note: This report is an abstract of a more detailed paper submitted by Mr. Bracey. Results of the individual experiments are summarised in the Tables.

Table 1
Strawberry

Crop Variety	Spray Date	Herbicidal Dosage/Acre	Soil Type and Condition	Plot Size and Replicates	% Weed Control	Crop Response	Location
a) Royal Sovereign	10.4.56	2,4-DES 4lb/60 gal (in alleys only)	Loam, dry	6 x 200 yards x 1	80 after 11 weeks	0	Norfolk
b) Cambridge 448	17.4.56	2,4-DES 5 lb/120 gal	Boulder Clay Wet	1 acre x 2	90 after 6 weeks	0	Suffolk
c) Royal Sovereign	3.5.56	2,4-DES 4 lb/200 gal	Keuper Marl, Dry	3 x 15 yards x 1	40 after 4 weeks	0	Dorset
c) Royal Sovereign	3.5.56	2,4-DES 4 lb) CIPC 2 lb) 200 gal	Keuper Marl, Dry	3 x 15 yards x 1	80 after 4 weeks	C	Dorset
d) Talisman	8.5.56	2,4-DES 2 lb) CIPC 2 lb) 200 gal	Keuper Marl, Dry	2 x 24 yards x 1	90 after 5 weeks	C	Gloucester
e) Cambridge 422	10.5.56	2,4-DES 4 lb) CIPC 4 lb) 90 gal (Pre-planting)	Peaty Loam, Dry	32 x 50 yards x 1	90 after 8 weeks	Slight C	Glamorgan
c) Royal Sovereign	19.6.56	2,4-DES 50 lb/200 gal (Over earlier treatment)	Keuper Marl, Dry	3 x 15 yards x 1		0	Dorset
c) Royal Sovereign	19.6.56	2,4-DES 50 lb/200 gal (Over earlier 2,4-DES CIPC plot)	Keuper Marl, Dry	3 x 15 yards x 1		0	Dorset
c) Royal Sovereign	19.6.56	2,4-DES 50 lb/200 gal	Keuper Marl, Dry	3 x 8 yards x 1		0	Dorset
c) Royal Sovereign	30.6.56	2,4-DES 25 lb/200 gal	Keuper Marl Dry	3 x 8 yards x 1		0	Dorset
f) Royal Sovereign	30.7.56	2,4-DES 4 lb) CIPC 2 lb) 100 gal	Keuper Marl, Wet	1 x 60 yards x 1	90 after 5 weeks	C	Somerset
f) Royal Sovereign	30.7.56	2,4-DES 6 lb/100 gal	Keuper Marl, Wet	1 x 60 yards x 1	90 after 5 weeks	0	Somerset
f) Royal Sovereign	30.7.56	2,4-DES 4 lb) fenuron 0.5 lb) 100 gal	Keuper Marl, Wet	1 x 60 yards x 1	90+ after 5 weeks	0	Somerset

0 = no effect C = checked followed by later recovery S = severe, crop badly stunted, deformed or killed.

Table 2

Gladiolus

Crop Variety	Spray Date	Herbicidal Dosage/Acre	Soil Type and Condition	Plot Size and Replicates	% Weed Control	Crop Response	Location
Bo-Peep Statuette	4.5.56	2,4-DES 5 lb/200 gal	Alluvium, Dry	2 x 6 yards x 1	60 after 9 weeks	0	Cornwall
Bo-Peep Statuette	4.5.56	2,4-DES 4 lb) CIPC 4 lb) 200 gal	Alluvium, Dry	2 x 6 yards x 1	80 after 9 weeks	0	Cornwall
Bo-Peep Statuette	4.5.56	Dalapon 5 lb/200 gal	Alluvium, Dry	2 x 6 yards x 1	30 after 9 weeks	0	Cornwall
Bo-Peep Statuette	4.5.56	CIPC 8 lb/200 gal	Alluvium, Dry	2 x 6 yards x 1	60 after 9 weeks	0	Cornwall
Bo-Peep Statuette	4.5.56	2,4-DES 2 lb) CIPC 2 lb) 200 gal	Alluvium, Dry	2 x 6 yards x 1	60 after 9 weeks	0	Cornwall
Cornish Queen	4.5.56	2,4-DES 5 lb/200 gal	Alluvium, Dry	0.33 x 6 yards x 1	60 after 9 weeks	0	Cornwall
Cornish Queen	4.5.56	2,4-DES 2 lb) CIPC 2 lb) 200 gal	Alluvium, Dry	0.33 x 6 yards x 1	70 after 9 weeks	0	Cornwall
Cornish Queen	4.5.56	CIPC 8 lb/200 gal	Alluvium, Dry	0.33 x 6 yards x 1	70 after 9 weeks	0	Cornwall
Cornish Queen	4.5.56	2,4-DES 4 lb) CIPC 4 lb) 200 gal	Alluvium, Dry	0.33 x 6 yards x 1	90 after 9 weeks	0	Cornwall
Bo-Peep Statuette	3.7.56	2,4-DES 4 lb) CIPC 4 lb) 100 gal	Alluvium, Dry	1.33 x 45 yards x 1	80 after 9 weeks	0	Cornwall
Bo-Peep Statuette	3.7.56	2,4-DES 5 lb/100 gal	Alluvium, Dry	1.33 x 45 yards x 1	80 after 9 weeks	0	Cornwall
Dutch various	27.7.56	2,4-DES 4 lb) CIPC 2 lb) 100 gal	Clay with flints wet	2 x 7 yards x 1	70 after 6 weeks	0	Wiltshire
Dutch various	27.7.56	2,4-DES 4 lb) CIPC 4 lb) 100 gal	Clay with flints wet	2 x 7 yards x 1	70 after 6 weeks	0	Wiltshire
Miniatures various	27.7.56	2,4-DES 4 lb) fenuron 0.5 lb) 100 gal	Clay with flints wet	2 x 7 yards x 1	90 after 6 weeks	0	Wiltshire
Beauty's Blush	27.7.56	CIPC 4 lb) fenuron 0.5 lb) 100 gal	Clay with flints wet	2 x 7 yards x 1	90 after 6 weeks	0	Wiltshire

Table 3

Herbaceous perennials and shrubs

Crop Variety	Spray Date	Herbicidal Dosage/Acre	Soil Type and Condition	Plot Size and Replicates	% Weed Control	Crop Response	Location
Rosa canina	19.4.56	2,4-DES 6 lb/50 gal	Loam, dry	1 x 157 yards x 1	20 after 6 weeks	0	Berkshire
Standard Roses various	19.4.56	2,4-DES 4 lb/200 gal	Loam, dry	1 x 15 yards x 1	20 after 6 weeks	0	Berkshire
Iris, bearded	19.4.56	2,4-DES 4 lb/200 gal	Loam, dry	1 x 25 yards x 1	20 after 6 weeks	0	Berkshire
Iris, bearded	19,4.56	2,4-DES 4 lb/50 gal	Loam, dry	1 x 25 yards x 1	20 after 6 weeks	0	Berkshire
Liquidambar sp.	23.4.56	2,4-DES 8 lb/200 gal	Sandy peat, dry	0.5 x 12 yards x 2	0 after 6 weeks	0	Surrey
Cornus sp.	23.4.56	2,4-DES 8 lb/200 gal	Sandy peat, dry	0.5 x 12 yards x 2	0 after 6 weeks	0	Surrey
Aronia sp.	23.4.56	2,4-DES 8 lb/200 gal	Sandy peat, dry	0.5 x 12 yards x 2	0 after 6 weeks	0	Surrey
Quercus sp.	3.4.56	2,4-DES 8 lb/400 gal	Sandy peat, dry	0.5 x 12 yards x 2	0 after 6 weeks	0	Surrey
Crab Seedlings	3.4.56	2,4-DES 8 lb/400 gal	Sandy peat, dry	0.5 x 12 yards x 2	0 after 6 weeks	0	Surrey
Gibbs Golden Gage	3.4.56	2,4-DES 8 lb/400 gal	Sandy peat, dry	0.5 x 12 yards x 2	0 after 6 weeks	0	Surrey
Azalea mollis simensis	3.4.56	2,4-DES 4 lb/200 gal	Sandy peat, dry	0.5 x 12 yards x 2	0 after 6 weeks	0	Surrey
Fallow ground	3.4.56	CIPC 8 lb/100 gal	Sandy peat, dry	4 x 12 yards x 1		-	Surrey
Rosa canina	12.6.56	2,4-DES 4 lb) fenuron 0.5 lb) 200 gal	Loam, dry	1 x 12 yards x 4	90 after 6 weeks	0	Surrey
Rosa canina	12.6.56	2,4-DES 4 lb) CIPC 8 lb) 200 gal	Loam, dry	1 x 12 yards x 4	90 after 6 weeks	S	Surrey
Verbascum	21.6.56	2,4-DES 4 lb/100 gal	Loam, wet	1 x 10 yards x 4		0	Berkshire
Verbascum	21.6.56	2,4-DES 4 lb) CIPC 2 lb) 100 gal	Loam, wet	1 x 10 yards x 4		S	Berkshire
Anchusa	21.6.56	2,4-DES 4 lb/100 gal	Loam, wet	1 x 10 yards x 5		0	Berkshire
Anchusa	21.6.56	2,4-DES 4 lb) CIPC 2 lb) 100 gal	Loam, wet	1 x 10 yards x 5		S	Berkshire
Kniphofia	23.6.56	2,4-DES 6 lb/200 gal	Loam, wet	1 x 10 yards x 1	90 after 4 weeks	0	Berkshire
Erigeron	23.6.56	2,4-DES 6 lb/200 gal	Loam, wet	1 x 10 yards x 1	90 after 4 weeks	0	Berkshire
Sedum	23.6.56	2,4-DES 6 lb/200 gal	Loam, wet	1 x 10 yards x 1	90 after 4 weeks	0	Berkshire
Peony	23.6.56	2,4-DES 6 lb/200 gal	Loam, wet	1 x 10 yards x 3	90 after 4 weeks	0	Berkshire
Lavender	30.7.56	2,4-DES 6 lb/300 gal	Loam, wet	0.5 x 15 yards x 12	90 after 6 weeks	S	Berkshire

Table 4

Asparagus

Crop Variety	Spray Date	Herbicidal Dosage/Acre	Soil Type and Condition	Plot size and Replicates	% Weed Control		Crop Response	Location
					After 7 weeks			
					Annuals	Perennials		
Asparagus	23.5.56	Monuron 2 lb/200 gal	Sandy, dry	2 x 48 yards x 1	90+	90+	0	Norfolk
Asparagus	23.5.56	Fenuron 2 lb/200 gal	Sandy, dry	2 x 48 yards x 1	90+	90+	0	Norfolk
Asparagus	23.5.56	20% Chlorxylenols 2 gal) 2,4-DES 4 lb) In 200 gal	Sandy, dry		80	0	0	Norfolk
Asparagus	23.5.56	Dalapon 10 lb) 2,4-DES 4 lb) 200 gal	Sandy, dry		0	0	0	Norfolk
Asparagus	23.5.56	CIPC 2 lb) 2,4-DES 4 lb) 200 gal	Sandy, dry		80	0	0	Norfolk
					After 6 weeks			
					Annuals	Perennials		
Asparagus	29.5.56	Fenuron 1 lb) Dalapon 4 lb) 60 gal	Sandy, wet	6 x 100 yards x 1	90	0	0	Norfolk
Asparagus	29.5.56	Monuron 1 lb/60 gal	Sandy, wet		90	0	0	Norfolk
Asparagus	29.5.56	Fenuron 1 lb/30 gal Diesel	Sandy, wet		90	0	0	Norfolk
Asparagus	29.5.56	CIPC 4 lb) 2,4-DES 4 lb) 60 gal	Sandy, wet		90	0	0	Norfolk
Asparagus	29.5.56	20% Chlorxylenols 2 gal 2,4-DES 6 lb	Sandy, wet		90	0	0	Norfolk

Table 5

Vegetables and salads

Crop Variety	Spray Date	Herbicidal Dosage/Acre	Soil type and Condition	Plot Size and Replicates	% Weed Control	Crop Response	Location
Lettuce, May Queen	5.3.56	2,4-DES 4 lb/50 gal	Loam, dry (Greenhouse)	1 x 30 yards x 4	50 after 3 weeks	S	Sussex
Cauliflower A.7. Round	9.5.56	2,4-DES 2 lb) CIPC 8 lb) 200 gal	Alluvium, wet	5 x 10 yards x 1	70 after 5 weeks	S	Glamorgan
Lettuce, Bore Wonder	9.5.56	CIPC 8 lb/200 gal	Alluvium, wet	2 x 24 yards x 1		0	Glamorgan
Pea, Onward	9.5.56	2,4-DES 6 lb/200 gal	Alluvium, wet	3 x 24 yards x 1	90 after 5 weeks	0	Glamorgan
Broad Bean	9.5.56	2,4-DES 6 lb) CIPC 4 lb) 200 gal	Alluvium, wet	2 x 24 yards x 1	90 after 5 weeks	See text	Glamorgan
Leek	9.5.56	2,4-DES 6 lb/200 gal	Alluvium, wet	3 x 24 yards x 1	90 after 5 weeks	S	Glamorgan
Celery	15.6.56	2,4-DES 4 lb/200 gal	Alluvium, wet	2 x 12 yards x 1	90 after 4 weeks	S	Glamorgan
Runner Bean	15.6.56	2,4-DES 6 lb/100 gal	Dutch light frame, wet	2 x 30 yards x 1	90 after 6 weeks	0	Glamorgan
French Bean	15.6.56	2,4-DES 6 lb/100 gal	Dutch light frame, wet	2 x 30 yards x 1	90 after 6 weeks	0	Glamorgan
Sweet Corn	20.6.56	2,4-DES 6 lb/100 gal	Dutch light frame, wet	1 x 2 yards x 1	90 after 6 weeks	0	Wiltshire

DISCUSSION ON THE PREVIOUS THREE PAPERS

Mr. J. L. Hunt (Introduction to discussion)

The first paper in this series dealing with weed control in row crops, reviews the performance of a PCP 12% miscible oil product which has been used extensively during the past two seasons, as a contact pre-emergence herbicide on a variety of vegetable and arable farm crops.

It is pointed out in the paper that this miscible oil formulation of PCP was selected as being most suitable for general use on farms and market gardens, for this purpose, taking into account efficiency, safety, convenience of handling and cost, after comparison with a number of other herbicidal compounds and formulations. These included petroleum oils, petroleum oils fortified with PCP, DNC oil emulsions, and dinoseb (ammonium).

It is clear that this type of weedkiller is essentially one for contact, as opposed to residual, pre-emergence weed control. It must be applied as near as possible to the time of crop emergence consistent with safety, so that a large proportion of the annual weeds will have emerged. There is, however, apparently a limited residual effect, as evidenced by the fact that the time during which the seed bed can be kept free from weeds may be lengthened by increasing the rate of application, in certain conditions. This effect, however, is only limited, and application before many weeds have emerged is unsatisfactory.

This necessity for accurate timing obviously imposes limitations on the practical use of this type of product.

Rates of application which have been found satisfactory in practice are from 3-5 lb/ac PCP in from 30 to 50 gal/ac of water. There appears to be no advantage in increasing the volume of water above about 50 gal/ac but volumes below 30 gal/ac have sometimes proved unreliable with existing spraying machines.

PCP at 3 lb/ac appears to be quite adequate on light and medium mineral soils, and where there is a predominance of weeds such as charlock and wild radish which germinate fairly evenly. With species such as knotgrass and willow weed and with organic fen soils, 5 lb will often give better results.

Crops which have proved most suitable for this type of application are sugar beet, fodder beet, mangolds, beans, peas, potatoes, and also kale if drilled in a stale seed bed. With most small seeded and shallow drilled crops, such as lettuce, main crop onions, carrots, some early check and thinning of the crop is not uncommon, and is invariably associated with light soils and heavy rain shortly after application. These adverse effects have seldom been more than temporary, but with these crops it is considered advisable not to exceed 3 lb/ac. It is noted in the paper that red beet and spring onions are not suitable for treatment. In the conclusions in this paper, the most promising conditions for worth-while application of this herbicide are noted.

These are:-

1. Early sowings of sugar beet and other crops, when the longest interval between weed and crop emergence may be expected, and when there has been less opportunity to destroy weed seedlings by thorough seed bed preparation.

2. After a spell of cold weather, when crop seedlings are emerging slowly.

3. On particularly weedy fields when there is a possibility of the crop being submerged by early weed growth.

4. When quick germinating weeds predominate.

It is considered that the method is of less value on late sowings in good growing weather, when both crop and weeds emerge rapidly.

The second paper in this group (B 15), deals with an investigation into the possibilities of residual pre-emergence weed control in sugar beet and kale, and is based on trials carried out in 1955 and 1956.

Herbicides tested in these trials were - TCA (sodium), PCP, CIPC and monuron. Application of all herbicides was made four days after drilling the crop.

In these circumstances, and at the rates used it was found that TCA, PCP and CIPC, had little if any effect on either weeds or crop, indicating that they were not suitable for residual pre-emergence purposes, when used at these rates.

The performance of monuron, on the other hand, was very different, and undoubtedly the most notable feature of this paper is its report of the striking effect of rainfall during the 3-6 week period immediately following spraying, on the toxicity of monuron to both weeds and crop.

The trials demonstrated that with abundant rainfall during this 3-6 week period, effective control of both grass and broad-leaf weeds was obtained with 0.3 lb/ac monuron but the crop sustained severe damage. When a negligible amount of rain fell during the same period after spraying, the crop was undamaged, but weed control was very inferior.

To both weeds and crop in these two experiments a low concentration was 3 or 4 times more toxic in a wet season than a high concentration as in a dry season.

It is concluded, therefore, that monuron is not a safe material to use in this country, for this purpose, owing to its very variable performance.

It should be noted, I think, that these trials were carried out on light soils, and one wonders whether more satisfactory and consistent results might not have been obtained with heavier soils or those with a higher content of organic matter.

This paper also reports that damage to kale was avoided by placement of applications of the spray between the rows. It was apparent that monuron applied in this manner did not move laterally in the soil to a sufficient extent to damage the kale during the early stages of growth. The practical drawback which I see to this technique is that weeds in the rows would not be controlled and this surely is one of the main attractions of any form of chemical weed control.

The third paper in this series is a report by Mr. Paul Bracey on farm trials with 2,4-DES, used alone and in combination with certain other compounds, for control of weeds in horticultural crops. Crops included in the report are

strawberries, gladiolus, herbaceous perennials, and a variety of vegetables. Of these, it is reported that Onward pea, broad runner, French bean and sweet corn may be treated with 6 lb 2,4-DES, from the two rough leaf stage. Lettuce, cauliflower, leek and celery are reported as being susceptible. Recommendations are also made for the treatment of asparagus.

Mr. Bracey's observations indicate that weed control with 2,4-DES alone is often unreliable, particularly with dry soils and low soil temperatures in the spring, when the process of conversion of 2,4-DES into 2,4-D in the soil, is slow. In these conditions, germinating weeds grow beyond the susceptible stage before the herbicide becomes active. 2,4-DES is also unable to cope with weeds which previous cultivation has failed to kill, notably chickweed in wet weather, and the importance of cultivating thoroughly immediately before applying the weedkiller in dry weather is emphasised.

Suggestions contained in the paper for adding such compounds as CIPC and fenuron to 2,4-DES, in order to overcome this difficulty are interesting, and perhaps other people here may be able to provide some further evidence from their own experience, in confirmation of this practice. It would seem from the paper that fenuron is the most promising additive.

Dr. W. S. Rogers

We have carried out replicated experiments with 3 and 5 lb/ac 2,4-DES on strawberries this year and, with applications in April, May and August have obtained good control of weeds, especially at 5 lb/ac, with no reduction in crop, no appreciable damage to the plants and no reduction in size of plants. The fruit appeared to ripen slightly earlier on the sprayed plots possibly because of shading by the weeds on the control plots. One point worth making is that people appear to be rather reticent about cost of this weedkiller and I think this treatment did not save us anything in comparison with hoeing by hand.

Mr. D. W. Robinson

Regarding the use of CIPC for pre-planting in strawberries, I would like to know if in both experiments carried out by Mr. Bracey, runners were planted out from pots; because where strawberry runners were planted in the usual manner I have seen very severe injury with CIPC at 3 lb/ac with damage to 45% of the plants and death to 40%. The activity of CIPC is affected by climatic conditions etc. and it would appear that great care will have to be taken with this chemical applied pre-planting.

Mr. P. Bracey

In the case mentioned, the strawberry runners were certified ultimately as reaching the standard of health and vigour required by the Ministry. There was an initial check but it soon wore off. An advantage of pre-planting spraying is that you do cover the whole of the ground including those parts which would normally be covered by leaves. Only one experiment was made with spraying before planting and in this the plants were in a ball of soil.

CIPC should not be applied on to plants for runner production during the growing season; and on fruiting plants an optimum time for application is immediately after mowing or burning-off the beds after harvest, when the plantation has been cleaned up.

Mr. M. J. Zwijns

I would stress the point that when weedkilling in strawberries, everyone has to be very careful. Together with my colleagues, I have been doing some weedkilling in strawberries for many years; we have found that 2 years after treatment there could be some check in the harvest of strawberries, so do not draw conclusions too quickly.

Dr. W. S. Rogers

Could the last speaker confirm whether he used CIPC or 2,4-DES?

Mr. M. J. Zwijns

I would say both.

Dr. K. A. Hassall

When we undertook our investigations we thought that rain following placement might have one of three effects. (1) The chemical if loosely adsorbed on soil, might be washed laterally so as to destroy the crop before it had developed beyond the initial sensitive stage; with insoluble monuron under our conditions this did not occur. (2) Following appreciable rainfall a strongly adsorbed chemical might be washed directly downwards. Both crop and weeds within the rows would then escape damage and Mr. Hunt's criticism would be quite justified. (3) A fanwise wash-down might occur slowly, the chemical being fairly strongly adsorbed on to the soil. If this happened, the crop could be beyond the susceptible phase by the time the substance had penetrated into the rows, while sensitive and later-germinating weeds could be weakened. It is believed that this is what occurred in the present tests.

The final yield figures for kale have just come in. Expressing the weight of kale on the fully cultivated, hoed plot as a hundred, the percentage on the other plots were as follows:-

No treatment - 46%. 0.25 lb/ac monuron broadcast - 77% plus a large selection of weeds most of which produced seeds. 1 lb/ac monuron broadcast - 45% i.e. a yield as low as on the untreated plots but here there were no weeds. 1 lb/ac by placement method - 80% and no or very few weeds present.

Mr. W. van der Zweep

We have observed that chemicals which decompose in the soil to 2,4-D may decrease perennial weeds - creeping thistle and coltsfoot emerging subsequently were checked in growth.

Mr. P. Bracey

I have made that observation in my full report - creeping thistle (no information on coltsfoot) was severely damaged by 2,4-DES and was in some cases killed completely. The residual toxic action mentioned by the last speaker might be due to his lower soil temperatures, because nothing like it has been experienced in my field trials.

Mr. F. A. Roach

I have noticed that bindweed has been checked by 2,4-DES but it recovered the next year.

Mr. A. Bylterud

Has anyone tried propham in strawberries? It seems to be safer than CIPC.

Mr. D. W. Robinson

I can support the previous speaker - in our experiments on Climax strawberries we had less injury with propham than with CIPC.

Dr. F. H. Feekes

Our experiments with strawberries have included combination with sodium isopropyl xanthate which we have added in practice in Holland for several years but there was a difference in susceptibility of different varieties of strawberries - for instance, variety Madame Moutôt was more susceptible than Jucunda or Deutsch Evern and because of this and other difficulties we have now stopped this application in general practice. A difference in susceptibility between different strains of the same variety (Madame Moutôt) has also been found.

THE USE OF 2,4-DES (SODIUM 2,4-DICHLOROPHENOXYETHYL SULPHATE) TO CONTROL WEEDS IN STRAWBERRIES

F. A. ROACH, N.A.A.S. Provincial Fruit Advisory Officer, South-West (Bristol)

Summary

1. This report covers the results of trials carried out from 1953 to 1956 on the use of 2,4-DES to control weeds in strawberry runner beds and fruiting plantations.

2. 2,4-DES is used as a spray on the soil surface and apparently requires rather warm, moist conditions in the soil for its conversion to the active weedkiller 2,4-D. Provided the ground is free of weeds at the time of application, it will give a reasonable control of most annual dicotyledonous weeds for a period of one to two months depending on the weather conditions. Control of grass seedlings is variable and it is not effective against established annual or perennial weeds. Under dry soil conditions it has been found that its activity as a weedkiller is considerably delayed until rainfall leads to moister soil conditions.

3. Since 2,4-DES gives little control of established weed seedlings it is best applied a few days after cultivations have been carried out. In these trials, the 2,4-DES has generally been used at high volume, equivalent to 200 gallons per acre, but equally good results are obtained with 50 and 100 gallons per acre, provided the whole soil surface is adequately covered by the spray.

4. Application rates of 2½, 5 and 7½ lb. of 2,4-DES per acre have been used. Control of weeds given by 2½ lb., although always considerably better than the controls, has been somewhat variable; 5 lb. has consistently given satisfactory results and there seems no need to go to higher rates. In practice, intermediate rates of 3 and 4 lb. per acre have often given adequate weed control.

5. No permanent symptoms of damage to strawberry plants or runners occurred with Climax, Royal Sovereign, Cambridge Prizewinner or Red Rich strawberries. There has sometimes been slight temporary twisting of the runners and a suggestion of a reduced runner production in one case where monthly applications of 2,4-DES were made to runner beds. One instance of damage where 2,4-DES was used on Cambridge Favourite strawberries has been seen in commercial practice. There have occasionally been reports of a check to strawberry plants where this material has been employed, though such has never been observed in these trials.

INTRODUCTION

It is commonly recognised that the control of weeds in both fruiting plantations and strawberry runner beds can involve the use of much labour and, if suitable chemicals could be found for use in this crop, there would be a considerable saving in expenditure.

The introduction of 2,4-DES (Crag Herbicide No.1) in the United States and its use in strawberry plantations has proved valuable to the commercial strawberry growers in that country. 2,4-DES is not, itself, absorbed by the plants but is apparently broken down on the soil surface, as the result of bacterial activity, to the active weedkiller 2,4-D. The conversion of 2,4-DES to 2,4-D is dependent on the supply of adequate moisture and a reasonably high temperature. For this reason, it has been found that during dry weather it may remain unconverted and so be able to act as a weedkiller when moister conditions return, at which time also weed seeds are more likely to germinate. Normally, this material is regarded as providing weed control for a period of three to four weeks. Since it is only of use in controlling weed seeds as they germinate or in destroying very small seedlings, it is best applied to the soil surface a few days after cultivations have been carried out.

Preliminary trials with 2,4-DES were started with strawberries in the South-West in 1953 and have been continued up to the present time. Information was sought as to the best rates of application per acre of the material, in addition to information on any effects of the spraying on the strawberry plants and, of course, its value for weed control purposes.

EXPERIMENTAL RESULTS

Use of 2,4-DES for the Control of weeds on uncropped land

In 1954, in order to obtain some information on the control of particular weed species, a trial was laid down at Bristol consisting of six uncropped plots, each 4 ft. sq. The ground was cultivated to remove weeds and the first application of 2,4-DES at 5 lb. per acre in 200 gallons of water was made to three of the plots on the 14th May. The remaining three plots served as controls. The spray applications were repeated at the same rate on the 14th June and the 26th July. No intermediate cultivations were made and existing weeds were left undisturbed.

The weed populations in the different plots several weeks after treatment are given in Table 1.

In another series of plots where there was a higher weed population, 2,4-DES used at 7½ lb. to the acre gave the results shown in Table 2.

As will be seen, the predominant weed in these plots was Fat hen which was practically 100% controlled by 2,4-DES, as was White clover, Cranesbill and Groundsel.

The miscellaneous weeds in the plots consisted of Dandelion (Taraxacum officinale), Greater plantain (Plantago major), Charlock (Sinapis arvensis), Annual nettle (Urtica urens), Treacle mustard (Erysimum cheiranthoides) Knotgrass (Polygonum aviculare) and Corn buttercup (Ranunculus arvensis). The trial showed that a good control of annual weeds can be obtained by monthly applications of 2,4-DES using either 5 or 7½ lb.

Table 1. Effect of 2,4-DES applied at the rate of 5 lb. per acre on several weec species

Weed	Average number of weeds per plot					
	Dates of spraying					
	14. 5.54		14. 6.54		26. 7.54	
	Dates of count					
	25. 6.54		26. 7.54		18. 8.54	
	Control	Sprayed	Control	Sprayed	Control	Sprayed
Fat hen (Chenopodium album)	12	1	13	-	9	1
White clover (Trifolium repens)	5	-	11	-	15	-
Cranesbill (Geranium molle)	4	-	3	-	4	-
Groundsel (Senecio vulgaris)	3	-	5	1	5	-
Grass (Poa annua)	1	1	2	1	1	1
Annual sowthistle (Sonchus oleraceus)	3	1	3	1	3	-
Miscellaneous	9	2	11	1	12	1
Totals	37	5	48	4	49	3

Table 2. Effect of 2,4-DES applied at the rate of 7½ lb. per acre on several weed species

Weed	Average number of weeds per plot					
	Dates of spraying					
	14. 5.54		14. 6.54		26. 7.54	
	Dates of count					
	25. 6.54		26. 7.54		18. 8.54	
	Control	Sprayed	Control	Sprayed	Control	Sprayed
Fat hen (Chenopodium album)	111	2	34	-	43	-
White clover (Trifolium repens)	2	-	12	-	12	-
Cranesbill (Geranium molle)	4	-	3	-	2	-
Groundsel (Senecio vulgaris)	2	-	3	-	5	-
Grass (Poa annua)	1	-	1	-	2	-
Annual sowthistle (Sonchus oleraceus)	4	-	7	1	6	1
Miscellaneous	7	1	13	2	12	2
Totals	131	3	73	3	82	3

Use on fruiting strawberry beds

During 1953, trials were carried out in Cheddar on 1-year old beds of Royal Sovereign strawberries. Three rates of application, i.e. 2½, 5 and 7½ lb. of 2,4-DES were used in 200 gallons of water per acre, applied on 7th August following hoeing of the beds. The results obtained are given in Table 3.

Table 3. Effect of 2,4-DES on weeds in a 1-year old bed of Royal Sovereign Strawberries

Rate of application, pounds per acre	Weed count per plot (six sq. ft.) one month after spraying			
	Groundsel (Senecio vulgaris)	Speedwell (Veronica chamaedrys)	Annual Meadow grass (Poa annua)	Misc.
2½	6	5	20	-
5	2	8	12	1
7½	-	1	48	2
Control	73	1	55	8

It will be seen in this trial that control of grass by 2,4-DES was variable and, as in other trials where there were weed seedlings of any size, the herbicide proved ineffective in destroying them. The strawberry plants were unaffected as a result of the spraying.

In another trial in 1953, carried out in Cornwall on a 4-year old bed of Huxley, applications of 2,4-DES were made to see their effect in controlling autumn weeds. The ground was clean cultivated before application of the herbicide which was used at 2½, 5 and 7½ lb. in 200 gallons of water per acre. Two sections of the field were sprayed, one on the 8th October and the other on the 15th October. Weed counts made on the 4th and 25th November are summarised in Table 4.

Table 4. Effect of 2,4-DES on autumn weeds in a 4-year old bed of the variety Huxley

Date of spraying	Rate of application pounds per acre	Average weed count per 144 sq. in.	
		4th November	25th November
8th October	2½	30	7
	5	3	5
	7½	4	4
15th October	2½	4	4
	5	4	2
	7½	15	4
Controls	Nil	71	52

The principal weeds in this trial were Speedwell (Veronica chamaedrys), Scarlet pimpernel (Anagallis arvensis), Chickweed (Stellaria media), Annual meadow grass

(Poa annua), Groundsel (Senecio vulgaris) and Parsley piert (Alchemilla arvensis). Speedwell, Groundsel and Chickweed were successfully controlled but grass and Scarlet pimpernel less effectively, though the overall control of weeds was regarded as quite satisfactory. There was no definite indication of damage to the strawberry plants.

In 1956, 5 lb. of 2,4-DES in 200 gallons of water to the acre applied to a 2-year old fruiting bed of Cambridge Prizewinner in late April, kept the sprayed areas comparatively free of weeds until after picking of the crop had been completed at the end of June; a striking contrast to the control plots which became choked with weed growth. There was no observable damage to the strawberry plants or any effect on the crop in the sprayed areas.

Use on strawberry runner blocks

In 1954, at Bristol, monthly applications of the herbicide were applied to 4 ft. sq. runner blocks of the variety Red Rich strawberry. The blocks were clean cultivated until the 26th May, when the first spray application was made at a rate of 5 lb. in 200 gallons of water per acre. No cultivations after the initial ones were carried out and spraying was repeated on June 28th, July 28th and August 28th.

The results obtained in this trial are given in Table 5.

Table 5. The effect of monthly applications of 5 lb. per acre of 2,4-DES on weeds of strawberry runner blocks

Date of spraying	Date of count	Average weed count per plot	
		Control	Sprayed
26. 5.54	-	-	-
28. 6.54	28. 6.54	25	8
28. 7.54	28. 7.54	40	9
28. 8.54	28. 8.54	46	10
-	27. 9.54	54	11

This trial showed that a fairly good control of the following weeds was obtained by spraying at monthly intervals with no cultivations whatsoever:-

Fat hen (Chenopodium album)
Groundsel (Senecio vulgaris)
Chickweed (Stellaria media)
Dandelion (Taraxacum officinale)
Cranesbill (Geranium molle)
Dock (Rumex obtusifolius)
Speedwell (Veronica chamaedrys)
White clover (Trifolium repens)
Annual meadow grass (Poa annua)
Buttercup (Ranunculus repens)

No observable damage was done to the strawberry plants but there was some indication that monthly spraying reduced the production of runners.

In 1955, in a trial at Cheddar, where 2,4-DES at 4 and 5 lb. in 200 gallons of water per acre was used on Royal Sovereign and Cambridge Prizewinner runner beds, one series of plots was sprayed twice on the 27th June and the 18th July, and another series had an additional application on the 8th August. No intermediate cultivations were given and there was little germination of weed seeds until early October when rain and warm weather aided rapid germination. The results of a weed count made on the 12th October are given in Table 6.

Table 6. Effect of repeated applications of 2,4-DES on weeds in runner beds of the varieties Royal Sovereign and Cambridge Prizewinner

Dates of spraying	Rate of application pounds per acre	Average weed count per 4 sq. ft. on 12th October, 1955
27th June) 18th July) 8th August)	5	17
27th June) 18th July)	5	22
27th June) 18th July) 8th August)	4	57
27th June) 18th July)	4	33
Controls	-	224

On lifting the runners from this trial for planting out, it was noted that the well rooted ones on the treated plots did not have such healthy roots as the well rooted ones on the controls and it also appeared that the number of first grade runners produced on the treated plots was not so high as on the controls. There was however no difference in the appearance, during the following summer, of strawberry beds planted up with runners from either the sprayed or control plots.

The use of butyric herbicides on strawberries

In 1955, trials were carried out to study the comparative effect of 2,4-DES and the substituted phenoxy herbicides on strawberry plants. One such trial was made at the Ellbridge Horticultural Station in Cornwall by Mr. D. J. Fuller, on an established bed of Cambridge Prizewinner strawberries which had been planted in the autumn of 1952, the materials used being:-

2,4-DES	5 lb. per acre
2,4-D (Amine)	½, 1 & 2 " " "
2,4-DB	½, 1 & 2 " " "
MCPA (Sodium salt)	½, 1 & 2 " " "
MCPB	½, 1 & 2 " " "

One application at 100 gallons per acre dilute spray of each of the materials was made after the strawberry crop had been picked and the ground had been clean cultivated. 2,4-DES was applied on the 9th August since it was the intention to try and compare this pre-emergence herbicide with the other materials applied at a later date. Owing to the dry weather, practically no weeds had germinated following the cultivation when the bed was cleaned up and an application of 2,4-D, 2,4-DB, MCPA and MCPB was made on the 20th August to note the effect of these materials on the strawberry plants. Apart from the effect of the herbicides on the plants themselves, records were kept of weed growth. (Table 7).

Table 7. Effect of several herbicides on weeds in an established bed of the variety Cambridge Prizewinner

Material	Application Rate pounds per acre	Total Dicotyledonous seedlings per 4 ft. sq. plot		Total Gramineaeous seedlings (mainly Poa annua) per 4 ft. sq. plot	
		Plot I	Plot II	Plot I	Plot II
2,4-DES	5	1	Nil	2	5
2,4-D	½	77	5	140	14
"	1	18	73	Numerous	Numerous
"	2	Nil	15	38	150
2,4-DB	½	13	29	160	Numerous
"	1	23	35	Numerous	135
"	2	6	23	71	60
MCPA	½	88	16	70	100
"	1	5	11	151	2
"	2	Nil	5	160	39
MCPB	½	6	5	130	Numerous
"	1	1	1	170	35
"	2	Nil	Nil	6	5
CONTROL		51	17	Numerous	7

The principal dicotyledonous weeds were Veronica agrestis, Sonchus oleraceus, Senecio vulgaris and Stellaria media.

In this trial, 2,4-DES caused very slight twisting of the petioles of the strawberry plants but the runners appeared to be normal and young growths developed perfectly normally. The plants on the plots treated with 2,4-D showed some twisting of both petioles and runners, the degree of damage increasing with the heavier rates of application. Applications of MCPA were more severe in their effects than 2,4-D, while both 2,4-DB and MCPB resulted in twisting of petioles and runners and some distortion of young growth on new crowns. MCPB was more damaging than 2,4-DB.

In another trial at Bristol with maiden Royal Sovereign plants, where 3 and 4 lb. of 2,4-DES per acre were compared with 2,4-D (amine), 2,4-DB and MCPB at ½, 1 and 2 lb. per acre rates, the 2,4-DES only caused slight twisting of the

petioles and no permanent damage to the plants. 2,4-D at all rates of application caused fairly severe twisting of petioles and runners and checked growth. 2,4-DB caused very severe twisting of runners and petioles and severely checked the plants, while MCPB was most severe in its effect leading to death of all plants in the trial.

Comparative effect of 2,4-D and 2,4-DES on Bindweed (Convolvulus arvensis)

In 1954, a trial with established plants of Field bindweed (Convolvulus arvensis) showed that one application of 2,4-D (Amine) at 1½ lb. per acre, applied on the 16th July, gave a reasonably good control but an application of 2,4-DES at the same time at 5 lb. per acre was comparatively ineffective, although there was some damage to the growing aerial parts of the plants.

DISCUSSION

These trials have shown that 2,4-DES applied to land which is free of perennial weeds, a few days after cultivation, can give a useful commercial control of most annual weeds when applied at 5 lb. per acre. In some cases, 2½ lb. to the acre has given a good control of weeds but results are variable and there are indications from observations carried out which suggest that normal rates of application should be between 3 and 5 lb. to the acre. Work in the U.S.A. has shown that the higher rates of application are needed on soils rich in organic matter and that smaller quantities are sufficient on light sandy soils. Provided the soil surface is adequately covered, equally good results have been obtained with 2,4-DES used in volumes of 50, 100 and 200 gallons to the acre but, where very heavy rain has followed shortly after application, subsequent control of weeds has sometimes proved disappointing, no doubt due to the washing out of the herbicide from the surface soil.

The somewhat poorer weed control given by 2,4-DES on strawberry runner blocks and fruiting beds compared with the excellent control given on uncropped land is doubtless due to the protective action of the strawberry plants' leaves in preventing a complete soil cover by the herbicide.

An interesting point which has been observed in most of these trials in which 2,4-DES has been used, has been the reduction in the year following application in the number of weed seedlings in plots treated with this material, presumably due to the reduction in the seeding of the weeds.

In none of these trials has any serious damage been observed to the strawberry plants although no attempt has been made to prevent the spray falling on the plants. There has, however, been one case on a commercial holding in the south-west of England of severe epinasty with Cambridge Favourite when sprayed with 2,4-DES at 5 lb. per acre in the early spring. There have also been instances reported from other parts of the country of a check caused to plants of Royal Sovereign following the use of 2,4-DES and so it is suggested that the material should still be employed with caution until further information is available on possible damaging effects.

CONCLUSIONS

In the United States, routine applications of 2,4-DES are being made in commercial fruiting plantations of strawberries in the spring and again after harvesting the crop. Further applications may be made in the autumn to control weeds developing at that time. Spraying of the plantations normally takes place following routine cultivations. In some cases, spraying is

confined to the rows making use of normal cultivations to destroy weeds in the alleys. Use of 2,4-DES in this country already suggests that the American method of use may be valuable here.

Until experience has been obtained with a wider range of varieties under varying conditions, it is suggested that the use of 2,4-DES on runner beds should be on an experimental scale.

In addition to its use on strawberry plantations, 2,4-DES is being found of value to control weeds in raspberries, black currants and woody nursery stock.

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