RECENT EXPERIENCES WITH HERBICIDES FOR ERADICATION OF AGROPYRON REPENS PB

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Summary

In earlier experiments on chemical control of Agropyron repens, sodium chlorate and TCA have been applied either in autumn or spring on black fallow to be sown with winter cereals. Since winter rape has become a common crop on black fallow the reaction of this crop to chemical treatments should be studied. Also, since American experiments with 2,2-dichloro-propionic acid for the control of grasses have given promising results, as reported by Dow Chemical Company, it was considered desirable to try this compound.

Consequently, in 1953 and 1954 experiments were carried out in which sodium chlorate and TCA were applied (i) in the spring on black fallow, and (ii) in the autumn. After the spring application winter rape and winter wheat were sown; after the autumn application spring rape and spring wheat.

Further, in two experiments laid out in 1954 sodium chlorate, TCA, and 2,2-dichloro-propionic acid were applied (i) in the spring on black fallow, and (ii) in the autumn. After the spring treatment winter rape, winter wheat, and winter rye were sown. The decomposition rate of TCA and 2,2-dichloro-propionic acid in the soil was studied in Mitscherlich jars during the 1954 summer months.

In 1954 three experiments were laid out with 2,2-dichloro-propionic acid,- two at Fredrikslund near Uppsala, and one at Hedenlunda, Södermanland. In one of the experiments at Fredrikslund, small quantities of 1.5 - 7.5 kg. per hectare were applied in the spring and peas were sown on the field. In the other two experiments 15 - 60 kg per hectare of 2,2-dichloro-propionic acid were applied in the spring on black fallow on which winter rape and winter wheat have been sown.

The following results have been obtained:-

1. Sodium chlorate, TCA, and 2,2-dichloro-propionic acid, applied on black fallow in spring have a detrimental effect on Agropyron repens, sodium chlorate being less effective than the other two chemicals. The effect of 2,2-dichloro-propionic acid does not show up until 2 - 3 months after application.

2. Sodium chlorate applied in spring has a very detrimental effect both on rape and wheat. Applied in the autumn the effect is less detrimental on spring crops.

3. TCA applied in the spring has hardly any effect on rape, but kills the wheat; applied in the autumn, the effect on spring rape is rather small while the effect on wheat is detrimental.

4. 2,2-dichloro-propionic acid applied in the spring has shown no effect at the present writing, neither on rape nor on wheat.

5. Even small quantities of 2,2-dichloro-propionic acid have a detrimental effect on peas sown after an early spring application of this compound.

Introduction

A number of experiments with sodium trichloro-acetate against Agropyren repens were carried out at the Department of Plant Husbandry in the years 1948 - 1951. These experiments were reported in 1952 by Åberg, Knutsson and Roland[1]. They showed that sodium trichloro-acetate (TCA) could be used with good results against Agropyron repens ir applied in quantities of 50 to 100 kg per hectare on newly ploughed or tilled ground. TCA can be applied late in summer, before the beginning of September. With such a late summer application the effect of TCA is generally not seriously detrimental on the crops sown next spring. On the other hand, if applied on a black fallow in May, the effect of the chemical does not disappear before the sowing in autumn, and winter wheat can therefore not be sown on such a fallow. Since TCA has a detrimental effect on Agropyron repens, it is only natural that wheat, being fairly closely related to Agropyron repens, is likewise rather sensitive to it. Wheat should therefore not be employed as the first crop following TCA treatment.

Under Swedish conditions winter wheat and rye are no longer the only crops sown on black fallow. This is used instead, to a great extent, for oil crops, notably winter rape. Consequently, it was a logical step in 1953 to let earlier experiments with TCA be followed by experiments in which winter rape was sown on black fallow, previously treated with TCA in the spring. Some preliminary results from such experiments are given below.

In 1953 the use of 2,2-dichloro-propionic acid* for the control of grasses was recommended by the Dow Chemical Company [2, 3]. It therefore seemed to be of interest to study also this compound under Swedish conditions. Samples of the sodium salt of 2,2-dichloro-propionic acid with 68 per cent active substance were obtained from the Dow Chemical Company and used in experiments started in 1954. Although the results from these experiments are merely preliminary, they seem to be of such an interest that they may be presented here.

Experimental Results

In two experiments carried out in 1953 sodium chlorate and TCA were compared after application (i) in the spring on black fallow, and (ii) in the autumn on a field to be sown next spring. The plan of the experiments was as follows:-

a. Untreated
b. Sodium chlorate, 200 kg per hectare
c. Sodium trichloro-acetate (90 per cent), 100 kg per hectare
d. Sodium trichloro-acetate (90 per cent), 50 kg per hectare

One experiment, in which the chemicals were applied on May 29th, was laid out in a field in Ultuna (Uppsala), where the soil is a rather heavy clay. Size of the plots 47.5 square metres, three replications of each treatment.

The effect of the chemicals on the weeds was studied on August 5th. On this occasion the frequency of the weeds was estimated according to a scale from 0 to 10 (0 = no weeds, 10 = complete cover of weeds). The main weed was Agropyron repens. In addition, the following species occurred: Convolvulus arvensis, Matricaria inodora, and some seedlings of Sinapis arvenis. The following figures were obtained:-

a = 2.2	c = 0.9
b = 0.7	d = 1.0

* Available under the trade-name "Dalapon".

The figures indicate an obvious effect on the weeds. After this estimate of the frequency of the weeds the field was prepared for sowing. On August 21st one half of each plot was sown with turnip rape, and on September 8th the other half was sown with winter wheat.

On October 12th the effect of the treatments on the crops was recorded. On plots with sodium chlorate the turnip rape was almost completely dead, and the wheat plants were yellow and apparently had suffered badly. On plots with 100 kg TCA per hectare there were signs of injury on the rape, while the wheat plants were practically all dead. On the plots treated with 50 kg TCA per hectare there was no injury to the rape, but very serious injury to the wheat.

These observations were confirmed after the winter 1953 - 54. On May 11th the stand on the plots was estimated according to a scale from 0 to 10 (0 = no stand, 10 = complete stand). The following results were obtained:-

Treatment	Rape	Wheat
a	9.0	3.7
b	0.7	1.0
c	7.3	0
d	9.0	0

It is evident from these figures that sodium chlorate had seriously damaged both rape and wheat, and that TCA had killed the wheat completely. 50 kg per hectare of TCA had caused no damage to the rape, and 100 kg had had but a slight effect. The influence of the chemicals on the crops as indicated by these figures is also expressed in the 1954 yields. In kilograms per hectare they were as follows (moisture content, 15 per cent):-

Treatment	Rape, harvested June 16th	Wheat, harvested August 27th
a	2,648	5,110
b	492	2,010
c	2,550	0
d	2,873	0

Another experiment was laid out on the same field in late summer of 1953. On September 8th sodium chlorate and TCA were spread according to the same plan as in the experiment above. On May 10th, 1954 the field was sown with turnip rape and spring wheat. No differences in weed frequency could be seen before the sowing, and the frequency of weed during the summer was at no time sufficient to allow any conclusions in regard to the effect of the treatments on the weeds. This experiment could therefore only be used for studying the effect of the chemicals on the cultivated plants.

Already on June 13th it was evident that the crops on some of the treated plots were injured. On June 29th the stand of rape on the plots treated with sodium chlorate was only about half as good as that on the untreated plots. On the plots treated with TCA it was about two-thirds of the stand on the untreated ones. There were no differences in the wheat on the treated plots, on all of them the stand of wheat being about two-thirds of that on the untreated ones. These differences remained during the summer. At heading time it was observed that a number of the wheat heads on the plots treated with TCA never left the boots. They were stuck with the top of the head in the boot and therefore curled out of the boot. There were 45 per cent such heads in treatment c and 22 per cent in treatment d. The effect of TCA on the plants

shows up also in the yields. These were as follows, in kilograms per hectare:-

Treatment	Rape, harvested August 17th	Wheat, harvested September 7th
a	960	4,333
b	534	2,967
c	722	2,589
d	786	3,348

The effect on the two crops is obvious, and it is clear that the chemicals were not washed out or broken down completely during the winter period.

In current experiments, started in 1954, sodium chlorate and TCA are being compared also with 2,2-dichloro-propionic acid. Of TCA the 90 per cent sodium trichloro-acetate has been used, and of 2,2-dichloro-propionic acid the sodium salt with 68 per cent active substance. These experiments were laid out at Ultuna on a rather heavy clay soil, one with spring treatment and one with autumn treatment. The plan of the experiments is as follows:-

a. Untreated
b. Sodium chlorate, 200 kg per hectare
c. Sodium trichloro-acetate, 50 kg per hectare
d. Sodium trichloro-acetate, 100 kg per hectare
e. Sodium salt of 2,2-dichloro-propionic acid, 25 kg per hectare
f. Sodium salt of 2,2-dichloro-propionic acid, 50 kg per hectare

Plot size 60 square metres, three replications.

In the spring treatment experiment the chemicals were applied May 28th. The frequency of Agropyron repens was recorded on three occasions during the summer, according to a scale from 0 to 10 (0 = no shoots, 10 = ground entirely covered with shoots). The following results were obtained:-

Treatment	June 18th	July 12th	August 13th
a	0.47	0.20	0.26
b	0.67	0.17	0.13
c	0.37	0.10	0
d	0.57	0.10	0.03
e	0.58	0.23	0.06
f	0.23	0.10	0

The effect of the chemicals is nicely shown in these figures. Both TCA and 2,2-dichloro-propionic acid have had a better effect than sodium chlorate. One-third of each plot was sown with turnip rape on August 20th, one-third with winter rye on September 4th, and one-third with winter wheat on September 6th. Observations on September 23rd showed that the turnip rape had not suffered at all from the treatments with sodium chlorate. The stand on the plots that had received 100 kg TCA per hectare was possibly somewhat weaker than the stand on the untreated plots. Sodium chlorate had badly damaged the wheat. Wheat and rye on the plots that had received 100 kg TCA per hectare were most considerably thinner than on the untreated plots, and slightly thinner on the plots that had received 50 kg TCA per hectare. 2,2-dichloro-propionic acid had not at all injured either rape or wheat. The effect of the treatments as indicated by these observations of September 23rd became even more accentuated during October.

The effects on the crops in this field experiment were more or less expected. During the summer the decomposition rate of the substances was studied in Mitscherlich jars. Soil from the field was brought into such jars

with regular intervals and then sown with turnip rape, wheat, and rye. The results from these studies will be published in a final report by Mr. Hugo Beinhauer, who is now continuing the experiments. At present no more can be stated than that TCA appears to be more resistant in the soil, i.e. it breaks down at a lower rate, than 2,2-dichloro-propionic acid. Further, it would seem that TCA influences wheat and rye sooner after the sowing than does 2,2-dichloro-propionic acid.

In the autumn treatment experiment the chemicals were applied on September 3rd. Observations during September and October indicate a reaction of Agropyron repens similar to that obtained in the spring treatment experiment.

In the spring of 1954 two experiments with 2,2-dichloro-propionic acid were laid out on sandy soil at Fredrikslund near Uppsala. On one of the experiments the following treatments were used:-

a. Untreated
b. 2,2-dichloro-propionic acid, 15 kg per hectare
c. 2,2-dichloro-propionic acid, 30 kg per hectare
d. 2,2-dichloro-propionic acid, 45 kg per hectare
e. 2,2-dichloro-propionic acid, 60 kg per hectare

Plot size 42 square metres, three replications.
The chemical was applied on May 25th.

Observations at three dates during the summer on the effect of the 2,2-dichloro-propionic acid on Agropyron repens gave the following results in terms of the above-mentioned scale 0 - 10:-

Treatment	June 18th	July 13th	August 21st
a	2.3	2.3	1.8
b	3.2	3.3	1.1
c	2.5	2.7	0.7
d	2.7	2.0	0.7
e	2.8	2.3	0.3

The effect of the 2,2-dichloro-propionic acid did not show up until in August. At an inspection on October 1st the turnip rape sown on the field on August 23rd showed no signs of having been affected by the chemical.

In the other experiment, small quantities of 2,2-dichloro-propionic acid per hectare were applied on May 25th, according to the following plan:-

a. Untreated
b. 2,2-dichloro-propionic acid, 1.5 kg
c. 2,2-dichloro-propionic acid, 3.0 kg
d. 2,2-dichloro-propionic acid, 4.5 kg
e. 2,2-dichloro-propionic acid, 6.0 kg
f. 2,2-dichloro-propionic acid, 7.5 kg

Plot size 30 square metres, three replications.

The field was sown with peas on May 25th. These emerged on June 6th. On July 1st they were graded in regard to the injury caused by the chemical. The injury appeared as chloroses and necroses. The grading also showed a thinner stand on the treated plots, as will be seen from the following figures (0 = no peas, 10 = the peas cover the ground). Yield figures in kilograms per hectare confirmed these observations:-

Treatment	Stand on July 1st	Yields on August 19th
a	7.0	1,583
b	6.0	1,125
c	4.7	863
d	4.0	448
e	3.7	390
f	3.0	278

During the summer no effect of these small quantities of 2,2-dichloro-propionic acid on Agropyron repens could be discovered. Wheat sown on the field on September 7th showed no abnormalities at an inspection on October 1st.

In addition, another experiment with 2,2-dichloro-propionic acid was laid out in the summer of 1954 at Hedenlunda near Flen, province of Södermanland, to be continued in 1955. The plan of this experiment is the same as in the first experiment carried out at Fredrikslund. Plot size 40 square metres, three replications.

The chemical was applied on June 24th. At two dates during the summer the effect of 2,2-dichloro-propionic acid on Agropyron repens was recorded according to the scale 0 - 10 (see above). The following results were obtained:-

Treatment	July 26th	August 30th
a	1.50	0.67
b	0.70	0.17
c	-.73	0.10
d	0.50	0.07
e	0.33	0.03

In this experiment, too, the effect of the treatment is obvious, but the effect did not show up until about two months after the application of the chemical.

Wheat was sown in September. No differences in the development of the wheat were discovered in October.

DISCUSSION

The results now presented have shown that both TCA and 2,2-dichloro-propionic acid are effective against Agropyron repens when applied at a rate of 50 kg per hectare. This quantity seems to be the most appropriate. Of the three crops tested in these experiments turnip rape seems to be the only one that can be used soon after application of TCA. The experiments with 2,2-dichloro-propionic acid have not been carried on for a sufficiently long time to admit of any conclusions as to differences in the reaction between rape and cereals. From what has been said above it is clear that TCA should be used, under Swedish conditions, for spring application. After autumn application the compound does not break down fast enough to allow the sowing of a crop the following spring. Even spring-sown turnkp rape was damaged after autumn application.

At Ultuna the summer of 1953 had no heavy rainfall while this was the case for the summer of 1954. The precipitation from the end of May to the beginning of September was in 1953 about 170 mm., in 1954 about 250 mm; from the beginning of September 1953 to the beginning May 1954 the precipitation was about 250 mm. There is nothing to indicate that this difference between 1953 and 1954 had any influence on the reaction of the plants to the chemicals.

Conclusions

For the control of Agropyron repens sodium chlorate should be replaced by TCA and 2,2-dichloro-propionic acid. TCA, 50 kg per hectare, should be applied in the spring on black fallow on which winter rape should be sown.

Preliminary results indicate that 2,2-dichloro-propionic acid, 50 kg per hectare, should be employed in the same way as TCA, although at present little or nothing can be said about the effect of autumn application.

It would appear that no summer crops can be grown after an early spring application.

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FURTHER DEVELOPMENTS IN THE USE OF TCA

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Summary

TCA was applied to uncropped land as a single application of 20, 25 and 30 lbs. per acre and as a double application at 20 lbs. per acre per application. The control of Agropyron repens was improved by cultivations before spraying and was probably further improved by post spraying cultivations. There was good control of A. repens on heavy land with a single treatment of 30 lbs. of TCA in 100 gallons per acre, and on light land with two applications of 20 lbs. of TCA per 100 gallons per acre. Cereals, sown 10-12 weeks after spraying, were not affected on most soils.

On fen soils the control of A. repens was poor, even with two applications of 20 lbs. of TCA in 100 gallons per acre, and spring cereals, sown 10-12 weeks after spraying, were adversely affected.

On blackcurrants 10-60 lbs. TCA per acre caused suppression of A. repens and Arrhenatherum tuberosum and the treatments caused reddening of the foliage as well as delayed ripening of the fruit.

On potatoes TCA at 20 lbs. in 100 gallons per acre gave approximately 75 per cent control of Avena spp. in the rows.

On sugar beet 20 lbs. TCA per acre applied at the 10 leaf stage checked Agrostis tenuis and A. stolonifera without adverse effect on the crop.

On lucerne 20 lbs. and 30 lbs. TCA per acre gave better control of Poa annua and Agrostis spp. when these amounts were divided into two applications rather than in a single application. There was no adverse effect on the crop when the plants were completely dormant.

Introduction

Since 1945 so much progress has been made in the control of dicotyledenous weeds that the farmer now considers his most serious weed problem to be the control of grass weeds. These weeds, especially the perennial grasses, resist control by culturel methods even more than the dicotyledenous weeds. It is probable that the most serious grass weeds are the perennials Agropyron repens and Agrostis spp. (stolonifera, tenuis, gigantea), Arrhenatherum tuberosum; and the annuals Avena spp., Alopecurus agrestis.

This paper gives observations on the field use of TCA in the past season, the material used being a preparation containing 90 per cent Sodium Trichloracetate.

Experimental Data and Results

1. Non-selective application

Nearly 100 fields in various parts of the country were treated with TCA and kept under observation for several months.

(a) Treatments. TCA was used as a single application at 20, 25 and 30 lbs. pwr acre and as a double application at 20 lbs. per acre per application. In the latter treatments the interval between applications was 4-6 weeks. The volumes used varied from 20-100 gallons per acre. In most instances applications were made between late September and mid-December 1953 to land intended

for sowing to cereals in the following spring. Before spraying, most of the land was cultivated, either by cultivators or shallow ploughing, in order to bring the maximum number of rhizomes and roots into the top few inches of soil. In many instances the sprayed ground was also cultivated several weeks after spraying.

(b) Results. As there was a wide variation in factors which may have influenced the degree of weed control, and as many different observers were used, the deductions from these trials are necessarily very general.

Better control of Agropyron repens was obtained by spraying on a cultivated surface rather than on an uncultivated surface, especially when the cultivations were carefully carried out and when TCA was applied immediately afterwards on the moist soil. There were indications that post spraying cultivations improved the control of A. repens.

Generally speaking, the degree of control of A. repens was increased as the amount of TCA increased. For all the dosages tried the degree of control also increased as the volume of application increased. 20 lbs. TCA applied in 20 gallons per acre rarely gave worthwhile control. 25 lbs. TCA applied in 100 gallons per acre on the average gave control of the order of 70-80 per cent. The control by 30 lbs. TCA in 100 gallons per acre was better still. The latter has given virtual eradication of A. repens on heavy soils. Two sprays of 20 lbs. per acre per application also gave excellent control of A. repens and were better than a single application of 30 lbs. per acre on light soils.

There was a tendency for the control from any particular dosage and application rate to be better on heavy soils than on light ones. There was evidence that fen soils reacted abnormally. Not only was the control of A. repens poor but the retention of the chemical in the soil was pronounced. There were a number of instances of the failure of spring cereals to germinate or to become established following an autumn application.

With the exception of fen soils, the sowing of the spring cereal 10-12 weeks after treatment had no adverse effect on the crop. The following examples show that a shorter period was used when a tolerant crop was sown.

Crop	TCA (lb./acre)	Volume g.p.a.	Treated	Sown	Soil
Marrow Stem and Thousand Headed Kale	28	100	March 2	April 30	Thin, light over chalk
H1 Ryegrass	35	100	March 10	May 8	Moderately heavy clay with flints.

These crops did not show any adverse effect from the treatment.

In another test the treatment was carried out on June 10th and the rape was sown 18 days later. The crop received a check in the early growth stages and the leaves became slightly chlorotic. These symptoms, however, disappeared and growth became normal by October. It is of interest to note that in this trial the germination of Spergula arvensis and Chenopodium album was generally inhibited while the growth of Cirsium arvense was unaffected.

2. Selective application

(a) Blackcurrant. Treatment with 60 lbs. TCA per acre gave marked

suppression of very strong A. repens when applied during the winter, but the grass had largely recovered by the following summer. A marked reddening of the foliage and delay in ripening of fruit for at least a week was a feature of this trial.

On bushes one year old, applications of 10, 20 and 30 lb. TCA per acre were given in July for the control of A. repens and Onion Couch, Arrhenatherum tuberosum, both of which were strongly suppressed for at least 3 months, but again reddening of the foliage of the Blackcurrants was marked. In this trial, there was a spectacular suppression of Wild Mint, Mentha sp., Charlock, Sinapis arvensis, Fat Hen, Chenopodium album and Bindweed, Convolvulus sp. No effect on Creeping Thistle, Cirsium arvense or Creeping Buttercup, Ranunculus repens was noted.

(b) Potatoe Early potatoes, Ulster Premier, heavily infested with Wild Oat, Avena spp., were sprayed with 20 lb. TCA per acre in 100 gallons per acre on April 8th.

The potatoes were within a few days of breaking through the soil and Wild Oat plants up to 4" tall were present, though many were still several inches below the surface. Frequent cultivation eradicated the plants between the rows, but in the rows the soil was not disturbed to any extent until lifting took place. Final examination on the day prior to lifting, June 18, indicated a reduction of about 75 per cent in the number of Wild Oat plants in the rows. The growth of the potatoes appeared to be slightly depressed, as compared with the unsprayed area, but the difference in yield, if any, was very small.

(c) Sugar Beet. In one trial, beet in the 6-8 leaf stage was sprayed at rates of 15 and 30 lb. TCA per acre. Growth of the beet was checked for up to 6 weeks, but recovery took place eventually. There was a severe check to the growth of A. repens.

In the second trial, 20 lb. TCA per acre was applied to beet in the 10 leaf stage, on August 3rd. No apparent check to growth of the beet could be detected, but Agrostis tenuis and A. stolonifera were strongly suppressed, though not killed.

(d) Lucerne. A series of trials in several counties was laid down, as this crop appears to be reasonably tolerant of TCA. It is well-known that infestation with grass weeds is a major factor limiting the life of lucerne, so that grass control commencing in the year of sowing might prove of considerable value. Trials were therefore carried out on young lucerne, i.e. sown a few months previously, as well as on established lucerne.

Young lucerne. TCA was applied to the dormant season at 20 lb. per acre in a single application at 100 gallons per acre and also in 2 applications of 10 lb. per 100 gallons per acre with an interval of about 4 weeks. The grass weeds were mainly well established seedlings of several species, with Annual Meadow Grass, Poa annua, usually common, but perennial species, especially Agrostis spp. were well represented.

On the lucerne, there was little if any depression of growth and a marked bias in favour of the double application where the control of grasses was concerned. This was especially evident in one trial, where the lucerne was topped with a mower prior to spraying, largely to enable better penetration of the spray but also to remove seed heads of mayweed etc. The cut material was gathered up with a horse rake, resulting in some scratching of the soil surface. Here the control of grass weeds was of a very high order indeed, but the area which had received the double application was much superior in that respect.

Old Lucerne. In these trials TCA applied at 30 lbs. per 100 gallons per acre was compared with two applications of 15 lbs. per 100 gallons per acre spaced at 4 week intervals. The pattern of grass control follows closely on that of the young lucerne. Where the lucerne had already commenced growth, a considerable depression took place in some instances, but this effect was very variable. Control of the established grass weeds similarly varied, but was sometimes of a very high order, even where surface cultivation had not been done. There is evidence that dosages greater than 30 lb. TCA per acre increase the injury to lucerne, without compensation in the increased control of perennial grasses.

DISCUSSION

Three major points suggest themselves as a result of experience with TCA in the field:-

1. Identification of the grass species, particularly of the Agrostis group, is probably of considerable importance, since the dominance of A. stolonifera would probably have a bearing on the desirability or otherwise of ploughing prior to treatment.

2. On fen soils two applications of 20 lbs. per acre adversely affected cereals sown 10-12 weeks later. It would therefore seem advisable to sow a non-susceptible crop in the season following treatment. It is probable that higher dosages of TCA would give better control of A. repens.

3. Assessment of the degree of control of rhizomatous grasses is a problem on which little information is available. If rhizomes of couch grass, A. repens, are dug and examined some weeks after spraying, it is usually found that, though dead and often hollow over much of its length, a rhizome will have a few buds making some growth. Such buds are usually rather swollen and easily break away. Possibly this initial growth is being sustained by the reserves in the rhizome and rooting from the node might not occur. Nevertheless, it is difficult to avoid the impression that post-spraying cultivation may well give the 'coup de grace' to many such buds. Estimation of the degree of control, if made a few weeks after treatment, is often biased on the low side, i.e. the actual control is often better, when judged later by the presence of normal growing plants. When examining stubbles of spring corn, following treatment in the previous winter, individual and often not very vigorous plants of couch grass are sometimes common, and the farmer naturally tends to the conclusion that the degree of control has been poor. If such plants are carefully dug, it is found that they have arisen from a bud on the rhizome, like those mentioned previously, while the remainder of the rhizome is dead. Such plants are, in fact, little more than seedlings and are easily pulled out by hand, quite unlike a typical plant of couch grass. A very shallow stubble cultivation would undoubtedly eradicate a high proportion of these plants. Even if TCA treatment therefore does not give a very high degree of control as judged superficially, it does make the job of couch grass control by cultivation very much simpler. It may also explain why farm workers, on some of the trials with sugar beet and swedes, have noticed that areas sprayed with TCA are much easier to hoe than the unsprayed.

CONCLUSIONS

1. When TCA was used non-selectively the control of *A. repens* was improved by cultivations before spraying and was probably further improved by post spraying cultivations.

2. The control of *A. repens* was better on heavy soils than on light soils.

3. Good control of *A. repens* was obtained on heavy soils from a single application of 30 lbs. TCA per acre and on light soils from 2 applications of 20 lbs. TCA per acre.

4. Control of *A. repens* was better when the TCA was applied at 100 gallons per acre rather than at lower volumes.

5. Except for fen soils, there was no adverse effect on cereals sown 10-12 weeks after spraying with the above dosages, or on more tolerant crops sown after a shorter period.

6. On fen soils higher dosages are required and a much longer period should be allowed before a susceptible crop is sown.

7. TCA shows further promise for the selective control of grass weeds in tolerant crops such as blackcurrants, potatoes, sugar beet and lucerne.

CHEMICAL CONTROL OF COUCH GRASSES (AGROSTIS ALBA AND AGROPYRON REPENS)

A PRELIMINARY TRIAL

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Summary

A trial on the control of couch by TCA and sodium chlorate, in conjunction with cultivations, was laid down at Litchfield Farm, Enstone, Oxon, in the Spring of 1954. The experiment showed that in the absence of cultivations TCA was markedly superior to sodium chlorate in controlling grass weeds. Cultivations immediately before spraying increased the control obtained with both materials and was superior to cultivating after spraying. There was a further improvement in the control obtained when the application of chemical was split into two equal dressings with cultivations immediately prior to each application.

Introduction

The trial was laid down, following an enquiry by the farmer for information on the control of couch, this spring in a field which was being cleaned prior to sowing kale in July.

The chemical treatments were as follows:-

1. No chemical treatment
2. TCA - one application of 20lbs/acre
3. TCA - " " " 30lbs/acre
4. TCA - two " " 10lbs/acre
5. TCA - " " " 15lbs/acre
6. Sodium chlorate - one application of 30 lbs/acre.
7. " " - " " " 60 lbs/acre
8. " " - two " " 15 lbs/acre
9. " " - " " " 30 lbs/acre

All plots were sprayed at 30 gal./acre.

Across the chemical treatments the following cultivation treatments were carried out:

1. No cultivations (NC)
2. Cultivations before first spraying (CA)
3. " " " and second spraying (CA2)
4. Cultivations after first spraying (CP)
5. " " " and second spraying (CP2)

Cultivation treatment 3 and 5, could of course only be carried out where there were two applications of chemicals.

All the treatments, except those not receiving any chemical were duplicated.

The first sprayings and cultivations were carried out under dry conditions on April 21st and the weather continued dry for ten days after spraying. A manual sprayer designed by the A.R.C. Unit of Experimental Agronomy and kindly loaned for the trial, was used.

The second spraying and cultivations were carried out after an interval of four weeks on May 19th. At the same time an estimation of ground cover of grass weeds was made and recorded on all plots. The sodium chlorate from the first spraying has had the most obvious effect, shown by the yellowing of the grass and other weeds. On the TCA plots there was some thinning out of the grasses but colour was generally green with some yellowing of tips.

Four weeks after the second treatments, on June 16th a final estimation of ground cover of couch was made.

Experimental Results

Firstly the plots receiving no chemical were assessed by awarding points from 0 to 10 with 10 corresponding to the plot which had had neither cultivations nor chemical treatment, and 0 indicating that no couch was present. The scoring was as follows: NC - 10, CA - 5, CA2 - 3, CP - 7, CP2 - 5.

The rest of the plots were then scored in a similar manner. The figures indicate the degree of ground cover relative to that of the control: thus, the figures can give the percentage of couch control compared with the untreated plot; for example a plot receiving a score of 8 has a ground cover 80% of the control plot, that is 20% less couch. The figures in the following table have been derived in this way.

TABLE

% Degree of Control of Couch

	No Cultivation	Cultivation before first spraying only	Cultivation before first and second spraying	Cultivation after first spraying only	Cultivation after first and second spraying
No chemical	0	50	70	30	50
TCA 1 x 20 lbs	77½	89	-	60½	-
" 1 x 30 "	85	94	-	72	-
" 2 x 10 "	75	87½	92½	79	87½
" 2 x 15 "	90	95	97½	81	95
$NaClO_3$ 1 x 30lbs	45	82½	-	46	-
" 1 x 60 "	60	88½	-	51	-
" 2 x 15 "	47½	75	86	40½	67½
" 2 x 30 "	55	86	90	58	82½

These figures except for those where no chemical was applied are the mean of two plots.

Heavier rates of application gave a better control than lighter rates; the best results were obtained with the highest rates of application which were split and the land stirred immediately prior to spraying. Cultivations after application of the chemical were generally inferior to cultivations before chemical application.

Where no cultivations were carried out TCA was markedly superior to sodium chlorate. With one cultivation the superiority of TCA diminished and where the application of the chemical was divided and cultivations carried out before each application, a total of 60 lbs. of sodium chlorate was almost as effective as a total of 30 lbs. of TCA.

There appeared to be a difference in selectivity between TCA and sodium chlorate on truch couch (Agropyron repens) and watergrass (Agrostis alba). The TCA tended to leave more Agrostis surviving than the sodium chlorate; while the sodium chlorate tended to leave more Agropyron surviving. A large amount of white campion was present on the trial area, particularly at one end. While sodium chlorate severely stunted the campion and caused premature flowering, the TCA appeared to have a beneficial effect - the campion on the uncultivated TCA plots was dark green and vigorous, so much so that the treatments could be identified at a distance by the campion. Bindweed and charlock were also apparently unaffected by TCA. On one TCA plot two potato plants were found and these were quite healthy. The site of the trial was drilled with kale in the second week of July. Subsequent visits have revealed no residual effects on the kale by either chemical.

Discussion

At present there is some difference in cost of materials; TCA costs about 3/6d per lb. and sodium chlorate about 1/- per lb. Both materials are readily water soluble. Therefore, under the conditions found in this trial sodium chlorate would have been the more economic material to use.

Generally it is anticipated that such spraying would be carried out in the autumn. Any annual weeds, such as Campion, which are not killed by TCA would be killed by the cultivations or the winter. Similarly, with both materials, the small amount of grass weed surviving would probably be killed either by the winter or cultivations when working down a seedbed in the Spring. A further advantage of autumn spraying is that there is more time for the chemicals to be leached out of the soil before a spring crop is sown. It should be noted that in this trial there was no residual effect on kale sown eight weeks after final treatment.

The trial has investigated the chemical control of couch. While the results indicate that a satisfactory control is possible in conjunction with cultivations, the cost of materials and good husbandry should restrict applications to parts of fields or persistently 'twitchy' fields.

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SWARD DESTRUCTION BY TCA

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Summary

Three observation trials are reported where TCA has been applied at various rates at two times of the year to undisturbed swards on the hills of Staffordshire and Shropshire. TCA under certain conditions killed, almost completely, grass swards and led to a seedbed being prepared with fewer cultivations than where no chemical treatment was applied. Under other conditions the use of TCA appeared to offer no advantages. The effect of TCA treatments on the subsequently sown grasses and clover is being observed to assess the persistency of TCA in the soil. Work on the trials is continuing.

Introduction

In the reclamation of upland areas and land of difficult contour, conditions are often such that ploughing has to be replaced by surface cultivations with discs or rotovator. Any mechanical operations under these conditions prove expensive, and the possibility of reducing the amount of cultivation necessary during reclamation is worthy of investigation. Normally, cultivations are aimed at killing the old sward as well as producing a seedbed; thus, the successful use of any grass herbicide as a means of killing the old sward prior to cultivation may lead to the preparation of a seedbed with the minimum of operations. (The trials reported here are confined to TCA, a chemical known to be toxic to most grass species.) A complete kill of the existing vegetation is essential, otherwise regrowth of the surviving species will hasten the deterioration of any new sward.

Sprague and Fraus (1) have investigated the effect of TCA on a pasture, consisting predominantly of Poa pratensis, on sandy and loamy soils in New Jersey, U.S.A. 25 lbs. of TCA plus a wetter, applied in 10 gals. of water in July and August, gave an almost 100% kill of Poa pratensis whilst Dactylis glomerata and Agrostis alba made good recovery. The treated land was sown down again 30 days later with no ill effect to Dactylis glomerata, Bromus inermis, Medicago sativa, Lotus corniculatus or 'Ladino' clover. Seedbeds were prepared by discing, and two discings following treatment with TCA were reported to have given as good results (in terms of establishment of the sown species and yields of the sward in the following two years) as ten or twelve heavy discings where no TCA was used. Reinvasion by Poa pratensis was also noted in the plots where no TCA was used.

There appear to be differences in susceptibility to TCA between different species of grass. This was shown in the trials by Sprague and Fraus, already quoted; Lynch (2) found that Festuca arundinacea was more resistant than Poa annua or Holcus lanatus; and Carder (3) says that 'common bromegrass' and Poa compressa are more tolerant of TCA than Agropyron repens. Carder in Canada also states that 80 or 100 lbs. of TCA are required to control Agropyron repens in an undisturbed sward and this rate of application compares with figures given by Abel (4); but Sprague and Fraus used only 25 lbs. of TCA per acre on the sward of Poa pratensis.

The effedts of TCA however, are also influenced by soil conditions and the weather. Loustalot (5) has demonstrated that the toxicity of TCA decreases more quickly at higher temperatures and in soils with a higher moisture content, and that the toxicity persists longer in clay than in sandy soils. Lynch (2) states that the chemical will not give a satisfactory control of grasses on land subject to frequent flooding.

TCA is very soluble and its persistency in the soil would be expected not to be very great. McCall and Zahnley (6) state that the effects of TCA may persist for one to three months, depending upon the rate of application etc; but Carder (3) says that in Western Canada the effects of 50 lbs, or more of TCA per acre (presumably applied in autumn) may last well into the following season.

The evidence available gives little indication as to the rates of TCA that are required to kill a sward, nor how long the toxicity of the chemical remains in the soil under British conditions, particularly upland conditions. It was with a view to obtaining more information on these and other aspects that three trials were laid down earlier this year (1954), one in Shropshire near Craven Arms, and two in North Staffordshire near Leek. The principal questions set out to be answered were:

(1) How much TCA is required to produce a satisfactory kill of turf under British conditions?

(2) How does the botanical composition of the sward, soil conditions, etc. affect the results?

(3) How long does the effect of TCA persist in the soil?

(4) Does treatment at different times of the year lead to a difference in the degree of kill of the sward or in the persistency of the effect of the chemical in the soil?

(5) Does preliminary killing of the sward lead to better results by (a) reducing the cultivations necessary and/or (b) leading to a better seedbed and seed establishment and/or (c) preventing reinvasion of the old turf?

The trials will not be completed until 1955 at the earliest, and although certain interesting results can already been seen, this report is necessarily in the nature of a progress report.

Experimental Results

The trials laid down at the three centres were identical in layout, except for the size of the plots.

At each centre non-replicated plots were sprayed in spring and in summer, the TCA being applied on each occasion at the rates of 20, 40, 80 and 120 lbs, per acre of the sodium salt made up in 100 gallons of water. Each spraying treatment was divided into three, for reseeding on consecutive dates, these dates being approximately one month apart and the first seeding taking place one month after treatment. Surface cultivations were carried out at the time of reseeding, and sufficient lime and compound fertilizer were applied to the seedbed. A non-sprayed area was reseeded to compare with those that had been sprayed.

STAFFORDSHIRE CENTRES. The turf at Centre A was one which had been reseeded eight years previously on a soil of the millstone grit formation at an elevation of 1250 ft. The composition of the turf, based on a percentage ground cover basis, was as follows:

Agrostis sp.	20
Festuca rubra	12
Holcus mollis	5
Poa sp.	25
Lolium perenne	18
Aira caespitosa	15
Trifolium repens	5

Centre B, four miles away, was an area of unreclaimed land 1200 ft. above sea level where Festuca rubra was dominant, with some Agrostis sp. and Juncus effusus. The turf consisted of 2 - 3 in. of dense mat overlying a very acid millstone grit.

The date of the spring spraying was the 14th April, and the dates of reseeding at Centre A were 25th May, 17th June and 9th July and at Centre B 1st June, 17th June and 15th July.

Weather conditions. The weather at time of spraying was cold and dry, and remained so at least 14 days after spraying; wet, cold conditions followed and persisted until 25th May. During this period the day temperature never rose above 50°F.

Between 25th May and 17th June the weather remained dry for three days with temperatures rarely rising to 60°F. Subsequently, there were periods of heavy rain. Details of rainfall are not available until 17th June. Between 17th June and 9th July 5.31 ins. of rain fell, temperatures being between 45°F and 50°F. The month following saw 5.93 ins. of rain with temperatures around 50°F. rising occasionally to 60°F.

Throughout the year unusually poor growing conditions have been met and the excessive rainfall has made it extremely difficult to carry out the surface cultivations which were necessary.

Assessment of treatment effects. All treatments produced a rapid scorching of the top growth within a few days of spraying, but the actual kill of the sward was delayed and tended to improve with time, the best kill for each rate of application not being recorded until the second or third date of reseeding. The higher rates produced a more efficient kill than the lower rates of application and the difference between treatments was still apparent two months after treatment at both centres and after three months on Centre B: at Centre A however at the end of three months 20 lbs. of TCA per acre had given almost as good a kill as the 120 lbs. rate.

TABLE 1

Effects of TCA on turf - spring treatment.
Scoring range 0 - 10 for apparent kill of sward (10 = 100% kill)

Rate of Application of TCA (lb./acre)	Date of observation					
	1st reseeding		2nd reseeding		3rd reseeding	
	Centre A	Centre B	A	B	A	B
20	4	4	6	4	8	5½
40	4	4	7	5	8	6½
80	6	4½	8	6	8	7
120	6	4½	9	6½	9	8½

TCA was effective against all species except Juncus effusus, which however, showed severe scorching, and Aira caespitosa, which was thriving even at the higher rates of application.

Reseeding. A rotovator was used prior to reseeding but wet conditions at both centres prevented efficient cultivation, particularly for the second and third reseedings. At Centre A cultivations were limited to three times rotovating, the seeds being sown and a light roller used; on the second and third occasion of reseeding, however, it was impossible to use a roller because of the excessively wet surface. At Centre B rotovating four to six times was necessary on each date in all plots, for although TCA had killed a good proportion of the sward there still remained a mat of dead (and rather slimy) material over a compacted heavy soil and these conditions demanded as much cultivation as the living sward in order to prepare a seedbed. Even under dry conditions the 'mat' of sward, whether sprayed or not, would probably have necessitated severe cultivation.

The following seeds mixtures were sown and were based on species which would be expected to germinate effectively under the seedbed conditions:-

	Centre A	Centre B
Agrostis tenuis	-	6
Poa pratensis	8	-
Phleum pratense (S.50)	4	6
Trifolium repens (S.184)	1½	1½
	13½ lb/ac.	13½ lb./ac.

Satisfactory establishment resulted from each sowing on all plots, except for the third reseeding at Centre B, where germination was slow because of the extremely poor tilth and wet conditions.

Subsequent observations. In late August it was noticeable on the areas first reseeded that, with the exception of the plots where 20 lb. of TCA per acre had been applied, the sown grasses and clovers were beginning to discolour and disappear rapidly. A similar effect was also beginning to show on the second reseedings where the higher rates of TCA had been used; but no harmful effects were apparent at that time on the last reseeded plots. There appeared to be no difference in the persistency of the different species of sown grass, and the clover also diminished in proportion to the grasses.

At Centre B, where the grasses and clovers sown at the first reseeding had been killed out numerous young rush seedlings were appearing; whereas on the plots receiving 20 lbs. TCA and no TCA, which still had a satisfactory take of seeds, there were very few rush seedlings present. No seedlings were noticed in late August on any plots reseeded at the second or third dates.

Reinvasion by species of the old sward was not apparent at Centre B in mid-September on any of the first reseeded plots, including the one receiving no TCA; but on all the plots reseeded at the second date, where cultivations were less thorough, some of the species of the old sward were re-appearing. At Centre A the unsprayed areas showed a great deal of reinvasion by the original sward species, but this was not the case for any of the sprayed plots except for some Aira caespitosa which had not been killed by spraying or subsequent cultivations.

Summer spraying. A second series of non-replicated plots identical with those of the spring spraying were laid down on July 9th. Wet conditions have prevented any reseeding this year at Centre A, but at Centre B one reseeding was completed in August and germination was satisfactory on all plots. Reseeding of the rest of the treated areas will be carried out next spring.

TABLE 2

Effects of TCA on turf - summer treatment

Scoring range 0 - 10 for apparent kill of sward (10 = 100% kill)

Rate of Application	Date of observation			
	One month after treatment		Two months after treatment	
	Centre A	Centre B	Centre A	Centre B
20	2	2	2	3
40	3	2	3	3
80	4	2½	5	4
120	4	3	5	4

The summer treatments do not appear to be as effective in killing the sward as those carried out in early spring. Observations are continuing.

SHROPSHIRE CENTRE. At this centre the site was a steep slope facing south west at an elevation of 700 ft, and carried a sward of the Agrostis-Fescue type with some Holcus lanatus, Cynosurus cristatus, Poa sp., Festuca sp. and Dactylis glomerata. Other species which made up the sward were Lotus corniculatus, Trifolium repens, Plantago lanceolata, Ranunculus repens, Geranium pusilium, Cerastium vulgatum, Galium verum, Myosotis arvensis, Bellis perennis and Hypochaeris radicata. The sward consisted of 60% grass species and 40% of other species mentioned. The site was well drained with a shallow stony soil (Silurian) - an area which would dry out quickly in a dry summer. Treatment was carried out on 23rd April and reseeding on 1st June, 2nd July and 17th August.

Weather conditions. The rainfall between spraying and the first reseeding was 3.1 inches and day temperatures were around 55°F. Between the first and second reseeding 3.49 inches of rain fell and day temperatures were around 60°F; and between the second and third reseeding rainfall was 4.20 inches. After the third reseeding day temperatures rose to 60-65°F.

Assessment of treatment effects. One month after spraying the grass species were effectively killed by all treatments, but dicotyledonous weeds, although scorched, tended to grow more vigorously after the kill of the grass dominating the plots. The higher rates of application (80 and 120 lbs. TCA) produced a much more rapid effect in that within one week of spraying most of the grass species had been killed, whereas the lower rates (20 and 40 lbs. TCA) took at least a further week to produce the same effect.

Reseeding. The area was cultivated with a small hand rotary cultivator and cultivations were made easier because of the kill of the grass species, although the persistency of the dicotyledonous species presented a difficulty. Three rotovations were sufficient to produce a reasonable tilth on the TCA plots but not on the unsprayed area, where the turf was cut up to some extent but not killed. In fact, on the unsprayed plots the old sward established itself again and tended to dominate the sown grass.

There was a satisfactory germination of seeds after each reseeding. The following seed mixture was used:-

Poa pratensis	8
Phleum pratense (S.50)	4
Trifolium repens (S.184)	1½
	13½ lbs./acre

By September there were no apparent differences in sward of any of the treated plots and there were no signs of residual TCA effects. Killing of the new sward, as noticed in the Staffordshire centres, has not occurred. With the ineffective killing of the dicotyledonous weeds by TCA, and where also mechanical cultivations did not kill, there is some regrowth of these weeds throughout the sward. Germination of weed-seeds has also occurred in the reseeded plots.

Summer spraying - July 2nd. The treatments were repeated. The turf to be sprayed was similar to that used for the spring spraying except that there was 6 ins. of grass and weed growth at time of spraying.

It was apparent that the TCA had been much less effective than in the spring; when the first reseeding took place on August 17th the following assessment of kill (on the same basis as at the Staffordshire centres) was made:-

TCA	at	20	lbs.	1
"	"	40	"	1
"	"	80	"	3
"	"	120	"	3

The turf made it difficult to produce a seedbed by surface cultivations and the TCA did not lessen the cultivations necessary. The TCA might have been more effective had the top-growth been removed before spraying.

Discussion

The most interesting feature of these trials is the difference in TCA persistancy from spring treatment between the Shropshire centre and the two Staffordshire centres. Whereas at the Staffordshire centres the higher rates of TCA have caused a killing out of the newly sown grasses and clovers some 14 - 20 weeks after sowing, this was not noticeable by September at the Shropshire centre. This may be due to the differences in soil and rainfall; there was a higher rainfall at the Staffordshire centres, and the soil being heavier it remained in a wetter condition throughout the season; at the Shropshire centre the soil was never saturated and moisture conditions were always satisfactory for cultivations to take place. Under the conditions prevailing at the Staffordshire centres it would seem that the TCA was fairly rapidly washed out of the upper soil level, but remained at a level which grass roots reached 3 to 4 months after sowing.

It was also noted that the use of TCA in the spring at the Shropshire centre led to a seedbed being prepared more easily than when no TCA was used, whereas this was not the case at the Staffordshire centres, particularly Centre B.

It is interesting, too, that at the Staffordshire Centre B, whilst the killing of the sward did not help to produce a seedbed more easily, neither did it appear, as judged in September, to have led to less reinvasion of the old sward. Where cultivations were more satisfactory, as at the first date of reseeding, there was no reinvasion by species of the old sward, even where no TCA was applied. At later reseedings, where cultivations were less satisfactory, a few clumps of the old sward were appearing in all plots. Further observations on reinvasion of the old sward will have to be made at all sites in 1955.

Conclusions

1. TCA sprayed in spring can be effective under certain conditions for sward destruction.

2. Spring applications of TCA appear to be much more effective than summer treatments.

3. Lower rates of application of TCA on an undisturbed sward can achieve, under some conditions, as good a kill as higher rates, provided that sufficient time is allowed before reseeding operations are commenced.

4. There is little difference in the resistance to TCA of the different grass species met with in the trials, except for Aira caespitosa which appears to be resistant even to the highest rates of application.

5. The persistency of TCA in the soil varies considerably, as reseeding one month after treatment led to a satisfactory sward which continued to flourish at one centre, whilst at the other centres ill-effects became apparent in the sown swards 3 - 4 months after treatment. The differences encountered here may be due to the more ready leaching of TCA from a light soil on a steep slope than on a heavy soil not well drained.

6. It is doubtful whether the use of TCA is justified under conditions where a thick mat of turf exists, particularly on heavy, poorly drained soils, since treatment may not reduce the amount of cultivation necessary. On more open swards or kinder soils, the use of TCA may help to reduce the need for cultivations.

7. Where dicotyledonous plants are dominant in the treated turf, the use of TCA alone is not a satisfactory pre-cultivation treatment.

Acknowledgments

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OBSERVATIONS ON THE USE OF MALEIC HYDRAZIDE

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Summary

An account is given of the effect of sprays containing maleic hydrazide on various types of grass, and on roadside verges. It has been shown that these sprays retard the growth of the grass, and if properly applied, can be used with safety on the coarser types of grass. The sprays also have a retarding effect on certain weeds, and may be used in conjunction with 2,4-D.

Introduction

Maleic hydrazide is not a new chemical. It was first described by Curtius and Foersterling (1) in 1895. However, its properties as a plant growth regulator were not discovered until 1949, by Schoene and Hoffman (2). Since that time it has been used to extend the storage life of potatoes, (3,4) sugar beet (5,6) and onions (7,8), and to retard the growth of grass (9,10,11). Some doubts were raised by Darlington and McLeish (12) about the advisability of using maleic hydrazide on food crops, but the inhibition of grass growth was of immediate practical interest. Therefore experimental work was done to determine the effect of various formulations of maleic hydrazide on fine and coarse grasses, and the most favourable conditions for applying the treatments.

EXPERIMENTAL RESULTS

Materials

In preliminary trials, which are not reported here, a number of formulations containing alkali metal and amine salts of maleic hydrazide were used. It was then decided to concentrate upon a liquid formulation containing 2½ lb. per gallon of maleic hydrazide as triethanolamine salt, and additives to give desirable wetting and spreading characteristics. This formulation was used in all trials described in this paper. Two types of 2,4-D formulation were used in conjunction with maleic hydrazide. These were 2,4-D (triethanolamine) containing 50% w/v of 2,4-D, and a 2,4-D acid-in-oil emulsion. In making up combined sprays, the 2,4-D preparation was diluted with water as required, and the maleic hydrazide (triethanolamine) was then mixed in.

Measurement of Grass

Measurements of height were made only on specially prepared plots of grass. Trials on roadside verges were assessed by inspection only. A measuring gauge was constructed for use on the prepared plots, but this could be used only on level ground. The gauge consisted of a light but rigid aluminium rod (T-section), six feet in length, supported at each end in such a way that it could be raised or lowered by means of a thumb-screw. The end supports had heavy flat metal bases. At each end, the height of the lower edge of the rod above the bottom of the base could be read from a vertical scale.

The instrument was placed on the grass plot, and the height of the lower edge of the horizontal rod was adjusted so that it just touched the majority of the grasses. The average height of the grasses was recorded. A second measurement was taken at right angles to the first and the process was repeated until the plot had been covered. By this means it was found possible to measure the average height of the grass with considerable accuracy.

Lawn Grasses - Summer Treatments

The plots were sown with New Zealand brown top, Chewings fescue, and various fine-leaved fescues. Maleic hydrazide (triethanolamine) was applied at 4 lb. and 6 lb. (actual maleic hydrazide) per acre in 40 gallons of water.

The trials extended over two seasons. The first application was made in mid-June during warm, dry weather. Sixteen days later the weather became unsettled and there were some heavy storms. When sprayed, the grass was 44 mm. high. After ten days the grass (47 mm.) was cut to 18 mm. Subsequent heights of the grass are shown in Section 1 of Table I, the period of growth being taken from the time of spraying. Seventy days after spraying, the grasses in all plots were growing well. No further treatment was given that year.

Patches of scorch appeared on the eleventh day after the 6 lb. per acre treatment, and fifteen days after the 4 lb. per acre treatment. The grasses began to recover when heavy rain fell in early July.

All plots were sprayed again at the same rates exactly one year after the first treatment. The weather was cool, with heavy showers. The grass was 46 mm. high. After ten days, the grass (50 mm. on treated plots) was cut to 16 mm. Subsequent growth is shown in Table I, Section 2. Scorch was much less severe than in the preceding year, because of the more favourable weather conditions.

Lawn Grasses - Autumn Treatments

Plots were sprayed in early October with 4 lb. and 6 lb. per acre of maleic hydrazide (triethanolamine). This was shortly before growth ceased. The weather was cool, with occasional light rain, and frosty nights. The lawns had been cut regularly throughout the summer, and the grass was 36 mm. high when sprayed. It was cut to 20 mm. ten days after spraying. When all growth stopped 36 days later, the grass was 22 mm. high. Observations were taken the following year as shown in Section 3 of Table I. The grasses showed no signs of damage. Growth was retarded until the June following spraying, when the grasses began to grow away.

Other plots were sprayed at the same rates at the end of October, in cold frosty weather. The grass was 32 mm. high when sprayed, and no growth took place until the following March. The plots were not cut after treatment. During March, the grass appeared to be dying, but responded slowly to treatment with fertiliser, raking, and frequent watering. The grass did not recover fully until the next year.

Coarse Grasses

Plots were prepared with Cocksfoot, rye grasses (Italian and perennial), timothy, R-S meadow grass, S-S meadow grass and various fescues.

The plots were treated in early June with 4 lb. and 6 lb. maleic hydrazide (triethanolamine) per acre in 40 gallons of water. Weather was the same as for lawn grasses. The grass was 115 mm. high when treated. Ten days later the grass (120 mm) was cut to 50 mm. A typical record of subsequent growth is given in section 4, Table I.

Some plots were given a second similar treatment with maleic hydrazide 58 days after the first spraying. There was no cutting before or after. The results are given in section 5, Table I. This treatment was much more effective than the first.

TABLE I

Height of grass after treatment with maleic hydrazide

	Days after Spraying	Days after Cutting	Height of Grass		
			6lb./acre M.H.	4 lb./acre M.H.	Unsprayed Control
SECTION 1	10	0	18	18	18
	34	24	23	23	56
	46	36	32	37	75
	58	48	36	45	104
	70	60	52	61	137
SECTION 2	10	0	16	16	16
	34	24	19	21	33
	46	36	27	28	49
	58	48	37	39	57
	70	60	46	48	74
	82	72	62	63	89
SECTION 3	Date of Observation				
	16th April		32	35	-
	20th May		38	40	-
	15th June		49	52	-
SECTION 4	Days after Spraying	Days after Cutting			
	10	0	51	51	51
	34	24	53	54	70
	46	36	60	63	105
	58	48	71	75	135
	70	60	84	90	166
SECTION 5	Days after 2nd Spray				
	12	60	72	77	166
	24	72	74	78	187
	36	84	75	80	204
	48	96	77	82	217
	60	108	79	85	229

None of these treatments gave rise to any serious scorch. In some instances, slight browning of the tips was noted, but this was not so marked as to be objectionable. During the period of growth inhibition, the grass was rather darker in colour than usual, but it returned to its normal colour as the inhibitory effect of the maleic hydrazide wore off.

Some plots were sprayed with a mixture of maleic hydrazide (triethanolamine) at 4 lb. and 6 lb. per acre and 2,4-D (triethanolamine) at 30 oz. per acre in 40 gallons of water. The results were indistinguishable from those obtained with maleic hydrazide alone. Observation of the few weeds present at the time of spraying showed the 2,4-D to be fully effective.

Roadside Verges

A number of trials were done on roadside verges. Maleic hydrazide (triethanolamine) was used at 4 lb. and 6 lb. per acre in 100 gallons of water. In other trials 2,4-D (acid-in-oil emulsion) was added at 60 and 100 oz. per 100 gallons of spray. Applications were made in early April, when the grass was about 55 mm. high. There were no appreciable differences in the periods of inhibition, growth being retarded on all plots until early June. Some plots were sprayed again with 4 lb. per acre maleic hydrazide in early June. This second spray inhibited growth throughout the summer.

Although the maleic hydrazide did not act as a selective herbicide, it retarded the growth of some weeds. Cat's ear, dandelion, hedge parsley, hog-weed and thistles were all affected. The plants were stunted, sometimes severely, and the flower heads were much reduced in size. In some instances, especially at the higher rate of application, flowering was prevented. At the 6 lb. rate only, plantains (broad and ribwort) and docks were sometimes affected, though results on these weeds were variable. The weed population was not significantly altered by maleic hydrazide alone, though the general appearance of the verge was improved because of the smaller size of the weeds. Addition of 2,4-D to the spray did not reduce the effectiveness of the maleic hydrazide. The kill of weeds was good, and the verges remained in a tidy state throughout the season.

Addition of 2,4-D did not increase the damaging effect of the spray. In some instances, especially at the 6 lb. rate of maleic hydrazide, some slight temporary browning of the tips of the grasses was noted, but there was no real scorch. During the period of inhibition, the colour of the verges was a rather deeper green than usual.

DISCUSSION

The effectiveness of maleic hydrazide treatments have been assessed entirely by measurement of the vertical growth of the grass. Escritt (13), who based his observations on yields of dry matter, noted a rapid increase in growth after about 40 days of inhibition. This is not apparent from our results, perhaps for the reason that an increase in grass cover (and therefore in cuttings) could take place without any great increase in actual height of the grass.

Weather conditions have been reported in some detail because they had a marked influence on the degree of damage caused to the grass. High temperatures during and after spraying tended to increase damage, but the most important factor was rainfall. If there was plenty of rain, even fine grasses were not severely damaged, but spraying during drought invariably resulted in

serious scorch. In effect, the margin of safety was too small for the treatment of fine grasses to be recommended, but coarse grasses were sufficiently resistant for spraying to be done under all normal conditions without risk of more than slight temporary discolouration.

When rain fell soon after treatment, the effectiveness of the spray was lessened. Absorption of maleic hydrazide into the plant seemed to be comparatively slow, and was probably not complete until about 30 hours after spraying. Heavy rain falling after this time did not reduce the effectiveness of the treatment.

A number of plots were mown at various intervals after treatment. It was apparent that cutting soon after spraying reduced the period of inhibition, and that there should where possible be a ten day interval. The spraying of grass immediately after cutting gave poor results. It was advisable to allow the grass four or five days to recover from mowing before applying the maleic hydrazide.

The period of inhibition was lengthened by increasing the dose of maleic hydrazide, but rates higher than 6 lb. per acre could not be applied with safety. Single applications of less than 4 lb. per acre did not give worthwhile inhibition, but repeated applications of smaller amounts gave excellent results. Two treatments with 2 lb. per acre were finally more effective than one application of 4 lb. per acre.

No evidence was found of varietal differences in response to maleic hydrazide. Even after three years of treatment, the composition of plots did not differ greatly from the controls. There was a tendency for weeds which were unaffected by maleic hydrazide to increase their hold. Weeds were best dealt with by including 2,4-D in the spray.

Toxicity of maleic hydrazide

Maleic hydrazide is virtually non-toxic, as is shown by comparison of its oral toxicity with those of 2,4-D and D.D.T. (14).

Maleic hydrazide	L D 50	=	4,000 mg/Kg.
2,4-D	L D 50	=	500 mg/Kg.
D.D.T.	L D 50	=	250 mg/Kg.

Tate(15) has shown that large quantities of maleic hydrazide can be tolerated by rats, dogs and cows. However, Darlington and McLeish(12) have shown that chromosome breakage in certain cells may be caused by treatment with maleic hydrazide solutions, and have suggested that maleic hydrazide might be carcinogenic, by analogy with certain known carcinogens which cause similar breakage. Tests so far carried out have shown that maleic hydrazide is not a powerful carcinogenic substance, though it has not yet been proved to be entirely devoid of carcinogenic properties. Until the results of further tests are known there may be doubts about the advisability of using maleic hydrazide on food crops, but there seems to be no risk in spraying grass with maleic hydrazide, since it is certainly not more dangerous than some mildly carcinogenic chemicals which have been used in public places for many years without ill effect.

Conclusions

Sprays containing maleic hydrazide (triethanolamine) retarded the growth of several varieties of fine and coarse grass. Fine grasses could not be treated with safety, but coarse grasses tolerated quantities up to 6 lb. per acre without significant damage. Applications could be made in spring, summer

or autumn, but spraying during dormancy caused more damage. It was not, therefore, advisable to spray later than the end of September. It was also essential to avoid spraying during drought. Mixed sprays of maleic hydrazide and 2,4-D gave the combined effects of both components. Such sprays had useful possibilities for the treatment of roadside verges and other areas of rough grass.

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PRELIMINARY EXPERIMENTS ON THE EFFECT OF THE SELECTIVE WEEDKILLER 2, 4 - D ON THE VEGETATION OF ROADSIDE VERGES

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Summary

1. Roadside verges provide a variety of habitats for characteristic communities of ecological interest.

2. Experiments are being carried out to demonstrate the effects of 2, 4 - D on types of verge vegetation. One series is to show the differential effects of spraying at three stages in the season and the second to compare the effects of the two preparations which were used on verges prior to 1952 - an amine salt of 2, 4 - D and the acid combined with an emulsifying oil.

3. On all sites spraying has reduced the proportion of dicotyledons in the sward. This has been brought about mainly by eradicating a few species which were originally present in significant quantities (Ranunculus repens, Stachys, Urtica), and a larger number of sparsely distributed small herbs.

4. There is no conclusive evidence for a positive effect on the agricultural weeds - Rumex crispus and Cirsium arvense. The ecologically important species, Anthriscus and Heracleum, have not been reduced to a significant extent but show evidence of susceptibility on some sites. The method of vegetative reproduction may account for the apparent resistance of these and similar species.

5. The importance of applying the spray before or at an early stage in flowering is emphasized. The two preparations of 2, 4 - D appear to be equally effective.

Introduction

The question of roadside spraying has been considered for the past five years by a number of prejudiced observers but apparently this investigation has been the only attempt to produce quantitative scientific data on the effects. The aim of this report is to give some idea of the problems involved, the experiments being carried out and preliminary results which have been recorded after two years' treatment.

The Nature Conservancy are interested in the future of roadside verges because they provide a variety of semi-natural habitats, harbouring characteristic communities and species, many of which are gradually becoming restricted as their potential habitat is eliminated. Thus the plant associations of verges are essentially those of ungrazed marginal land on base-rich soils, a habitat which is reduced to a minimum under the present system of land use in well-farmed regions; extensive areas of waste land remain only on poor soils. The additional factor of human disturbance plays a predominant role in determining the floristic composition of verge communities. Common examples of disturbance are hedging and ditching, clearing thicket growth on neglected verges, dumping road-making materials, cutting the edges and leaving the material on the verge and the churning up of the ground by tractors, gypsies, etc. The main results of these activities are, first to enrich the surface soil with extraneous material and to delay soil deterioration on acid substrates; and secondly to open up the habitat, allowing invasion by aggressive pioneer species and preventing the succession towards a stable sward. Hence the verge is a favourable habitat both for species with high demands for nutrients or requiring specialised

conditions such as abundant leaf litter, shelter, etc., and also for adaptable species capable of colonising any unoccupied niche. Examples of the first type are Anthriscus sylvestris and Urtica dioica; of the second agricultural weeds such as Cirsium and Rumex spp. and Ranunculus repens.

Experimental Sites

The sites were chosen on verges where there were comparatively uniform stretches of characteristic vegetation including a high proportion of dicotyledons. Species which the advocates of roadside spraying were particularly anxious to control were the agricultural pests, e.g. Cirsium arvense and Rumex crispus, the tall growing Umbellifers - Anthriscus sylvestris and Heracleum sphondylium - and other undesirable species such as Urtica dioica. The latter three species have high constancy in verge associations and were abundant on all plots in at least four of the experimental sites whereas Cirsium and Rumex are generally more sparse and in fact were recorded from a limited number of plots. A brief description of the pre-spraying condition of those sites from which quantitative data were recorded will give some idea of the problems under consideration.

I. Ready Token - an unstable open habitat resulting from the recent cutting down of an overgrown woody thicket. This was originally a low-growing community in which Anthriscus, Stachys and Urtica were the most abundant dicotyledons among the scattered stumps of Prunus and Crataegus.

II. Akeman Street - a wide, shaded verge on which Anthriscus and Heracleum were co-dominant with the grasses, forming a comparatively uniform stand.

*III. Sheepscombe - a steep, shady bank characterised by woodland communities.

*IV. Aston Magna - a stand of Geranium pratense, Lathyrus and Vicia, somewhat overgrown with woody species from the hedge.

V. Fawler - a verge which was predominantly grassy near the road but graded into a dense stand of Anthriscus, Heracleum, Stachys and Urtica near the recently cut hedge.

VI. Ducklington - a narrow verge between a recently made-up road and a deep ditch and hedge. The vegetation varied with the type of substrate (influenced by grit, tar, etc.) but the predominant dicotyledons were Heracleum, Potentilla reptans, Rumex crispus, Ranunculus repens and Rubus.

VII. Freeland - a wide, recently levelled verge colonised by a low growing grass with Trifolium, Taraxacum, Plantago, Heracleum and Rumex abundant.

Each site was divided into a number of plots and different treatments were applied in triplicate with a control in each block, except at site VI where the five treatments were duplicated.

Summary of Treatments

Sites I - IV, situated in Gloucestershire, were sprayed by Burt, Bolton and Hayward, Ltd. The object of the experiments was to show the effect of spraying at different stages in the season.

A plots - sprayed during the first week in May when Anthriscus was in bud or the early flowering stage and most other species showed early vegetative growth.

B plots - sprayed during the third week in May, when Anthriscus was in full flower, Stachys and Urtica in bud and later species (Heracleum and Rubus) in the vegetative stage.

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* Sites III and IV were chosen for the variety of species of ecological or aesthetic interest.

C plots - sprayed in the middle of June when Anthriscus was shedding ripe seed and dying back; Stachys and Urtica was in the late flowering stage; Heracleum was in bud or beginning to flower; and later-growing species such as Cirsium arvense, Tamus communis and Rubus gave their maximum vegetative cover.

D plots - unsprayed controls.

At each site all the plots were sprayed with either the amine salt of 2, 4-D[1] (Site I) at the rate of 5.0 lbs. acid equivalent per acre; or the acid of 2, 4-D combined with an emulsifying oil[2] (Sites II, III and IV) at 5.0 lbs. per acre.

The plots were sprayed with a hand lance using number 3 discs and a two slotted swirl plate; the output being 100 gallons per acre at 100 p.s.i.

Sites V - VII, in Oxfordshire, were sprayed by the A.R.C. Unit of Experimental Agronomy. All the plots were sprayed at approximately the same stage (in mid-May) but at each site three (V and VII) or five (VI) different treatments were used:-

A plots - sprayed with 2, 4-D (amine) at 6.25 lbs. acid equivalent per acre.

Bplots - sprayed with 2, 4-D (acid) 6.25 lbs. acid per acre.

C plots - sprayed in 1952 with the oil/emulsifier constituents only of the 2, 4-D acid formulation; in 1953 either 2, 4-D (amine) or 2, 4-D (acid) was applied in May and again in September in order to show the effect of two doses in one season as opposed to two successive years' treatment.

AL and BL plots at site VI were sprayed with half concentrations of the respective compounds and the C plots with two doses of AL in 1953.

These trials were sprayed with a Land Rover mounted sprayer, using hollow cone jets at 9 inch spacing, the output being 80 gallons per acre at 75 p.s.i. and 4 m.p.h.

Assessment of Plots

The aim of the experiments was to obtain quantitative data on the permanent effects of spraying, i.e. the effect of spraying on the following season's growth of biennial and perennial species. All plots were assessed in early spring, before spraying in 1952 and at approximately the same time in subsequent years, before further treatment was applied. The plots have now been sprayed for three consecutive years (1952-1954) and the assessments therefore show the effect of the first two years' treatment.

Point quadrat assessments were considered the most accurate rapid method which is applicable to all types of vegetation from a tall thicket to a low grass sward. On sites I, II, V and VI the counts were made on plots 20 yards long and 3 yards wide (30 x 2 yards at Ducklington). The method was either to throw a single long point 400 times within each plot or to place a frame of 10 points, set 2 inches apart, 40 times; test counts made by each method in turn gave good repeats for most species. The randomization of points was restricted, the plot being divided into quarters with approximately 100 points per 12 sq. yards (2 yard margins were left at either end of the plots). On

(1) formulated as 'Ialine A'

(2) formulated as 'Ialine B'

sites III and IV smaller plots were sprayed and the points were restricted to fixed metre quadrats, taking 200 points in regular lines. This method gives accurate repeat counts and is recommended for future experiments of this kind. In all cases every hit of the point as it passed through the vegetation was counted and the results are given as total number of hits per plot made by each species or group of species.

On site VII the assessment was made by throwing fifty 25 cm. quadrats in each plot, the cover value of the species being noted by eye. The results of this subjective estimation were considered of little value as compared with the more laborious point counts.

Two factors complicated the interpretation of results:-

1. The difficulty of choosing sites where a series of comparable plots could be laid out. The nature of the experimental sites, chosen for their high proportion of "roadside weeds", indicated their unstable state and they showed marked changes in floristic composition, independent of spraying and not uniform throughout the site. It is essential to compare the counts on the three plots receiving the same treatment with corresponding controls and no deductions should be made from a single series of readings.

2. The marked differences in season between 1952, an early spring, and the following two years, both late springs, also caused considerable differences between the control counts for most species.

Results

The immediate effects of treatment were to cause withering and distortion in the majority of dicotyledons but this did not necessarily signify any lasting damage to the plants. Moreover, a species sprayed during a non-susceptible phase of the life history, e.g. Anthriscus in late flower or fruit, showed no distortion and some species sprayed in the vegetative stage and showing initial distortion, recovered and produced normal flowers and viable fruit later in the season (e.g. Heracleum, Knautia). In general, there was a marked contrast between sprayed and control plots for two to three months after spraying. This was particularly obvious at sites with abundant growth of woody species, where treatment caused defoliation and acted as a check to renewed shoot production.

The main object of this investigation was, however, to show the long-term effects; these are demonstrated by the quadrat counts. As it is impossible to publish the complete species lists, Table I shows the counts for the total grass, total non-graminaceous angiosperms and the predominant dicotyledons at each site. The main trends shown by the records are:

1. On all plots sprayed with 2, 4-D there has been an increase in the ratio of grasses: non-graminaceous angiosperms. The oil/emulsifier alone (C) had no effect and these plots cound be considered as additional controls in 1953.

2. The majority of dicotyledons showed a certain degree of susceptibility to 2, 4-D and the total number of species present on sprayed plots was considerably reduced.

3. Only a limited number of species recorded from several sprayed and control plots gave counts which were of statistical significance. These could be divided into three classes according to their susceptibility or resistance to spray.

Table II

Species showing significant reductions, with controls	Species of doubtful susceptibility (5-20%)	Species showing no differential counts between treatments and controls.
Fragaria vesca	Angelica sylvestris	Anthriscus sylvestris
Geranium pratense	Achillea millefolium	Arum maculatum
Galium mollugo	Arctium lappa	Crataegus monogyna
Glechoma hederacea	Agrimonia eupatoria	Galium aparine
Hedera helix	Cornus sanguinea	Geum urbanum
Lathyrus pratensis	Cirsium arvense	Geranium robertianum
Pastinaca sativa	Galium cruciata	Heracleum sphondylium
Plantago lanceolata	G. verum	Lamium album
Potentilla reptans	Rumex crispus	Lapsana communis
Prunus spinosa	Viola spp.	Mercurialis perennis
Ranunculus repens		Ranunculus ficaria
Stachys sylvatica		Rubus fruticosus
Taraxacum officinale		Scilla non-scripta
Urtica dioica		Veronica chamaedrys
Vicia sepium		

In most cases the susceptibility or resistance of the species can be deduced by cursory examination of the counts. Of the species in the "doubtful" category some were too sparse to give sufficient evidence and others, in particular Cirsium arvense and Rumex crispus, appear spasmodically in open parts of the habitat and may disappear as conditions change and competition increases. Hence control counts were not repeatable in successive years and spraying effects could not be proved.

The interpretation of the counts for Anthriscus and Heracleum was complicated by the natural fluctuations in population and successional changes. In a general analysis the effects of spraying appeared insignificant but it is evident that on sites I and II Anthriscus was adversely affected by spraying early in the season. Growth was actually encouraged by late spraying, owing to reduction of the competition factor after other tall-growing species had been killed. Heracleum was also affected on site II, on all sprayed plots. At this stage of the experiments the changes in cover of Anthriscus and Heracleum cannot definitely be attributed to spraying. Their apparent resistance may be explained by the fact that both species are biennials which propagate by root offsets at all times in the growing season. The spray only affects individuals with aerial growth and the separated offsets in the soil can then grow up to replace the dying shoots in the autumn or following spring. Hence the point quadrat counts include the survivals from the previous season's spraying plus this new growth; seedling establishment is probably important only in open habitats. It is suggested that, if susceptible to 2, 4-D, Anthriscus and

Heracleum may be weakened gradually by successive doses until production of offsets becomes negligible. Thus the eradication of established stands of this type of species may take up to five years but this will depend on other factors such as disturbance of the substrate and the stage in the succession reached by the community. For example, if the habitat is "open" as a result of recent hedging, the species may be actively spreading and will be more difficult to control than an established stand of mature plants.

TABLE I(a) Assessment of Plots

I READY TOKEN (2, 4 - D amine)

	Number of hits per 400 points per plot (averages of 3 replicate)			
	Spr. early May	Spr. mid May	Spr. mid June	CONTROLS
Total grass				
1952	521	507	394	628
1953	752	703	429	623
1954	x (1)	630	453	253
Total non-gram. angiosperms				
1952	587	401	420	496
1953	294	231	383	840
1954	x (1)	147	235	437
Anthriscus sylvestris				
1952	243	126	79	188
1953	162	133	232	299
1954	x (1)	78	175	133
Stachys sylvatica				
1952	79	40	101	65
1953	-	-	2	98
1954	x (1)	-	-	54
Urtica dioica				
1952	69	82	48	106
1953	3	12	3	82
1954	x (1)	13	1	122

(1) All plots of this treatment at Ready Token and 2 out of the 3 at Akeman Street, were sprayed in error before assessment in 1954.

II AKEMAN STREET (2, 4 - D acid)

	Number of hits per 400 points per plot (averages of 3 replicate)			
	Spr. early May	Spr. mid May	Spr. mid June	CONTROLS
Total grass				
1952	1089	1093	1259	1249
1953	1010	1009	840	901
1954	1000(1)	1022	894(2)	984
Total non-gram. angiosperms				
1952	761	851	1036	765
1953	280	392	507	569
1954	302(1)	336	323(2)	517
Anthriscus sylvestris				
1952	428	520	303	414
1953	213	321	362	324
1954	198(1)	280	287	297
Heracleum spondylium				
1952	209	149	216	193
1953	51	50	130	168
1954	36(1)	35	29	141

III SHEEPSCOMBE (2, 4 - D acid)

	Hits per 200 points in metre quadrats (averages of 3 replicates)		
	Spr. mid May	Spr. mid June	CONTROLS
Total grass			
1952	271	332	363
1953	120	199	327
1954	220	187	225
Total non-gram. angiosperms			
1952	425	291	245
1953	141	99	285
1954	158	103	253

IV ASTON MAGNA (2, 4 - D acid)

Total grass			
1952	669	447	627
1953	519	275	337
1954	460(3)	394	300
Total non-gram. angiosperms			
1952	394	479	401
1953	34	85	219
1954	26(3)	117	288

(1) All plots of this treatment at Ready Token and 2 out of the 3 at Akeman Street, were sprayed in error before assessment in 1954.

(2) One plot sprayed before 1954 assessment.

(3) Two plots of this treatment were bared by gypsies before 1954 assessment.

TABLE I(b) Assessment of Plots

V FAWLER

	Number of hits per 400 points per plot (averages of 3 replicates)			
	Spr. 2, 4 - D amine	Spr. 2, 4 - D acid	Oil emulsifier '52 2 doses 2, 4 - D acid '53	CONTROLS
Total grass				
1952	1438	1447	1303	1017
1953	1280	1325	1025	1045
1954	1351	1430	1386	1269
Total non-gram. angiosperms				
1952	895	910	984	951
1953	422	502	675	828
1954	430	407	560	683
Anthriscus sylvestris				
1952	212	287	189	215
1953	175	223	159	206
1954	283	248	289	190
Heracleum sphondylium				
1952	133	53	203	150
1953	63	36	165	109
1954	42	32	103	108
Stachys sylvatica				
1952	174	76	100	93
1953	21	4	92	90
1954	-	1	3	37
Urtica dioica				
1952	117	88	129	143
1953	44	52	68	111
1954	7	14	12	109

	Number of hits per 400 points per plot (averages of 2 replicates)					
	2,4-D amine	½ conc. amine	2,4-D acid	½ conc. acid	oil/emulsifier '52 2 doses ½ conc.amine '53	CONTROLS
Total grass						
1952	1230	833	868	1476	1073	1232
1953	1107	1019	1045	1006	982	878
1954	1570	1482	1277	1434	1561	1196
Total non-gram. angiosperms						
1952	617	838	833	732	923	712
1953	311	859	621	519	1001	872
1954	298	722	546	236	309	669
Heracleum sphondylium						
1952	184	74	359	53	192	33
1953	118	49	207	17	82	29
1954	174	60	195	51	35	84
Rumex crispus						
1952	20	100	79	74	54	45
1953	33	34	60	19	45	36
1954	18	14	36	22	22	36
Rubus fruticosus						
1952	70	113	120	120	45	94
1953	61	203	132	125	65	146
1954	11	54	67	4	7	12
Urtica dioica						
1952	26	102	34	92	140	170
1953	10	76	30	65	206	280
1954	3	88	60	40	40	178

TABLE I(c) Assessment of Plots

VII NORTHLEIGH Percentage cover - quadrat method

	Spr. 2, 4 - D amine	Spr. 2, 4 - D acid	oil emulsifier '52 2 doses 2, 4 - D acid '53	CONTROLS
Percentage grass				
1952	53	49	50	48
1953	76	71	66	57
1954	83	78	79	60
% Anthriscus sylvestris				
1952	0.4	1.5	1.7	3.5
1953	2.1	2.7	2.7	6.0
1954	2.1	3.4	3.1	6.0
% Heracleum sphondylium				
1952	15.0	6.3	12.8	9.6
1953	10.1	5.8	10.1	10.1
1954	5.8	4.5	5.8	10.4
% Rumex crispus				
1952	4.3	7.1	5.4	6.3
1953	1.8	3.2	1.7	3.0
1954	0.5	2.7	2.2	3.4

Mr. J. R. Escritt: I should like to ask two questions. The first is directed to Professor Blackman, or anyone else present who might be able to give information on the possible carcinogenous properties of maleic hydrazide and the desirability of using it in public places.

The second question is directed to Mr. Eaton. Has he any information regarding the possibility of bringing about diseases in treated swards consequent upon the checking of growth by the use of maleic hydrazide?

Dr. G. F. Harding: The question of the possible carcinogenic effect of maleic hydrazide is, of course, a very important one which is being investigated at present by Dr. Barnes of the M.R.C. Toxicology Unit. Complete results are not yet available but no evidence has been found of any carcinogenic properties of maleic hydrazide though a complete clearance has not yet been given to the chemical.

Dr. G. O. P. Eaton: As regards disease in the treated swards, these trials which we have been carrying out have taken place over the past three years and up to the present time we have noted no difference in the stands of grass. We have not noted that any of the grasses which normally have an upright habit have become procumbent and we have certainly noted no diseases whatsoever. If there is anybody in the hall who has been using this material and who can give any information on this point we shall be very pleased to hear of it.

Mr. A. L. Abel: On the question of TCA and the other substances which have been mentioned for grass and particularly couch control, the results that have been given should, I think, convince even Professor Sanders that at least there are now in existence three compounds which could be used for the eradication of couch. There are one or two common factors which one hopes to find in a range of papers based on the same materials, for example the rates, whether the treatments are economic, how they are applied, the different soil types, what crops can follow and how soon afterwards, and also in what crops can the treatments possibly be used selectively. Regarding the rates, we have rather a difference between the papers - Professor Osvald has indicated the recommendation should be 50 kgs per hectare, which is approximately 50 lbs. per acre. Mr. Jary on the other hand proposes that you have two separate applications of 20 lbs. but that on occasions 30 lbs. per acre have given good results. Mr. Jary mentioned that it is preferable to use high volume and this raises one question I would like to ask Professor Osvald. At what volume was the treatment applied, if indeed it was sprayed? It may possibly have been applied in the dry state. On the question of cultivations - cultivations alone give a certain proportion of control of couch grass and I think the best usage of these chemicals is combined with cultivations; the paper which Mr. Evans presented indicated that possibly cultivations before the application might be best. I think that this is one aspect which must be investigated in greater detail. Soil types are very important. We have not got, in this country, exactly the same conditions, in particular the heavy soils, mentioned by Professor Osvald, but our experience would seem to indicate that the soil does not hold the material in the top 6", during and after the winter, although this apparently happens in Sweden. From the quotation that Davies and Evans made in their paper, the same sort of thing occurs in Canada, TCA being held in the soil during the winter and affecting the succeeding crop if this is susceptible. I feel from what has been presented that we can follow a TCA application with certain crops in this country and I think perhaps Professor Osvald, although he is speaking from his own conditions in Sweden, is perhaps a little sweeping when he says it would appear that no summer crops can be grown after an early

spring application. Lastly, there is the question of how does dichloro-proprionic acid compare with TCA? We have Professor Osvald's results indicating that under Swedish conditions, the rates should be the same as for TCA and yet we have published evidence from America that the dichloro-proprionic acids can be used at much lower rates. I would like to direct a question to Dr. Warren Shaw and ask him whether there is a difference in the rates of dichloro-proprionic acids used on the Eastern States, and the Central States of the U.S.A. I would think that the very dry summer conditions that prevail in continental land masses may possibly explain the difference between these materials which are so dependent on climatic factors for their effective use.

Professor Hugo Osvald: In previous experiments we have used TCA in high volume, but in the experiments which we have reported today it was spread over the soil in a dry condition as a powder, as was the dichloro-proprionic acid. When TCA or sodium chlorate are applied in the autumn in central Sweden, they remain in the soil for a long time because the soil is frozen most of the winter. In consequence, it is usually not possible to grow spring crops after an autumn application of sodium chlorate. We generally follow the chemical treatment with a bare fallow and sow wheat about one year after the application.

Professor H. G. Sanders: Can I ask for more information about TCA on couch? I can see from the slides that the speakers have shown to us that it has certainly not given a 100 per cent kill. I presume the perfectly clean area around the plots in Mr. Hood's experiments had been properly cultivated. Is TCA available and how much does it cost?

Mr. S. Evans: The field around Mr. Hood's trial was very well cultivated: the farmer apparently thought that by using TCA we were going to do a better job than he could by cultivation so he worked the land extremely well and did, generally, obtain a better control than we did. But then the farmer was making sure whilst we were carrying out a trial; and our cultivations consisted simply of running once through with a cultivator on two separate occasions. The degree of control is mentioned in the table given in Mr. Hood's paper. You will see that up to 70 per cent control has been obtained by simply cultivating twice, and that this was increased to over 95 per cent where a chemical treatment was combined with the cultivations.

TCA is available commercially at between about 2/- and 3/6 a pound depending upon the source of supply. The lower price refers to the crude material supplied in bulk.