Research Report No. D.7

CONTROL OF HORMONE-RESISTANT WEEDS IN CEREALS

T. C. Breese & A. F. J. Wheeler

Plant Protection Ltd., Fernhurst Research Station

Summary

This paper reports the results of a series of large-scale trials carried out in 1956 to test sodium monochloroacetate (a soluble powder relatively non-toxic to mammals) as a contact weedkiller against hormone-resistant weeds in cereals. The main emphasis of the work was placed upon the control of cleavers (Galium aparine) in autumn and winter sown cereals, and, in general, observations on other weeds were subsidiary to this objective.

The trials showed that sodium monochloroacetate controlled cleavers and many other hormone-resistant weeds in cereals and was particularly efficient when applied in low volumes of water. Greater weed control was obtained by increasing dosage rates, but it is evident that 25 lb/ac of the material is approaching the region of phytotoxicity to cereal crops. Sodium monochloroacetate at 20 lb in 20 gal/ac of water consistently gave good weed control without depression of cereal yield. At this rate the chemical was only slightly inferior to DNC. Further work is necessary to ascertain the susceptibility of spring sown barley.

Introduction

Late in 1954, W. Ochiltree of Plant Protection Ltd., Fernhurst, observed that a solution of sodium monochloroacetate in water had certain selective properties when applied to some weedy crops. Promising results were obtained in a number of small-plot trials during 1955 by spraying autumn and winter sown cereals infested with cleavers with sodium monochloroacetate. Further small-plot and greenhouse trials were carried out in the late winter 1955/56 to test related derivatives of the chemical. None of these proved equal to the original compound. Sodium monochloroacetate was therefore subjected to large-scale field trials during the spring and summer of 1956 and these were supported by a grower-usage project on a country-wide scale under the supervision of Plant Protection Ltd. representatives.

Experimental methods and results

Twenty-three large-scale trials were sprayed during 1956. The trials were designed to test the weedkilling propensities of sodium monochloroacetate and its phytotoxic effect upon cereal crops under the following conditions:

(a) In comparison with DNC (dinitro ortho cresol), the standard chemical in use for the control of hormone-resistant weeds.

(b) At different dosage rates, and at two stages of spraying.

(c) Applied in different volumes of water and at two stages of spraying.

(d) With the addition of a wetting agent.

(e) In mixtures of various ratios with MCPA (potassium).

The trials were distributed across the "cleavers belt" from Gloucestershire and Herefordshire in the west to Essex and Norfolk in the east.

Layout of trials

Each trial consisted of four randomized blocks. Each plot was the width of the sprayer boom (5 yd) and the plot length generally 100 yd with a run in/out of 5 yd. Chemicals were applied by a Land Rover mounted sprayer.

Methods of assessment

The stage of growth of the crop and weeds present at the time of spraying was determined by measuring random plants across the trial area. Weedkill was estimated by taking at random 10 counts of 1 sq. yd quadrats per plot.

Weed control

(i) Comparing sodium monochloroacetate with DNC on cleavers

The following table illustrates the results of this group of trials:

Treatments	Average % control of cleavers	No. of trials
15-lb sodium monochloroacetate in 20 gal/ac water	74.3	4
20-lb " " " " " "	87.3	6
25-lb " " " " " "	88.0	2
15-lb " " " 80 " "	52.3	4
20-lb " " " " " "	63.5	6
25-lb " " " " " "	76.5	2
DNC 1 ac pack (6 lb) in 80 gal/ac of water	92.7	6

Statistical analysis of the results of these trials confirms:

(a) That 20-lb and 25-lb sodium monochloroacetate applied in 20 gal/ac of water were only slightly inferior to DNC.

(b) That sodium monochloroacetate applied at low volume was considerably more effective than at high volume.

Crops, with one exception, were winter wheat, 2-4 tillers and 5 to 8 in. in height.

(ii) The effect of different dosage rates of sodium monochloroacetate on cleavers

The following table illustrates the increased control of cleavers obtained with higher dosage rates in this group of trials.

Dosage rate of sodium monochloroacetate in 20 gal/ac of water	15-lb	17.5-lb	20-lb	22.5-lb	25-lb	30-lb
Average % control of cleavers	70.6	78.9	81.2	85.3	89.2	95.0
No. of sprayings	8	8	10	8	5	2

Four dosage rate trials were sprayed at two stages, about 3 weeks apart. Late spraying was significantly more effective than early spraying in two of these. The other two showed good control at both early and late application.

(iii) The effect of different volumes of application on cleavers

Four trials (two of which were sprayed at two stages, about 3 weeks apart) were laid down to test the relative effect of applying sodium monochloroacetate in 10, 20, 40 and 80 gal/ac of water. No firm advantage was shown by any volume over the others.

The two stage trials revealed no advantage of early over late spraying or vice-versa. A fair level of control was obtained throughout these trials by both 15 lb and 20 lb of sodium monochloroacetate.

(iv) The effect of adding a wetting agent

The addition of 0.025% v/v concentration of 'Agral' LN to 20 lb/ac sodium monochloroacetate had no significant effect upon performance in either low or high volumes of water. Both applications gave a good kill of cleavers and an acceptable control of chickweed in the single trial in which they were compared.

(v) Sodium monochloroacetate in mixture with MCPA (potassium)

Three trials were laid down on spring sown cereals infested with a variety of weeds. These were cleavers, redshank (Polygonum persicaria), corn gromwell (Lithospermum arvense), field bindweed (Convolvulus arvensis), chickweed (Stellaria media), coltsfoot (Tussilago farfara), creeping thistle (Cirsium arvense), yellow charlock (Sinapis arvensis) and fat hen (Chenopodium album).

The mixtures were tested in different ratios but revealed no weedkilling characteristics over and above those of the constituents.

(vi) Effect of sodium monochloroacetate on weeds other than cleavers

Sodium monochloroacetate at 20 lb in 20 gal/ac of water gave efficient control of redshank, day nettle (Galeopsis tetrahit) and yellow charlock. It usefully checked chickweed and field bindweed in the advanced seedling stage and creeping thistle, corn gromwell and coltsfoot at all stages of growth. It did NOT control advanced seedling fat hen or knotgrass (Polygonum aviculare).

Cereal yield

Cereal yield data have been obtained from seventeen of the trials. The remainder were abandoned owing to the difficult harvesting season. Comparisons of yield were made by weighing the yield of a single cut of the cooperating farmer's pusher-type combine harvester (usually 8 ft 6 in.) through the centre of each 15 ft plot. The area of each plot thus harvested was about 1/17th ac.

2-lb samples of grain were taken from each plot harvested in order to determine the percentage of weed seed present. Analysis of these samples has shown that the yield data are biased against sodium monochloroacetate and DNC since the weed seed content of untreated plots is higher than that of the treated plots. (In one trial weed content of the samples from untreated plots accounted for over 15% of the gross weight).

Sampling for moisture content of grain has not revealed any consistent trend between treatments.

The following main points have emerged from statistical analysis of yield data:

1. There has been no yield depression on autumn and winter sown cereals sprayed below the height of about 9 in.

2. Some depression in yield has occurred when crops were sprayed beyond a general height of about 9 in. Over 16 treatments (64 plots) this depression averaged about 10%. In order to reduce variability between plots trials were sprayed across the drills. The wheels of the spraying vehicle are each 6 in. wide; the usual width of the combine harvester cut was 8 ft 6 in. Thus 12% of the area harvested would be affected by spraying at a time when plants are crushed beyond recovery by the wheels of the spraying vehicle.

Control plots were not run over with the spraying vehicle, and it is therefore considered that the 10% yield depression was caused by mechanical damage followed by chemical spray.

3. There is no evidence of increasing yield depression on autumn and winter cereals with increasing dosage rates up to 25 lb/ac sodium monochloroacetate.

4. There is no evidence of yield depression of spring sown wheat or oats by 20 lb sodium monochloroacetate in 20 gal/ac of water. In one trial, however, 25 lb and 30 lb sodium monochloroacetate in 20 gal/ac of water caused a significant depression of spring wheat. The crop was 3 tillers, 8 in. high when sprayed.

20 lb sodium monochloroacetate in 20 gal/ac of water caused a significant depression (18%) of spring barley, 3 tillers, 14 in. high. It is thought that mechanical damage owing to lateness of spraying substantially contributed to this yield depression.

5. There were no clear differences of yield resulting from sodium monochloroacetate applied in different volumes of application.

6. Yields from sodium monochloroacetate treated crops have not proved inferior to DNC.

7. The addition of 0.025% v/v concentration 'Agral' LN to 20 lb/ac sodium monochloroacetate applied in low and high volumes of water gave similar cereal yields to 20 lb sodium monochloroacetate without the wetting agent.

Undersown clovers and grasses

Two trials were undersown with clover and grass seed mixtures 10 days after spraying. Clovers and grasses were undamaged in both trials. In one of these trials the stand of clovers in plots sprayed with sodium monochloroacetate was 20% greater than untreated plots when assessed after harvest. This was no doubt due to removal of weed competition.

Discussion

The table at the end of this paper indicates the average weed control by different dosage rates of sodium monochloroacetate and volumes of water per acre; also the resulting cereal yields. This table clearly shows that increasing the dosage rate improved the control of cleavers throughout the trials, but at rates below 25 lb/ac there was no corresponding reduction in cereal yields.

Despite the lack of consistent evidence emerging from the volume comparison trials, sodium monochloroacetate has given a better overall performance in 20 gal/ac of water than at high volume at all three dosage rates in which comparison was made i.e. 15 lb, 20 lb, 25 lb/ac. There is, however, a slight tendency for reduced cereal yield when the chemical is applied in 10 gal/ac of water, although the limited number of trials involved would not justify any firm conclusions.

The general picture is one of consistent weed control when the chemical is applied in 20 gal/ac of water but firm evidence is lacking as to whether late spraying at high volume is more effective than early spraying at low volume. It is thought that autumn and winter sown cereals should be sprayed as late as possible in order to include later germinating cleavers and susceptible annual weeds since sodium monochloroacetate has no apparent value as a pre-emergence weedkiller. The susceptibility of charlock and day nettle to sodium monochloroacetate is valuable in this respect. It also checks the aerial growth of creeping thistle. The resistance of fat hen to sodium monochloroacetate presents a problem and suggests that investigation into the effect of a full strength mixture of MCPA and sodium monochloroacetate would be justified in order to control a dual infestation, e.g. cleavers and fat hen.

In general the performance of sodium monochloroacetate has compared very favourably with that of DNC, both as a weedkiller and in safeguarding yields. It is perhaps, slightly inferior in its all-round effect upon hormone-resistant weeds, but decidedly superior in convenience in use. The yield figures of DNC shown in the table are slightly misleading, since they include one trial where heavy rain followed 2.5 hours after spraying. No weedkill resulted. However, each of the four sodium monochloroacetate treatments yielded nearly 20% more than untreated whilst DNC plots yielded 31% more than untreated plots.

A limited amount of work on spring sown cereals showed no depression of cereal yield of wheat or oats when 20 lb sodium monochloroacetate was applied in 20 gal/ac of water. However, the depression of spring barley caused in a single trial suggests the necessity for further work before sodium monochloroacetate can be considered safe on this crop.

Sodium monochloroacetate is not rainfast when an appreciable amount of rain follows spraying, but over 50% weed control was obtained in one trial when steady rain followed 3.5 hours after spraying.

It has been generally observed that plots treated with sodium monochloroacetate are more easily harvested by the combine harvester than are untreated plots. Furthermore this difficult harvesting season has revealed untreated tracts of cereals severely laid alongside standing areas of sprayed crops.

The results of these trials are substantially confirmed by the 1 ac trials conducted in the grower-usage project, with the additional information that spurrey (*Spergula arvensis*), black bindweed (*Polygonum convolvulus*), speedwell (*Veronica spp.*) and viper's bugloss (*Echium vulgare*) are also susceptible to sodium monochloroacetate.

Conclusions

Sodium monochloroacetate is an easily soluble powder, relatively non-toxic to mammals. It has proved efficient in controlling cleavers, redshank, day-nettle and yellow charlock and useful in checking chickweed, field bindweed and creeping thistle without injury to the crop. It is effective when applied in a low volume of water. 25 lb and 30 lb/ac of actual material have proved at least equal to DNC in their performance, but it is felt that these rates are approaching the region of phytotoxicity to cereal crops. 20 lb sodium monochloroacetate in 20 gal/ac of water has proved consistent in both weedkill and crop safety over a large number of trials, although further work is necessary to establish its safety to spring sown barley.

These properties will enable the farmer to apply the chemical in his own spraying machine without the accompanying restrictions and hazards of DNC.

(47011)

765

Control of cleavers (Galium aparine) in relation to cereal yield, with sodium monochloroacetate

Rate lb/ac sodium monochloroacetate	15 lb	17.5 lb	20 lb	22.5 lb	25 lb	30 lb	15 lb	15 lb	15 lb	20 lb	20 lb	20 lb	25 lb	DNC 6 lb
Volume of water/ac	20 gal	20 gal	20 gal	20 gal	20 gal	20 gal	10 gal	40 gal	80 gal	10 gal	40 gal	80 gal	80 gal	80 gal
No. of sprayings in average	16	8	19	8	7	2	3	3	8	3	2	9	2	7
Average % control	70%	79%	80%	85%	89%	95%	67%	69%	56%	77%	76.5%	61%	76.5%	89%
No. of harvestings in average	11	6	18	6	8	2	2	2	4	3	2	7	2	4
Average yield as % of untreated	99%	100.5%	100.8%	98.1%	96.7%	86.5%	94.7%	97.6%	102.1%	97.5%	104.2%	104.8%	110.5%	112%

The above figures include early and late spraying in some trials.

The difference between numbers of sprayings and harvestings is caused by abandoned trials.

THE CONTROL OF WEEDS IN KALE BY SPRAYING WITH SULPHURIC ACID

INTERIM REPORT OF FIELD EXPERIMENTS

by W. Q. CONNOLD, D. G. BAGLOW and R. E. ROGERS
N.A.A.S. - South West

Summary

Further work with dilute sulphuric acid (without a wetter) seems to confirm previous pointers; namely that if kale is going to be sprayed with this material against weeds, there is much less check to the crop, as well as other advantages, if it is done early.

Introduction

A survey[1] carried out in 1954 of farm practice and investigational work to date in England and Wales showed that, whilst kale crops were usually treated as a last resort when the crop was smothered and would otherwise be ploughed in, it might well prove advantageous to spray earlier, despite the fact that the weed growth would then provide no "protective canopy". The certain advantages would be that resistant weeds would be more effectively controlled and weed competition largely removed before the crop had suffered; and a likely advantage would be that lower strengths of acid could be used. The important point in doubt was whether the crop itself would suffer a greater or lesser check if sprayed in the earlier stages of growth.

An observation study carried out in Devon in 1954 by D. G. Baglow[1] and reported to the British Weed Control Conference of that year, appeared to demonstrate beyond doubt that in that very wet summer, earlier spraying gave both better weed control and less set-back to the crop, but the treatments were not fully replicated and no weighings were attempted.

Experimental Results

In 1955, in as dry a summer as 1954 was wet, two fully replicated trials were laid down in Devon and Wiltshire. In Devon the work was again undertaken by D. G. Baglow, N.A.A.S., on the farm of Mr. D. Ferens, Ipplepen, and in Wiltshire by R. E. Rogers, N.A.A.S., on the farm of Colonel G. R. Smith, Shrewton.

The layout was the same at both centres except for minor modifications. Each plot was about 40 yards long by one boom width of a field-sprayer, and treatments were in quadruplicate. The differences were that at Shrewton four dates of spraying were used as against three at Ipplepen and that as very few weeds appeared at Shrewton, the hand-weeded strip running across all plots as a check was dispensed with.

The crop at Ipplepen was Thousand-head kale and that at Shrewton Marrowstem interpersed with rows of Hungry Gap to facilitate electric fencing. It will not be necessary to refer to the Hungry Gap again, after mentioning that, as might be expected from the more crinkled nature of its leaf, it suffered more scorching from the acid than the Marrowstem. At both centres the spray consisted of 10 gallons of B.O.V. plus 90 gallons of water without the addition of a wetter. All plots received a top dressing of 2 to 3 cwts Sulphate of ammonia immediately after spraying, the controls being treated at an intermediate date.

What few annual weeds appeared at Shrewton (mainly charlock, chickweed, knotgrass and fat-hen) were in general effectively killed on the sprayed plots, and on the control plots they made only stunted growth and flowered prematurely. At Ipplepen weeds were more numerous and they made considerable growth (although nothing like so much as in the 1954 plots). Quadrat counts were taken for kale and weeds before and after spraying, but these were "random" instead of "fixed", with the result that the figures from the earlier and later counts were not strictly comparable. Nevertheless they show that there were about 4 kale plants per square foot which was only reduced by the earliest spraying (to 3) and that by reason of the uneven braird, resulting in the presence of some plants in the 2-leaf stage or less at the time of spraying. There were on average about 6 charlock plants per square foot and these were reduced to 0.2 by spraying. Other weeds included sowthistle seedlings, creeping thistles and chickweed. Of these, only sowthistles were present in large numbers and spraying killed or severely checked them. At the time of the last spraying at Ipplepen damage to the kale was as great, if not greater, where the weeds were thickest.

Five and ten samples per plot of one square yard equivalent were taken for yield at Ipplepen and Shrewton respectively in December and late November, and the calculated weights of crop per acre are shown in Table I.

Table I (a) Yield of Kale in tons per acre at Ipplepen

		Control	Sprayed at true leaf stage 2-4	5-6	9-10	Mean
	Standard error			(± 0.512)[x]		
Handweeded strip	(± 0.631)[ø]	15.99	14.15	14.15	11.88	14.04
Others	(± 0.354)[ø]	12.48	14.04	12.96	11.78	12.82
Mean	(± 0.185)	13.65	14.08	13.36	11.81	13.23
Increase	(± 0.262)		+0.43	-0.29	-1.84	

Standard error per sub plot 1.478 tons per acre or 11.2% (28 d.f.)
Standard error per whole plot 0.371 tons per acre or 2.8% (9 d.f.)

[x] For use in diagonal comparisons only.

[ø] For use in horizontal comparisons only.

(Table I Contd.)

(B) Yield of Kale in tons per acre at Shrewton

Treatments	Control	Sprayed at true leaf 2-3	4	6	Late Treatment	Mean
Mean (±0.88)	11.74	11.15	11.95	9.55	7.60	10.40
Increase (±1.24		-0.59	+0.21	-2.19	-4.14	
Standard error per plot 1.75 tons per acre 16.9% (12 d.f.)						

DISCUSSION OF RESULTS

It will be seen that in neither experiment was there any appreciable gain in crop yield from the elimination of weeds by spraying. At Shrewton there was virtually no weed competition, and at Ipplepen the season was such that, even with a moderate weed population, the kale was in no danger of being smothered. In both experiments however there is clear evidence of greater crop-resistance to the acid up to about the 5-leaf stage, with a marked fall after that point was reached. There was also evidence at both centres that spraying when the kale plants have only 2-true leaves may kill some of the weaker plants or result in a slightly lower yield.

Conclusions

Bearing in mind that better weed control of a larger range of species is sure to result from as early spraying as is practicable, our results in 1954 and 1955 would appear to indicate that spraying (without a wetter) when the kale has 3-true leaves is about the best compromise.

Acknowledgement

An analysis of the results by Rothamsted is gratefully acknowledged.

Reference

(1). W. Q. Connold and E. I. Prytherch (1954)
"The Use of Sulphuric Acid for Controlling Weeds in Brassica Crops"
British Weed Control Conference Proceedings, Vol.ii, pp. 457-463.

CONCLUSIONS OF EXPERIMENTS ON THE EFFECTS OF THE SELECTIVE WEEDKILLER 2,4-D ON THE VEGETATION OF ROADSIDE VERGES

Miss O. E. Balme, Nature Conservancy

Summary

1. Two series of experiments were started in 1952. The object was to investigate the long-term effects of annual applications of 2,4-D on typical communities of roadside verges. Preliminary results were described in 1954; this report gives the results of the continuation of one series of experiments.

2. Changes in plant cover from year to year (1952-1956) were followed. Susceptible species were killed by a single application and moderately resistant species by two applications. In subsequent years changes in cover by several dicotyledons were recorded but they could not be related to spraying effects.

3. It was concluded that, in unstable communities of this type, natural changes in floristic composition were as significant as changes brought about by spraying.

Introduction

The report presented to the Weed Control Conference in 1954 explained the object and lay-out of the experiments and the results to date. Two groups of experimental sites were originally used:-

1. Four sites in Gloucestershire; the plots were sprayed at two or three different stages in the season, with either the amine salt of 2,4-D or the acid combined with an emulsifying oil.

2. Three sites in Oxfordshire; all plots were sprayed on approximately the same date (mid May) but at each site the two formulations were used (see below) and some plots received a second application in the autumn.

Since the 1954 report, no further work has been carried out on group 1 but all Oxfordshire plots were re-treated in 1954 and 1955 and the vegetation assessed each spring. The final assessment in 1956 therefore gives the results of consecutive years of treatment. This report will give a summary of the changes from year to year on the three Oxfordshire sites and the conclusions drawn from the whole series of experiments.

Summary of results on Oxfordshire sites

1. FAWLER

12-60 sq. yd plots in 3 blocks with 3 treatments and a control in each:-

A. plots sprayed with the amine salt of 2,4-D	)	sprayed in early May 1952 - 55.
B. plots sprayed with the acid of 2,4-D combined with an emulsifying oil	)	

C. plots sprayed with the emulsifying oil only in 1952 and with 2 doses (May and September) of the amine of 2,4-D in 1953-1955.

Applications were at the rate of 6.25 lb/ac a.e. The plots were assessed by point quadrat analysis.

This was a moderately shaded verge, the vegetation varying from the open grassy edge, though a mixed grass - Umbellifer zone back to the Urtica - Stachys community on the disturbed ground in the shade of the recently cut hedge. The predominant dicotyledons in the sprayed area were Anthriscus sylvestris, Heracleum sphondylium, Stachys sylvatica, Urtica dioica; Galium spp., Lamium album and Mercurialis perennis were locally abundant.

Point quadrat counts taken in the first spring following spraying showed the overall increase over 1952 in the grass:dicotyledon ratio on A and B plots, the main changes being the disappearance of Stachys and the reduction in cover of Heracleum and Urtica. Several species previously present in small quantities had also disappeared. Anthriscus, Mercurialis and Lamium, showed no consistent changes in abundance on sprayed plots as compared with controls and plots sprayed with oil emulsifier only.

Annual counts, made at approximately the same date each year, showed that the floristic composition of the unsprayed verge (D plots), subjected to an annual midsummer mowing remained fairly constant from year to year; certain early colonisers near the cut hedge e.g. Stachys sylvatica and Glechoma hederacea were gradually shaded out by taller growing associates; and species which occur sporadically in disturbed areas - mainly Cirsium arvense and Sonchus oleraceus showed similar fluctuations. On sprayed plots, the results of the first treatment were borne out in subsequent years. Highly susceptible species had been killed by a single treatment and those species which were not reduced by the first season's spraying showed no ill effects after 4 years treatment, i.e. there was apparently no cumulative effect on Anthriscus, Lamium and Mercurialis; on some sprayed plots one or other of these species showed significant increases, probably the result of reduced competition from Urtica dioica, which formed locally dense stands on the original verge. Two species were mentioned as being moderately resistant to the first treatment - Heracleum and Urtica. Urtica was reduced to negligible proportions after 2 treatments applied either in successive years (A and B plots) or at two stages in the same year (C plots). Heracleum gave somewhat anomalous results. After one year's spraying the count (in 1953 on A and B plots and in 1954 on C plots) was significantly reduced but in subsequent years there was little or no further reduction and in the final assessment (1956) there was an actual increase over the previous year; on some plots the species regained its 1952 cover values. The results suggest that Heracleum is less resistant than Anthriscus to 2,4-D but that it readily recolonises either by seed or by vegetative propagation from existing plants.

2. DUCKLINGTON

12-60 sq. yd in 2 blocks with 5 treatments and a control in each.

A and AL plots sprayed with 2 concentrations of the amine salt of 2,4-D, 6.25 lb/ac and 3 lb/ac.

B and BL plots sprayed with 2 concentrations (as above) of the acid plus emulsifier.

C plots sprayed with the emulsifier only in 1952 and with 2 doses of the low concentration of the amine salt in 1953 - 55.

All plots were sprayed at the same dates as Fawler and assessed by point quadrat analysis.

This road had recently been re-made and the material dumped on the road edge was colonised by characteristic invaders of an "artificial" substrate - Ranunculus repens, Potentilla reptans, Rumex crispus etc. On the more natural soil (clay) Heracleum, Urtica, Equisetum, and Anthriscus were locally abundant and Rubus grew out from the hedge and ditch into the sprayed area.

The 1953 spring count showed a general small increase in the grass: dicotyledon ratio on plots sprayed with 2,4-D (as compared with C and D) due mainly to the disappearance or reduction of the following species:-

Lathyrus pratensis
Pastinaca sativa
Potentilla reptans
Ranunculus repens

Potentilla required 2 doses of the low concentration for a complete kill but the other species were eliminated by a single treatment of either concentration.

There was little further increase in the grass:dicotyledon ratio in subsequent years as there were no consistent reductions in cover of other abundant species; Heracleum and Urtica were reduced on certain treated plots in certain years but, after 4 years spraying, both species still gave substantial counts on all except the two C plots, where Urtica was reduced to negligible values. Rumex crispus, another moderately resistant species, was killed off gradually by successive years' treatment. Other changes in vegetative cover could not be related to spraying. Anthriscus increased throughout the site, becoming locally dominant on some plots, while Equisetum species which were locally co-dominant or abundant in 1952, practically disappeared during the next few years. These significant changes in plant cover, dependent on other habitat factors, possibly masked the effects of spraying. For example, the persistence of Urtica on treated plots may have been the result of continual reinvasion of an unstable habitat rather than resistance of plants actually sprayed. The experiment clearly demonstrated the impermanence of chemical control of perennial weeds in an unstable habitat of this type.

3. FREELAND

12-60 sq. yd plots in 3 blocks with 3 treatments and a control in each.

A plots sprayed with amine salt of 2,4-D

B plots sprayed with acid of 2,4-D plus emulsifier

C plots sprayed with emulsifier in 1952 and with 2 doses (May and September) of the acid plus emulsifier in 1952-1955

All plots were sprayed at same dates and concentrations as at Fawler.

This verge had recently been levelled and the open habitat was colonised by a grassy sward with Heracleum and Rumex locally abundant. The most frequent dicotyledons throughout the site were low-growing pasture plants - Lathyrus, Plantago spp., Ranunculus spp., Taraxacum, Trifolium spp. and Vicia. These plots were assessed with 25 cm quadrats, a method which was practicable in the original low sward but proved very difficult to repeat in subsequent years, when the vegetation varied in height. However, the main features of interest were clearly demonstrated and supported the results at Ducklington and Fawler. The following species were shown to be susceptible to treatment:-

(i) After 1 year's spraying:-

Lathyrus pratensis
Plantago lanceolata
P. media
Ranunculus acris
R. repens
Taraxacum officinale

(ii) After 2 or more years' spraying:-

Rumex crispus
Trifolium spp.
Vicia sativa (an annual probably checked by prevention of seeding)

As at other sites there was a definite reduction in Heracleum cover after one or two years spraying but the results were not consistent and there followed a marked increase on several plots in 1956, as compared with 1954 and 1955. Anthriscus increased on most plots and showed no spraying effects. The relatively slow colonisation of a newly made habitat by Anthriscus agrees with the results at Ducklington.

Conclusions

The main features demonstrated by the annual quadrat counts can be summarized as follows:-

1. On all sprayed plots there was a marked increase in the ratio of grass:dicotyledons after the first year's spraying and in many cases this was augmented in subsequent years.

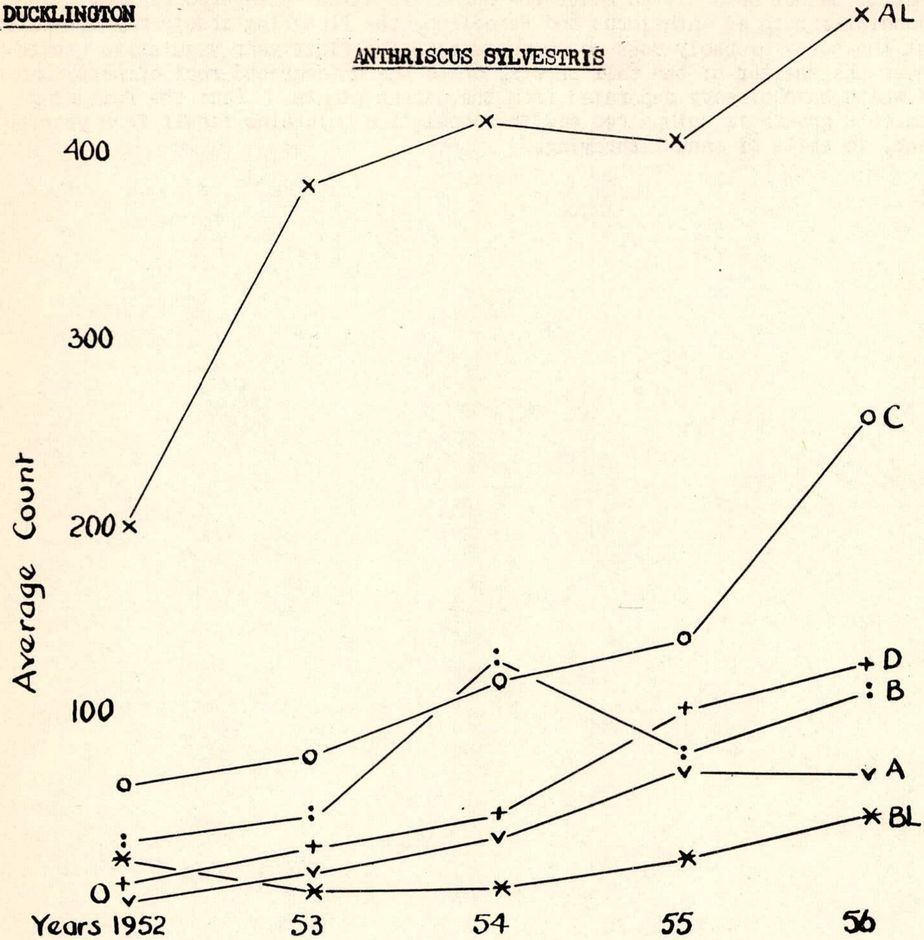
2. This was brought about by the elimination of a number of dicotyledons by one treatment, thus reducing the total number of species present on sprayed plots. Moderately resistant species gave reduced counts but required two or more doses to effect a significant kill. e.g. Rumex crispus, Urtica dioica. Heracleum sphondylium was effectively controlled only by the high dosage rates applied on Gloucestershire sites.

3. Several dicotyledons with significant cover values were apparently unaffected by spraying (Lamium, Anthriscus, Heracleum, Mercurialis, Geum urbanum) but some of these showed changes in abundance during the course of the experiments. For example Anthriscus increased from year to year on many plots and this was interpreted as being in part a normal successional change and in part an indirect result of spraying, as competition with associated species (in particular Urtica) was reduced. Anthriscus did show susceptibility to abnormally heavy doses of spray applied early in the season on Gloucestershire A and B plots.

It was concluded that, in this type of community, the natural changes in floristic composition from year to year were as significant as the changes imposed by spraying. Only a limited number of dicotyledons were effectively controlled; some, which were killed by the spray, are liable to recolonise in locally disturbed areas, e.g. Urtica and Cirsium arvense, so that lasting control cannot be achieved under the normal roadside - hedgerow regime. In biennials, such as Anthriscus and Heracleum, the flowering shoots may be killed but the spray probably does not penetrate to the first year vegetative growth under the shelter of the tall shoots, or to the underground root offsets, many of which have already separated from the parent plants. Thus the following season's growth is unimpaired and the population maintains itself from year to year, in spite of annual spraying.

DUCKLINGTON

ANTHRISCUS SYLVESTRIS

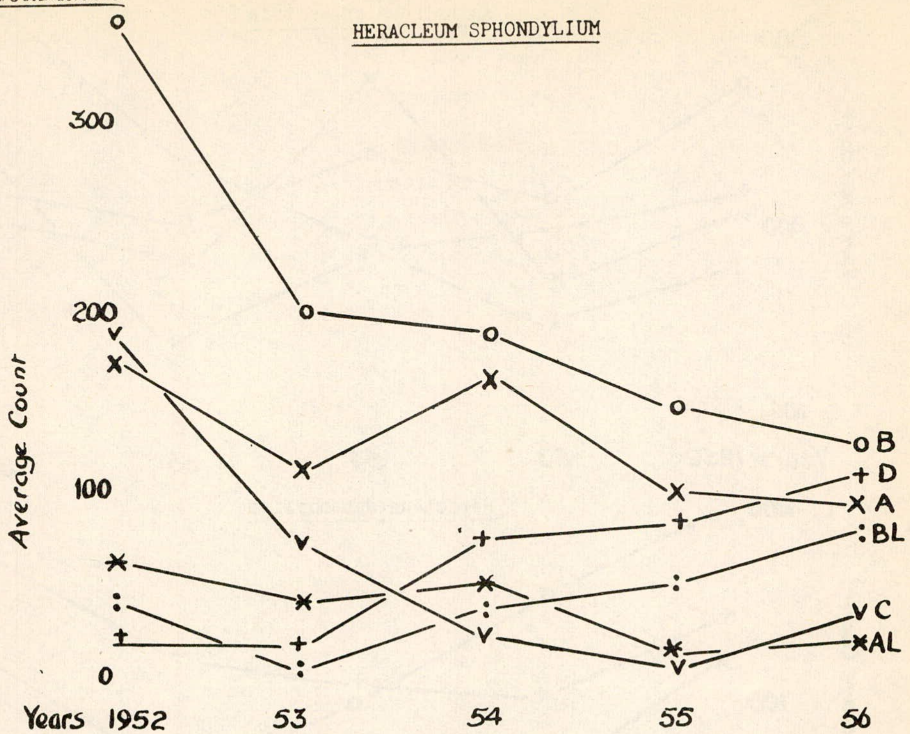


Graphs showing changes in cover of Anthriscus sylvestris Heracleum sphondylium and Urtica dioica under different treatments (counts given as average total lists for 2 (Ducklington) or 3 (Fawler) replicate plots.

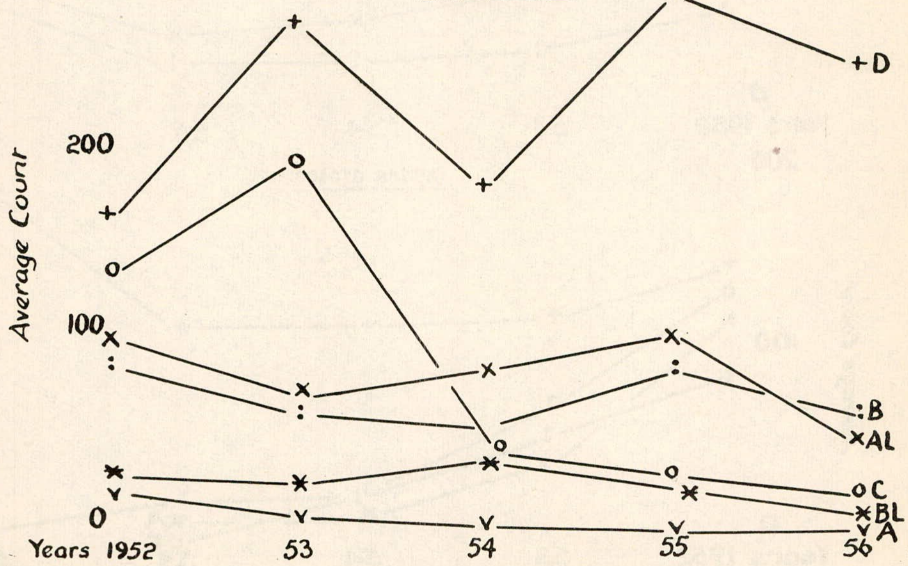
A & AL plots treated with amine of 2,4 - D
B & BL " " " acid
C " " " 2 doses of amine or acid (see text)
D " untreated controls

DUCKLINGTON

HERACLEUM SPHONDYLIUM



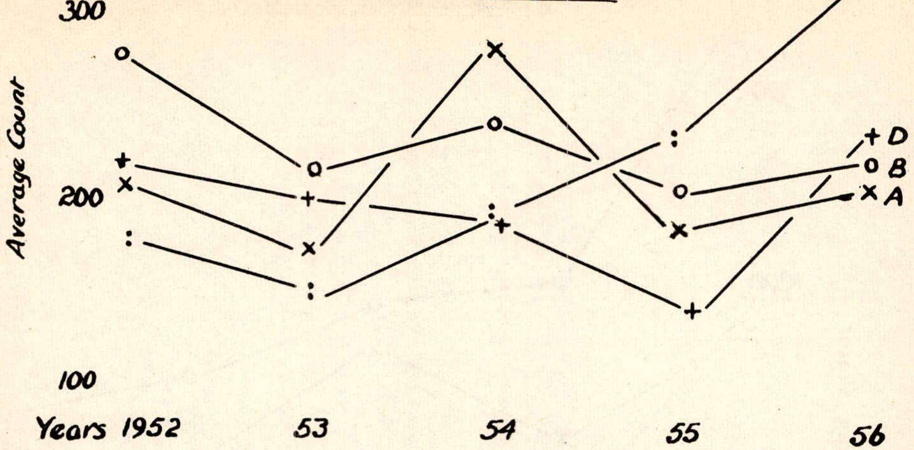
Urtica dioica



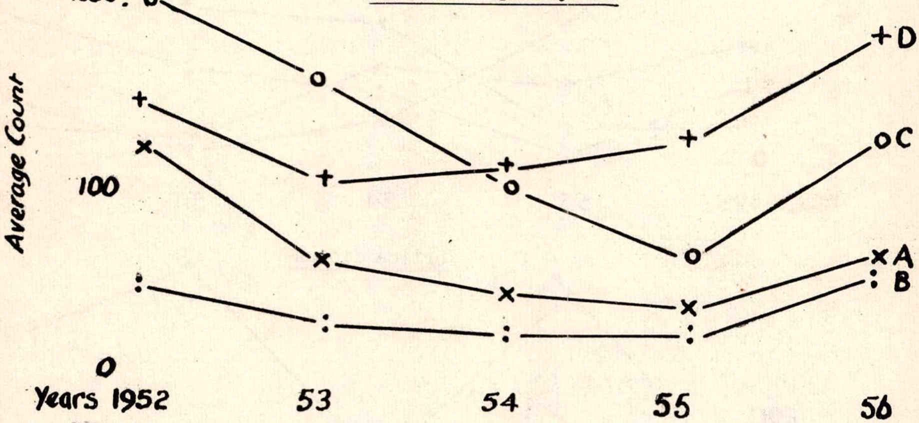
(47011)

FAWLER

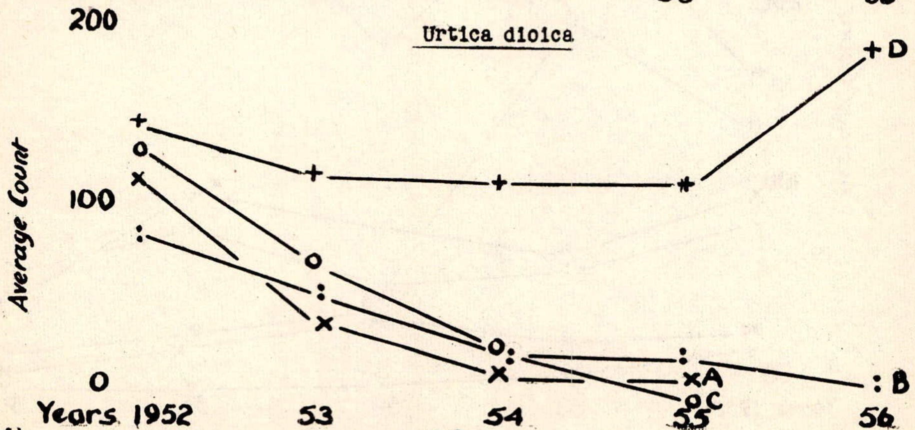
Anthriscus sylvestris



Heracleum sphondylium



Urtica dioica



FURTHER DEVELOPMENTS IN THE CONTROL OF MOSSES IN SPORTS TURF WITH CALOMEL (MERCUROUS CHLORIDE)

R. V. Blandy

F. W. Berk & Co. Ltd.
Tilgate Research Station, Crawley, Sussex

Summary

An account is given of the control obtained with applications of calomel on certain Pleurocarp mosses infesting sports turf. Experiments have shown that control of these mosses has been achieved with rates of calomel as low as 0.3 gal/sq. yd, and the evidence suggests that freedom from these species can be maintained with an annual dressing of this amount.

Introduction

The majority of turf weeds are efficiently controlled by the synthetic growth regulators. These materials, however, have no permanent effect upon mosses, which the greenkeeper now considers to be one of his most serious problems especially during the early spring and late autumn when the growth of the grasses is limited and the conditions are most favourable for the mosses. These weeds are not easy to control by cultural methods, and chemical control - based on ammonium sulphate and ferrous sulphate or potassium permanganate - will only be temporary unless the applications are often repeated.

The property of inorganic mercury compounds in preventing the development of mosses was first reported by Booer[1]. Subsequent experimental trials showed that when calomel (mercurous chloride) was incorporated with a normal lawn sand to give an application of 1 g of calomel/sq. yd, this combined dressing gave an effective control of mosses for a whole season. (Blandy 2.)

The object of this report is to produce quantitative data on the effect of the addition of calomel to materials containing ammonium sulphate and ferrous sulphate and to show that calomel alone will effectively control mosses in turf. This report also presents the results which have been recorded over the last two years with reduced rates of calomel.

Experimental

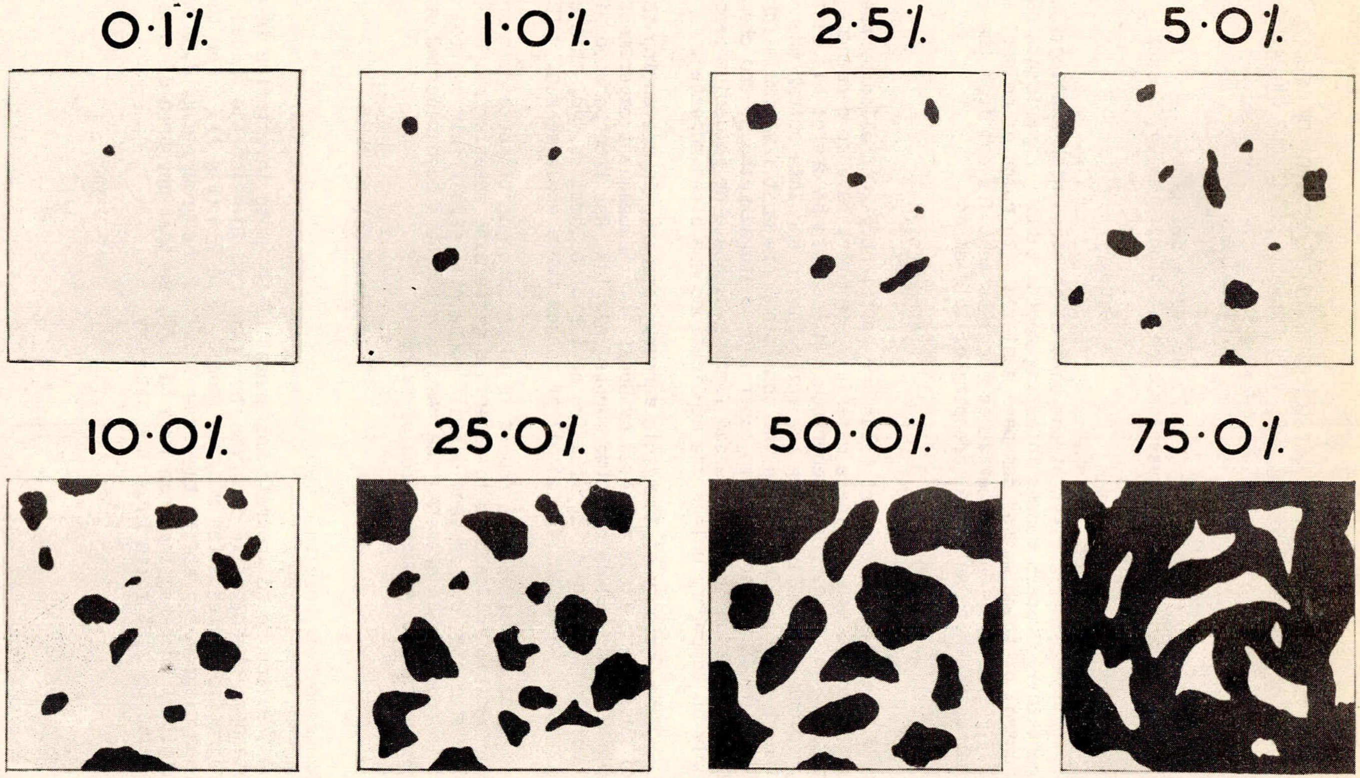
Assessment of results

To enable an accurate assessment of the moss infestation in a turf, standard quantitative diagrams were prepared in which the shaded areas represent degrees of infestation ranging from 0.1% to 75% (Fig 1). For the assessment, each diagram represents the upper limit of the group, e.g. 2.5% as the upper limit of that ranging from 1.0% to 2.5%, so that any area of moss just over 1.0% and up to 2.5% falls into this category.

(47011)

FIG. 1

STANDARD DIAGRAMS
ASSESSMENT OF MOSS INFESTATION IN TURF



The areas under trial were divided into units of 1.5 ft x 1.5 ft. Each unit was assessed separately against the diagrams and the mean percentage area of each plot calculated from the series of assessments. The method has been subjected to statistical analysis and the accuracy proved.

Trial 1

Materials

1. Lawn fertilizer with analysis 4.4% N_2 as ammonium sulphate.

4.3% P_2O_5) as potassium
8.0% K_2O) phosphate.

7.9% ferrous iron as ferrous sulphate.

2. 1% Calomel dust - the diluent being an inert filler.

A lawn infested with mosses the predominant species being Rhytidiadelphous squarrosus, Brachythecium rutabulum, Hypnum cupressiforme, Acrocladium cuspidatum was divided into 12 plots - each 4.5 ft x 7.5 ft. The lawn fertilizer was applied as a single application and as a mixture with two rates of the 1% calomel dust on 24th March, 1954. Each treatment was either duplicated or replicated three times.

All plots were assessed on 23rd March 1954 the day before the treatments were applied. Subsequent assessments were made in the autumn and spring of 1954 and 1955.

Results

The lawn fertilizer in each treatment produced an immediate scorch and blackening of the mosses and turf. With the new growth and cutting of the turf this effect gradually disappeared - the mosses, however, remained black and withered. The results of this trial are shown in Table 1.

Table 1

The effects of various treatments on the control of mosses in turf

Treatment	Rate sq. yd	No. of Replicates	Mean % Area Infested with Mosses			
			Date of Assessments			
			23.3.54	23.12.54	15.6.55	26.11.55
Untreated control	-	x 2	23.3 *	25.9	4.6	27.7
Lawn fertilizer	2 oz	x 2	36.5 *	24.5	2.5	27.2
Lawn fertilizer) 1% Calomel dust)	2 oz) 4 oz)	x 3	31.2 *	0.3	0.1	1.9
Lawn fertilizer) 1% Calomel dust)	2 oz) 2 oz)	x 3	32.1 *	0.4	0.1	1.7

* Assessments made before treatments were applied on 24th March, 1954.

Although an initial effect on the mosses was obtained with the treatments containing the lawn fertilizer, the results show that where this material was used alone a reinfestation occurred in the following autumn similar to that recorded in the untreated plots. On the other hand all treatments containing calomel have given a control of mosses which has persisted until the autumn 1955.

Trial 2

A site containing the same species of mosses as Trial 1 was used to compare the effects of two rates of ammonium sulphate and ferrous sulphate when incorporated with calomel - each treatment to give approximately 1 g of calomel/sq.yd when the materials were applied at a rate of 4 oz sq. yd. The site was divided into 12 plots 7.5 ft x 4.5 ft and arranged in three randomized blocks of four treatments. A moss assessment was made on 9th March 1954 and the treatments applied on 19th March 1954. The subsequent control of mosses is given in Table 2.

Table 2

The effect of incorporating ammonium sulphate and ferrous sulphate with calomel

Treatments	Rate sq. yd	Mean % Area Infested with Mosses			
		Date of Assessments			
		9.3.54	21.10.54	1.6.55	8.11.55
Untreated control	-	33.1 *	34.3	10.2	55.4
Calomel + 24.9% ammonium sulphate 20.0% ferrous sulphate	4 oz	29.3 *	0.3	0.0	11.9
Calomel + 4.0% ammonium sulphate 4.0% ferrous sulphate	4 oz	27.8 *	1.1	0.0	17.9
Calomel + inert filler	4 oz	28.6 *	0.3	0.0	5.1

* Assessments made before treatments were applied on 19th March 1954.

All treatments have effected a similar degree of control and indicate that the amounts of ammonium sulphate and ferrous sulphate added to the calomel are not critical. A similar control has been obtained with calomel alone, so that it would appear the main advantage of the addition of ammonium sulphate and ferrous sulphate is to cause an immediate phytotoxic effect on the mosses together with a stimulus to the turf.

Trial 3

A further site - the predominant moss species being Brachythecium rutabulum, Acrocladium cuspidatum and Hypnum cupressiforme was marked off into twenty plots each 7.5 ft x 4.5 ft and arranged in four randomized blocks of five treatments.

Materials

1. 50% Calomel as a dispersible powder.

2. 1% Calomel dust - the diluent being an inert filler.

The treatments consisted of an untreated control, three rates of 50% dispersible calomel applied as a suspension in water at the rate of 1 gal/4 sq. yd and one rate of 1% calomel dust to give a dressing of about 1 g calomel/sq. yd. An assessment was made 9th March 1954 and the treatments applied on 4th June 1954. Reassessments were made on 21st October 1954. See Table 3.

Table 3

The effect of different rates of calomel on the control of mosses

Treatment	Rate of Calomel in g/sq. yd	Mean % Area Infested with Mosses, Date of Assessment 9.3.54	21.10.54
Untreated control	-	30.1 *	37.5
50% dispersible calomel	0.31	25.8 *	1.1
50% dispersible calomel	0.62	46.6 *	0.3
50% dispersible calomel	0.93	21.0 *	0.1
1% calomel dust	1.1	25.9 *	0.5

* Assessments made before treatments were applied on 4th June 1954.

Each rate of calomel has given a very good control of the mosses (Table 3).

Since this has been achieved with one third of the rate of calomel previously employed, it was decided to study the persistence of each rate and to find out whether control could be maintained by yearly applications of these smaller applications. One replicate was, therefore, retreated on 2nd July 1955. Reassessments were continued on all plots the following autumn and spring, the results of which are given in Tables 4 and 5.

Table 4

The effect of different rates of calomel on persistence of control of mosses

Treatment	Rate of Calomel g/sq. yd	Mean % Area Infested with Mosses (Mean of 3 replicates) Date of Assessment 9.3.54	21.10.54	1.6.55	8.11.55	19.4.56
Untreated control	-	20.3 *	37.4	16.3	49.5	36.6
50% dispersible calomel	0.31	21.4 *	0.1	0.0	10.8	1.8
50% dispersible calomel	0.62	18.7 *	0.4	0.0	10.2	2.5
50% dispersible calomel	0.93	23.9 *	0.1	0.0	5.0	1.1
1% calomel dust	1.1	18.1 *	0.2	0.0	7.5	1.9

* Assessment made before treatments were applied on 4th June 1954.

Table 5

The effect of yearly applications of different rates of calomel on the control of mosses

Treatment	Rate of Calomel in g/sq. yd	Mean % Area Infested with Mosses Date of Assessment 9.3.54	21.10.54	1.6.54	8.11.55	19.4.56
Untreated control	-	28.0	36.2	9.5	37.3	44.2
50% dispersible calomel	0.31	42.0 *	4.0	0.7	0.7	0.6
50% dispersible calomel	0.62	19.0 *	0.0	0.1	0.0	0.1
50% dispersible calomel	0.93	26.7 *	0.2	0.0	0.1	0.7
1% calomel dust	1.1	26.7 *	1.3	0.3	0.0	0.0

* Assessments made before treatments were applied on 4th June 1954.

Table 4 shows that a reinfestation of mosses is taking place in the autumn of 1955 to the same degree in all treated plots and to obtain complete freedom from mosses the plots would have to be retreated in the summer of 1955. When this was done complete control has been maintained by all rates of calomel (Table 5).

Discussion

It is evident in Trial 1 that a spring dressing of a lawn fertilizer, which contained sufficient ammonium sulphate and ferrous sulphate to scorch the aerial growth of the mosses and cause an immediate withering of their shoots, has not had a sufficiently permanent effect to control a re-infestation the following autumn. The addition of calomel with this fertilizer to give a dressing of approximately 1 g of calomel/sq. yd has obtained a practical control for two seasons.

Trial 2 indicates that the actual amount of ammonium sulphate and ferrous sulphate applied with the calomel is not critical, and it has been shown that control of the mosses has been obtained with the calomel alone. It would, therefore, appear that the main advantage of the addition of the ammonium sulphate and ferrous sulphate to calomel is their immediate phytotoxic effect and the fact that they act as a general stimulus to the growth of the turf.

The most interesting results are those which show that a control of the Pleurocarp mosses has been obtained with a dressing of calomel equivalent to 0.3 g/sq. yd approximately one third of that previously employed. Freedom from these mosses has also been maintained for two years with an annual dressing of this small amount. These trials are continuing.

Similar trials are being carried out on the Acrocarp species. These species are more often found in situations, such as bowling greens, where it is necessary to keep the grass closely mown. At the moment, it would appear that they are the more difficult to eradicate once they have established themselves, since by their habit of growth they form a series of brush-like tufts which are firmly attached to the soil by numerous rhizoids. The most sensible way would seem to include a dressing of calomel in the normal spring application of an inorganic fertilizer at the first sign of moss infestation, and maintain a control before they have seriously established themselves.

Conclusion

These trials have demonstrated that calomel is a useful chemical for the control and prevention of mosses infesting sports turf. They also show that this material has a distinct advantage over the chemicals commonly employed on account of the greater persistence of its control.

Two years work indicate that certain moss species can be controlled with relatively small amounts of calomel which in certain circumstances may make it economic to maintain complete freedom from mosses with an annual dressing.

References

(1) BOCER, J. R. (1951), Ann.appl.Biol., 38, 334.

(2) BLANDY, R. V. (1954), J. Sci. Fd Agric., 8, 397.

EFFECT OF COPPER SULPHATE ON AQUATIC WEEDS

H. S. Foster, c/o British Sulphate of Copper Assn., Ltd., 1, Great Cumberland Place, London, W.1.

and

W. Plant, The Court, Tickenham, Somerset.

Summary

A stream forming part of the Blind Yeo Drainage System (Somerset) was continuously treated with copper sulphate to maintain a copper concentration around 1 p.p.m. in the water for a period of about three months, with the object of controlling the aquatic weeds.

The total weed growth if reduced at all, was not reduced enough to obviate the need for manual clearance.

The composition of the weed flora was changed, in particular, water crow-foot (Ranunculus aquatilis) and Canadian water weed (Elodea canadensis) were suppressed.

No ill effects on animals using the stream for drinking or on fish, were seen.

Introduction

The addition of copper sulphate to bodies of water is established practice for the control of many species of algae. Additions made for this purpose or single larger additions made for other purposes, such as snail control, have not been observed to control rooted weeds to any very great extent. In the last few years however, the maintenance of a small concentration of copper in the water for periods of weeks and months has been found in some places to bring about a very useful reduction in the aquatic flora, with the elimination of many species.

Wilson-Jones(1) has reported that in the Sudan copper sulphate added to the the water entering the Gezira irrigation system to the extent of 1 p.p.m. (equals 0.25 p.p.m. copper) has satisfactorily controlled the more troublesome weeds and enabled hand weeding to be dispensed with. Sharaf el Din and El Nagar(2) also Sharaf el Din and Wilson-Jones(3), had earlier reported good results with higher concentrations, but now even small concentrations, less than 1 p.p.m., have also often proved quite effective there. Similarly, Derby(7), Derby and Graham(4), Derby and Townsend(5), also Weight(6) report that the addition of copper sulphate to the water entering the Los Angeles reservoir system has eliminated many species of weeds, thus saving much of the labour of mechanical weeding and improving the quality of the water. In this case the addition is made in the summer only at the rate of 0.8 p.p.m., reduced later in the season to 0.6 p.p.m. (equivalent to 0.2 and 0.15 p.p.m. copper respectively).

Preliminary small scale trials in Ceylon suggest that it can be used to control Salvinia, a floating aquatic, very harmful to the rice fields there.

These results suggested that possibly in this country too, copper sulphate applied in small quantities over considerable periods, might be effective in controlling weed growth.

Experiments

An experiment was started at Tickenham (Somerset) on a stream forming part of the Blind Yeo drainage. The water in these streams is said to be alkaline due to its origin in limestone hills. The water in the stream used for the experiment had a pH of 7.6 to 7.7. The very numerous channels which constitute this drainage scheme must be kept clear and the farmers have to find most of the labour for this, often at inconvenient times. A chemical method of killing the weeds or of arresting their growth, might therefore, be very useful.

One of us has already reported some experiments using tar oils Plant (8), but the effect of these on fish rules out their use. It was thought that the property of copper of disappearing after a time from natural waters whether due to precipitation as carbonate, adsorption by clay or organic matter, or from other causes, would tend to prevent any serious damage to the fauna.

The experiment was started as soon as weed growth in the stream became active (1.5.56). The rate of addition aimed at was 1 p.p.m. of copper (4 p.p.m. copper sulphate crystals). This was a considerably higher rate than that found effective elsewhere, but as there was some reason to believe that the phytotoxicity of copper decreases with temperature, it was thought desirable to start at about this figure which could be reduced later if results should warrant it.

The rate of flow of the stream was normally from 10,000 to 15,000 gal/hour, and the rate of addition of copper sulphate was calculated on this basis. The flow was undoubtedly at times faster than this, and fairly often considerably slower - when the farmers higher up diverted it for their own purposes.

This stream, for the first 300 to 400 yd down from the treatment point, averaged about 5 ft wide by 1 - 2 ft deep and had a soft peaty bottom. Beyond 400 yd it was narrower, more rocky and consequently more rapid in flow. The stream above the point of treatment, regarded as the control portion, was similar to the first portion below.

The reduction in copper concentration down the stream was steady but may perhaps be regarded as small. The rapid fall to a small figure which then remained nearly constant reported by Wilson-Jones[1], was not observed here. A typical reduction with a steady feed would be 10% at 100 yd, 50% at 400 yd. The average time to flow this 400 yd was about five hours. At 800 yd a definite positive reaction for copper was generally found, but not more than 0.1 p.p.m. Mixing in the stream was not marked and when the rate of feed had been reduced it was not unusual to find concentrations at considerable distances down the stream higher than at the treatment point. The water emerging from a small ditch completely choked with weeds and about 150 yd long fed with copper containing water from a leak in the bank of the stream, contained copper equal to at least two thirds of that entering it.

At first the method used was to add a solution of copper sulphate (1 lb/gal) and adjust the rate so as to give the required concentration in the water determined colorimetrically on the spot by means of sodium diethyl dithiocarbamate. By measuring then the rate of flow of the solution, the flow of the stream could be calculated.

Copper sulphate in the concentration aimed at, or indeed, at two or three times that concentration, did not produce any visible milkiness in the water due to precipitation of copper carbonate. Such a milkiness was seen only when the copper concentration was locally much higher, or temporarily while adjusting the feed rate. Laboratory trials with the same water show visible precipitation only at about 8 p.p.m. of copper.

The arrangement for maintaining a constant flow of solution was not very satisfactory, and after the experiment had been in progress for five weeks the method was changed to that of hanging bags of copper sulphate each containing 28 lb of crystals in the stream clear of the bottom. Bags lined with bitumenised paper such as are used for nitrochalk, were found to give a slow rate of solution, one bag contributing about 0.4 p.p.m. copper to the water while fairly full. One bag was added every two or three days without removing partially dissolved bags so that some copper was coming from about three bags at any one time. The copper content of the water was checked from time to time in the same way as before.

The total amount of copper sulphate added was 0.5 ton over a period of 103 days, which included one period of 20 days when flow nearly ceased owing to water diversion and practically no copper was added. This quantity is sufficient to give an average concentration of 1.1 p.p.m. of copper in an average flow of 12,500 gal/hour for 83 days. It seems reasonable to assume therefore, that the concentration over the period did average about 1 p.p.m. of copper, but undoubtedly large deviations from the average occurred at times due to unintentional variation in the rate of addition and to fluctuations in the flow of the stream.

In the stream used for the experiment, the growth of certain weeds was inhibited, but total weed growth was not materially reduced beyond the first ten to twenty yd from the treatment point. In the next three to four hundred yd, growth was vigorous mainly of _Callitriche aquatilis_, and the necessity for manual clearance was therefore, not avoided. It appears that this weed, which is a common aquatic weed in the district, is quite resistant to the action of copper in the concentration used. Another weed prevalent in the treated portion of the stream was _Veronica anagallis_ of which the emergent inflorescences were notable.

Weeds conspicuously absent were _Ranunculus aquatilis_ and _Elodea canadensis_. These were present in other streams in the district and in the control portion of the stream, i.e. that above the point of treatment, though they were by no means the dominant species there, _Callitriche_ being by far the commonest there as in the treated part. Algal growth was practically absent and in consequence the water in the treated part of the stream appeared much brighter than in the untreated, where green scums occurred together with brown slimes clinging to the vegetation. Duckweed (_Lemna_) also was absent in the treated portion. Watercress did not occur to any extent in either parts of the stream, but it flourished in a ditch fed by water containing copper leaking from the treated portion.

Effects on animals

Cattle and poultry occupied the field bordering the experimental stream from the point of addition for a distance of about 300 yd and used it for drinking with no ill effects.

During the first month or so of the experiment, tadpoles and sticklebacks as well as other forms of water life, were very obvious in the stream and appeared to be suffering no harm.

Later on when weed growth was thicker, the fauna was less obvious in both parts of the stream. No detailed comparison of the populations of the two parts was undertaken. Certainly no dead fish were seen, nor was any obvious difference noted between the two parts of the stream which was believed to contain no fish of any size.

Discussion

Although the results of this pilot experiment are mainly negative and do not suggest that the use of copper sulphate will provide a solution to the farmers' problem in this district, yet these preliminary results are believed to have some interest. The selective nature of the action of copper sulphate on water weeds noted by Wilson-Jones(2) in Sudan, Derby and Graham(4) and others in California, appears to be in evidence here also. It occurs even in the case of algae, as there are species resistant to concentrations which are quickly fatal to the commoner sorts. The suppressive action of copper sulphate on the growth of *Ranunculus* and particularly of *Elodea*, may prove valuable where, as is often the case, either of these is the troublesome weed. It suggests that further work in confirmation of these observations will be worth while.

Conclusion

The maintenance of a small copper concentration (1 p.p.m. or less) in the water of streams and canals appears to have a selective action on the weeds grown in them, inhibiting the growth of some species while having little or no effect on others.

Acknowledgment

We wish to thank Mr. K. Wilson-Jones(2) of the Colonial Pesticides Research Committee, for his interest in this work and for valuable advice.

References

(1) WILSON-JONES, K, (1956), Weed control experiments in the Sudan. Pesticide Abstracts & News Summary Sec. C, 2, 44-53.

(2) SHARAF el DIN, H. & EL NAGAR, H, (1955). Control of snails by copper sulphate in the canals of the Gezira irrigated area of the Sudan. J. trop. Med. (HYG), 58, 260-263.

(3) SHARAF el DIN, H. & WILSON-JONES, K, (1954). Copper sulphate as an aquatic herbicide. Nature, Lond., 174, 187.

(4) DERBY, R. L., & GRAHAM, D. W. (1953). Control of aquatic growths in reservoirs by copper sulphate and secondary effects of such treatments. Proc. amer. Soc. Civ. Engrs., 79, Separate No. 203.

(5) DERBY, R. L. & TOWNSEND, F. W. (1953). Reservoir treatment by improved methods, Wat. & Sew. Wks., 100, 210-216.

(6) WEIGHT, W. K., (1956), Aquatic weed control practice in potable water supply reservoirs. Weeds, 4, (3), 235-240.

(7) DERBY, R. L. (1954), Methods of controlling aquatic growths in reservoirs - Joint Discussion. J. amer. Wat. Wks. Ass., 46, 1150-1158.

(8) PLANT, W, (1953) Weeds you can't spray. Farmers Weekly Nov. 6/53, 57-61.

THE BREAKDOWN OF MCPA, 2,4-D and CIPC IN SOIL

J. Holroyd, Allington Farm, Porton, Nr. Salisbury, Wilts.

Summary

Agricultural land was sprayed with the butyl esters of MCPA, 2,4-D and 2,4,5-T at 0.5 lb and 2.0 lb/ac a.e. and CIPC at 0.5 lb, 2.0 lb and 4.0 lb/ac a.e. Five or 15 days after spraying the land was ploughed either deeply or shallowly and then after a further 5 or 15 days sown with either wheat, barley, mustard or beet.

Yield reductions on the whole were under 10% even when sowing was carried out after the shortest time intervals but yields of wheat were reduced 20-25% by CIPC at 4 lb/ac unless sowing was delayed.

Introduction

Large areas are sprayed annually with the chloro-substituted phenoxyacetic acids for the control of broad-leaved weeds in cereals, grassland etc. and also for the control of 'brush' in reclaimed agricultural land and roadsides. The alkyl phenyl carbamates are used to a lesser extent for the control of chickweed and grassy weeds in some broad-leaved crops. Occasionally it happens that land is over-dosed or wrongly sprayed or a treatment mistimed with consequent crop damage or loss. It is therefore desirable to know how soon contaminated land can be resown and what, if any, cultural measures can be taken to speed up the disappearance of the residues.

Audus and others (1), have shown that the breakdown of the phenoxyacetic acids in soils is largely due to the build up of a 'detoxicating bacterial flora' although leaching also plays an important part in the removal of the more soluble salts, particularly when rainfall is high (3). The speed at which the phenoxyacetic acids disappear from soils has been related to a wide variety of soil conditions such as soil moisture, (2,3) soil temperature (2), organic matter content (4) etc. and it seems highly probable that it is largely the effect of these conditions on the build up of the population of the appropriate micro-organisms which is the important factor. Thus any cultural operations which will modify these conditions so as to make them more suitable for such a build up will help the detoxicating process (6). Ploughing for example in addition to burying the surface layers of the soil which can be expected to contain the larger proportion of the more insoluble compounds will also improve aeration.

Cultivations can be modified in various ways; ploughing may be deep or shallow, and the time of ploughing in relation to the spraying or sowing date can be varied.

Some of these factors were investigated when a series of field experiments were carried out in 1952, 1953 and 1954 using various crops, compounds and cultural techniques. These are reported below.

The soil type was a light loam, depth 8-12 in. overlying chalk which might be expected to reduce the speed of breakdown (4).

Experimental design

To prevent the experiments becoming too large and complex the number of variables was restricted and only the following taken into account:-

1. the amount of compound applied to the soil.

2. the time interval before ploughing.

3. the depth of ploughing.

4. the period after ploughing, before the crop could be sown.

5. the type of crop which could be sown.

Some restriction on the degree of variability was also essential, thus two dosages only were used 0.5 and 2.0 lb/ac a.e. The interval before ploughing was confined to a minimal time of approximately one week (E) and a maximum time of approximately three weeks (L). Two depths of ploughing were used 4-6 in. shallow and 8-10 in. deep. The interval between ploughing and sowing was also restricted to a shorter period (W) and a longer period (M). The compounds used were the butyl esters of MCPA, 2,4-D and 2,4,5-T and CIPC.

Cereals, mustard and fodder beet were used as indicator crops. In the 1952 season all the spray applications were made on the same day and the sowings of the various crops were made after the appropriate time intervals. Also the experiment was laid out as a 'split-plot' design incorporating the three different crops. Thus the experiment consisted of a large number of small plots containing different crops at different ages - sowings having been made at intervals. As a result the barley and mustard were very vulnerable to the attacks of pigeons and rooks, from which they suffered severely. For this and a number of other reasons the design was modified for the 1953 season to that shown in Fig. 1.

(47011)

795

Fig. 1

DW		A_2 E		C_2 E		B_2 E			O_1 E			O_2 E		A_1 E		B_1 E		C_1 E	D_2 E	D_1 E
	A_2 L		O_2 L		C_1 L		C_2 L	A_1 L		D_2 L	O_1 L		B_2 L		D_1 L		B_1 L			
SM									A_2 E	O_1 E		C_2 E	O_2 E	B_1 E	A_1 E	B_2 E	C_1 E		D_2 E	D_1 E
	D_1 L	D_2 L	O_2 L	C_1 L	B_1 L	A_1 L	A_2 L	C_2 L			O_1 L							B_2 L		
SW	B_2 E	O_1 E	B_1 E					A_1 E				D_2 E	C_2 E	C_1 E		A_2 E	O_2 E			D_1 E
				C_1 L	C_2 L	D_2 L	A_2 L		A_1 L	D_1 L	C_2 L				O_1 L			B_1 L	B_2 L	
DM	D_2 E	B_2 E		O_2 E	A_2 E				A_1 E		C_1 E	D_1 E		C_2 E	O_1 E			B_1 E		
			A_1 L			C_2 L	B_2 L	O_1 L		D_2 L			B_1 L			A_2 L	D_1 L		O_2 L	C_1 L
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

In this new design each crop constituted a separate experiment. The different time intervals between the various operations was obtained by varying the dates of spraying, not those of sowing, thus each experiment could be sown pure and on the same day. Ordinary farm implements were used for cultivations and sowing, thereby reducing hand labour to a minimum.

Spraying dates were calculated as follows:-

If x represents the sowing date and W = 5 days, M = 15 days, E = 5 days and L = 15 days, the first spraying date will be x - (M + L) = x - 30 days, the second x - (M + E) or (W + L) = x - 20 days and the final one x - (W + E) = x - 10 days.

The experiment was replicated twice and comprised 160 plots (only one replicate is shown in Fig. 1).

Plot size was 4 yd x 20 yd so that the cereals and mustard could be harvested with an 8 ft 6 in. 'front cut combine harvester'. A. B, C and D represent the four compounds namely the butyl esters of MCPA, 2,4-D, and 2,4,5-T and CIPC respectively at the two dosage rates (1) and (2) of 0.5 and 2.0 lb/ac while O_1 and O_2 were control plots.

Plots labelled E were ploughed a shorter time interval after spraying than plots L. For convenience ploughing was carried out in strips as shown. Thus the strip labelled DW was ploughed deeply (8-10 in.) a short time inverval (W) before sowing, the strip labelled SM was ploughed shallowly (4-6 in.) a longer time interval (M) before sowing, the strip labelled SW was also ploughed shallowly but at the same time as DW i.e. the shorter time interval was left before sowing, and DM was ploughed deeply a longer time interval before sowing.

The ploughed strips being 20 yd wide, an ordinary tractor drawn two furrow plough was used without trouble. Discards of 4 ft were left between the plots in the strips, of 3 yd between the strips and of 10 yd between the replicates. The compounds were applied as solutions in diesel oil at a volume rate of 10 gal/ac. The CIPC was made up as a 12.5% solution in petroleum ether before being added to the diesel oil. All applications in 1952 and 1953 were made with a hand-drawn compressed air operated, spraying machine mounted on bicycle wheels and fitted with a 9 ft boom carrying six '000' ceramic 'Bray' jets. In 1954 an Oxford Precision Sprayer was used.

The corners of replicates were fixed by reference points in the headlands, this allowed the removal of demarcating posts and strings as required during ploughing operations and their total removal for the disking and harrowing necessary to produce a suitable seed bed after the final ploughing. Normal seeding and fertiliser application rates were used.

Results

No significant conclusions could be drawn from the 1952 results except that the design of the experiment was unsuitable for the particular field conditions.

In the seasons 1953 and 1954 the experimental design was modified as has already been mentioned and separate experiments were carried out on wheat, barley, mustard and sugar fodder beet. The effects of deep and shallow ploughing were compared in only the wheat and beet experiments.

In 1953 the butyl esters of the three phenoxyacetic acids MCPA, 2,4-D and 2,4,5-T and the chlorinated alkyl phenyl carbamate CIPC were used.

In 1954, 2,4,5-T was omitted from the experimental programme.

The cereals and mustard were 'combine harvested' and all figures are grain weights, weighings being made at intervals after harvest until a steady figure was reached. The beet was weighed as soon as pulled and topped.

All yield figures were subjected to an analysis of variance.

The crop varieties used were:- wheat - Atle: Barley - Karlesberg: Beet - Pajbjerg Rex.

Table 1

Mean yields from plots treated with 2 lb/ac of active material (acid equivalent in the case of the phenoxyacetic acids)
Yield in cwt/ac

Year	1953				1954			
Compound	Wheat	Barley	Mustard	Beet	Wheat	Barley	Mustard	Beet
A MCPA	34.0	20.9	10.8	86	26.7	31.2	9.7	289
B 2,4-D	32.8	20.1	11.2	102	26.7	30.5	8.8	285
C 2,4,5-T	35.6	20.6	11.5	102	-	-	-	-
D CIPC	34.8(29.2)	21.2(19.9)	12.2(11.7)	116(98)	27.9	30.5	8.8	306
Control	35.9	21.4	11.5	108	28.7	30.9	9.6	314
Min. sig. dif. P = 0.05								
Between treatment and control	1.6	0.8	1.1	20	1.6	2.0	1.2	20
Between treatments	1.8	0.9	1.2	23	1.7	2.3	1.3	23

The above table gives the mean yields from all the plots treated at 2 lb/ac (active material of CIPC and acid equivalent of the phenoxyacetic acids). In 1953 plots were also treated with CIPC at 4 lb/ac and the yields from these are given in brackets.

The light chalk soils on which these crops were grown although capable of producing good yields of cereals are not so suitable for beet, particularly in a dry season such as 1953 - the yield figures illustrate this point.

It is apparent that these compounds at rates up to 2 lb/ac will not produce any catastrophic reductions in yield provided the land is ploughed after spraying. CIPC at the 4 lb/ac rate in 1953 did significantly reduce the yields of wheat and barley but only in the case of the wheat did the reduction exceed 15%.

At comparable dosage rates 2,4-D reduced the yields of the cereals significantly more than CIPC in 1953 and the trend was similar in 1954.

This is a little surprising as CIPC is inherently more toxic to the cereals than 2,4-D. However these figures are means of all the treatments and thus represent not only the direct toxicity of the particular compound to the particular crop but also its persistent toxicity and the effect of the various cultural treatments on that persistence, i.e. the CIPC is rendered ineffective by break-down, volatilisation etc. more rapidly than the 2,4-D.

The following Tables from the 1954 season's analyses illustrate the effects of the various cultural treatments and their significance.

Table 2

The effect of ploughing depth
(deep = 8-10 in., shallow = 4-6 in.)
Yield in cwt/ac

Compound	Wheat Deep	Wheat Shallow	Beet Deep	Beet Shallow
A MCPA	28.5	27.1	303	284
B 2,4-D	28.5	27.5	308	276
D CIPC	28.9	28.1	312	294
Control	29.1	28.2	324	303
Mean	28.7	27.7	312	289
Min. sig. dif. P = 0.05				
Between Means	0.5		14	
Between treatment means	1.4		26	
For interaction	1.9		37	

The deeper ploughed plots gave significantly higher yields than those ploughed more shallowly but this tendency is shown not only by the sprayed plots but also by the unsprayed controls. In several cases the difference between sprayed plots ploughed at the two depths is greater than the difference between the controls, but in none is it significantly so, i.e. there is no interaction. This means that the difference is to a certain extent due to the effect of the two types of ploughing on the natural fertility of the soil and not entirely on the residual toxicity of the compounds.

Table 3

Effects of varying the length of the interval between spraying and ploughing
Yields expressed in cwt/ac (E = approx. 5 days, L = approx. 15 days)*

Compounds	Wheat E	Wheat L	Barley E	Barley L	Mustard E	Mustard L	Beet E	Beet L
A MCPA	27.0	27.7	31.2	30.6	9.5	9.3	288	300
B 2,4-D	27.8	28.2	30.3	31.4	9.7	9.5	290	294
D CIPC	28.7	28.3	30.1	31.2	9.5	9.2	313	292
Mean	27.8	28.1	30.5	31.1	9.6	9.3	297	295
Min. sig. dif. P = 0.05								
Between means	0.5		0.9		0.5		14	
" treatment means	1.4		1.9		1.0		26	
For interaction	1.9		2.7		1.4		37	

* Spraying was occasionally delayed by weather.

Controls are not included in Table 3 as time of spraying can have no effect on untreated plots.

None of the yield variations were significant.

Table 4

Effect of varying the length of the interval between ploughing and sowing
Yields expressed in cwt/ac (W = approx. 5 days, M = approx. 15 days)*

Compounds	Wheat W	Wheat M	Barley W	Barley M	Mustard W	Mustard M	Beet W	Beet M
A MCPA	26.9	28.8	31.3	30.5	9.4	9.4	290	297
B 2,4-D	27.8	28.1	30.7	31.1	9.2	10.0	286	297
D CIPC	28.2	28.8	30.8	30.5	9.5	9.3	296	310
Control	28.5	28.8	30.9	30.8	9.3	9.8	300	327
Mean	27.8	28.6	30.9	30.7	9.3	9.6	293	308
Min. sig. dif. P = 0.05								
Between means	0.5		0.9		0.5		14	
Between treatment means	1.4		1.9		1.0		26	
For interaction	1.9		2.7		1.4		37	

* Spraying was occasionally delayed by weather.

Controls are included in Table 4 as ploughing time can be expected to influence natural fertility.

Delaying sowing after ploughing increased the yields of wheat and beet slightly but significantly, but again the difference could not be attributed wholly to a reduction in residual toxicity for there was some influence on fertility.

Discussion

Of the crops chosen barley and wheat might be expected to be relatively resistant to the residual effects of the phenoxyacetic acids but susceptible to those of CIPC, and mustard and beet relatively susceptible to the phenoxyacetic acids but moderately resistant to CIPC. As an additional differentiation the cereals and mustard may be classed as shallow rooting in comparison with beet.

At 4 lb/ac CIPC did reduce the yields of the cereals fairly heavily in 1953 but at a comparable dosage rate 2,4-D showed more residual toxicity in all the experiments. CIPC is a more volatile compound than the butyl ester of 2,4-D and it seems probable that this factor contributed to its rapid removal. As a further indication, plots which were treated with 4 lb/ac of CIPC and then ploughed soon after spraying yielded less than plots which were left longer before ploughing, although the interval between spraying and sowing was the same. This is the reverse of the trends of the yields from the plots treated with the other compounds, i.e. loss of the more volatile compound was more rapid on the surface.

Unfortunately the significant variations in yield which were produced by the various ploughing depths and the timing of these cultivations could not be attributed wholly to an effect on the residual toxicity of the compounds. However this did indicate that simply ploughing in the compounds after spraying would permit the growing of almost normal crops if the dosage rates did not exceed 2 lb/ac.

At higher dosage rates the problem hinges on the interaction of two factors, - the time required for the breakdown of the phytotoxic residues in the soil and the time required by the crop to reach maturity. The first of these factors can be influenced to some extent by cultivations such as deeper ploughing at the appropriate times and the second by type and variety of crop. An early maturing variety of barley could be sown late in the season thus leaving more time for the breakdown of residues but on the other hand a resistant crop e.g. beet if the contaminant is CIPC, could be sown earlier than a more susceptible one.

A little more should perhaps be said about the design of the experiments. The initial design was much more satisfactory from a purely statistical point of view, for as all spray applications were made on the same day they were subjected to the same subsequent weather conditions and all comparisons were valid. However external factors such as damage by pests, drilling by hand etc. introduced other large errors. The modified design eliminated these but introduced a more fundamental one as spray applications were made on different dates. However as the two sets of plots WL and ME were both sprayed at the second date, the most interesting comparison, between the rate of breakdown on the surface and when ploughed in was valid. Unfortunately differences proved to be not significant statistically. However there were some indications which have already been mentioned.

The difference in rooting habit between the crops did not prove to be important in these experiments.

Conclusions

The absence of any significant differences between the yields from sprayed plots due to variations in the depth of ploughing or the timing of that ploughing in relation to spraying or sowing, makes it impossible to state definitely which combination of timing and depth was most successful in removing residual phytotoxicity.

However if land sprayed with the phenoxyacetic acids at dosage rates up to 2 lb/ac is ploughed a week after spraying and then sown a week after ploughing with a resistant crop such as barley, yield reductions should not be more than 10%. If the contaminant is CIPC at a dosage rate of 2-4 lb/ac yield reductions may be as high as 20 - 25% unless a time interval of 4 - 5 weeks is left before sowing a cereal crop. It is also probably better to delay ploughing until just before sowing.

A more resistant crop such as beet could be sown earlier.

References

(1) AUDUS, L. J. (1951). The biological detoxication of hormone herbicides in soil. Plant and Soil, 3,(2),170-192.

(2) BROWN, J. W. AND MITCHELL, J. W. (1948). Inactivation of 2,4-dichlorophenoxyacetic acid in soil as affected by soil moisture, temperature, the addition of manure, and autoclaving. Bot. Gaz., 109,314-323.

(3) HANKS, R. W. (1946). Removal of 2,4-dichlorophenoxyacetic acid and its calcium salt from six different soils by leaching. Bot.Gaz., 108, 186-191.

(4) KRIES, O. H. (1947). Persistence of 2,4-dichlorophenoxyacetic acid in soil in relation to content of water, organic matter, and lime. Bot.Gaz., 108,510-525.

(5) MITCHELL, J. W.AND MARTH, R. C. (1946). Germination of seed in soil containing 2,4-dichlorophenoxyacetic acid. Bot.Gaz., 107,408-416.

(6) WEAVER, R. J. (1948). Contratoxification of plant growth regulators in soils and on plants. Bot.Gaz., 109,276-300.

EXPERIENCES WITH MIXTURES OF HERBICIDES, INSECTICIDES AND NUTRIENTS FOR THE CONTROL OF PLANT DISEASES, PESTS AND WEEDS

By H. INGVARD PETERSEN, Statens Ukrudtsforsøg, Skovlunde, Denmark.

In practice, an interest is very often taken in giving a treatment for the purpose of preventing plant diseases and of killing insects and weeds simultaneously. Thus, it is very common in Denmark to add, for instance, manganous sulphate to the hormone spray fluid in order to kill weeds and to make good a deficiency of manganese by the same spraying.

Statens Ukrudtsforsøg has therefore occasionally conducted experiments with mixtures in its laboratories with a view to ascertaining which agents permit of admixture without forming a large amount of unwanted sediment. In addition, a number of experiments have been carried on in the field in order to investigate the effects of the mixtures on the plants.

In Table 1 the average results from three experiments on barley have been given.

Table 1

Experiments on Barley with Mixtures of MCPA and Various Agents against Pests and Plant Diseases.

Averages from 3 Experiments	Yield 100 kilos of Grain per hectare	Weeds per sq. metre Number	Weeds per sq. metre Weight	Relative Figures for weights of Weeds
Untreated	37.8	293	631	100
MCPA, 1/4 kilo of effective substance per hectare	40.4	10	26	4
MCPA, 1/4 kilo of effective substance + 10 kilos manganous sulphate per hectare	38.9	20	49	6
MCPA, 1/4 kilo of effective substance + 10 kilos of copper sulphate per hectare	37.0	22	26	4
MCPA, 1/4 kilo of effective substance + 10 kilos of borax per hectare	39.6	16	26	4
MCPA, 1/4 kilo of effective substance + 20 kilos of potassium sulphate per hectare	38.6	20	32	5
MCPA, 1/4 kilo of effective substance + 500 c.c. of parathion, 35 per cent., per hectare	35.9	40	55	9
MCPA, 1/4 kilo of effective substance + 4 kilos of D.D.T., 25 per cent., per hectare	39.3	16	32	5

In the experiments MCPA was applied to weeds, and only 1/4 kilo of effective substance was used per hectare; the existing weeds consisted chiefly of charlock, which, as is well-known, can easily be killed.

MCPA was partly used by itself and partly with the admixture of various agents against plant diseases and pests. The latter agents were applied approximately in the concentration that would have been chosen if they had been applied exclusively for spraying purposes, viz. 10 kilos of manganous sulphate per hectare, 10 kilos of copper sulphate, 10 kilos of borax, 20 kilos of potassium sulphate, 500 cubic centimetres of parathion and 4 kilos of Gesarol spraying agent per hectare.

The yield figures for grain reflect a tendency towards a somewhat smaller yield from the mixture than from spraying exclusively with MCPA, and this in particular holds true of the mixture with parathion. The differences are slight, however, and the data are not so comprehensive that too great importance should be attached to them.

The effect on the weeds is good and strong as far as all the mixtures are concerned.

On the basis of these investigations there is no reason why the killing and the disease-preventing agents in question should not be used by way of admixture to MCPA.

However, heavy damage was caused in 1955 to fibre flax in various places in Denmark, and a special investigation showed that the cause of this damage was to be sought in the fact that the insecticides parathion or malathion had been added to the spray fluid that was applied to the weeds.

For weed control in fibre-flax a mixture of MCPA and DNOC (Na), consisting of 250 grammes of MCPA and 625 grammes of DNOC (Na), effective substance in either case, is applied. This mixture has been applied in Denmark with great success to weeds among fibre-flax plants.

Table 2 gives the results of experiments that have been carried on in order to explain the heavy damage arising when these mixtures are combined with parathion or malathion.

Table 2

Experiments on Fibre Flax with MCPA, DNOC (Na) and Mixtures of These with Parathion or Malathion.

A. Field Experiments Flax 15-20 cm at spraying. 500 litres of liquid per hectare	Marks assessing damage, 0 to 10 10 = destroyed	Length of Flax in cm.	Percentage of Weeds
Untreated	0	69.3	6.6
MCPA, 0.23 kilo of effective substance per hectare	3	65.7	1.0
DNOC (Na), 25 per cent., 3.15 kilos per hectare	2	70.0	2.5

Table 2 (Contd.)

A. Field Experiments (Contd.)	Marks assessing damage, 0 to 10 10 = destroyed	Length of Flax in cm.	Percentage of Weeds
Flax 15-20 cm at spraying. 500 litres (Contd.) of liquid per hectare			
Untreated (Contd.)			
MCPA, 0.23 kilo of effective substance + DNOC (Na), 25 per cent., 3.15 kilos per hectare	3	65.6	1.5
MCPA, 0.23 kilo of effective substance + DNOC (Na), 25 per cent., 3.15 kilos and parathion 1 litre per hectare	8	63.1	2.0
MCPA, 0.23 kilo of effective substance + DNOC (Na), 25 per cent., 3.15 kilos + malathion 1.5 litre per hectare	9	54.2	0.5

B. Experiments in Hotbeds	Marks 0 to 10,		10 = destroyed	
	125 litres per hectare		500 litres per hectare	
	Hormone Damage	Scorching Damage	Hormone Damage	Scorching Damage
MCPA, 0.5 kilo of effective substance per hectare	0	0	0	0
MCPA, 0.5 kilo of effective substance + parathion 1 litre per hectare	6.5	0	4.5	0
MCPA, 0.5 kilo of effective substance + malathion 1.5 litre per hectare	6.5	0	4.0	0
DNOC (Na), 25 per cent., 5 kilos per hectare	0	0	0	0
DNOC (Na), 25 per cent., 5 kilos + parathion 1 litre per hectare	0	5.0	0	2.5
DNOC (Na), 25 per cent., 5 kilos + malathion 1.5 litre per hectare	0	5.0	0	1.0
MCPA, 0.25 kilo of effective substance + DNOC (Na) 2.5 kilos per hectare	1.0	0	0	0
MCPA, 0.25 kilo of effective substance + DNOC (Na) 2.5 kilos + parathion 1 litre per hectare	6.5	7.0	3.5	1.0
MCPA, 0.25 kilo of effective substance + DNOC, 2.5 kilos + malathion 1.5 litre per hectare	8.0	5.5	5.0	0

MCPA and DNOC (Na) have been used separately, mixed together, and in combination with parathion and malathion. The doses applied correspond exactly to those causing heavy damage in practice. These doses differ a little from those mentioned before.

From the marks assessing the amount of damage to the flax it appears that the admixture of parathion or malathion is responsible for an almost destroying effect on the flax. The length of the flax was also reduced, and there is a tendency that malathion has increased the effect on the weeds.

The lower half of Table 2 gives the results from experiments carried on in frames in hotbeds. The object was to ascertain whether parathion and malathion intensified the effect of both MCPA and DNOC (Na). MCPA applied separately in a quantity of 1/2 kilo of effective substance per hectare has not caused hormone damage or scorching damage. The addition of 1 litre of parathion per hectare to the hormone liquid resulted in a heavy hormone damage, but no scorching damage. The admixture of malathion likewise gave a heavy hormone damage, but no scorching damage.

DNOC (Na) applied alone caused some scorching damage, but with the addition of parathion or malathion the scorching damage became great.

Next, an addition of parathion and malathion to the mixture of MCPA and DNOC (Na) that normally is used in Denmark, was tried. It will be seen that the addition of parathion and malathion has increased the hormone effect as well as the scorching effect of the two weed-killing agents. Parathion especially seems to increase the scorching effect of the mixture, while malathion especially increases the hormone effect.

In the experiment two quantities of spray liquid were used: 125 litres per hectare and 500 litres per hectare. As was to be expected, the hormone effect and the scorching effect are greatest in connection with the smallest quantity of liquid.

Next, it has been sought to find out, if possible, whether the damage is due to the compounds of parathion or malathion or to the spreaders and solvents contained in these agents. It has not been possible to procure pure compounds of parathion or malathion. Therefore, the agents were used in the form that they are available on the market. The most important spreaders and solvents, on the other hand, were tested. It appeared from these investigations that the solvents and spreaders only increased the hormone damage to a small extent. It was the prepared agent itself that in particular increased the damage. Parathion powder, which does not contain so much of such solvents, has not caused so great damage as the spraying agent. D.D.T. has not increased the hormone effect as strongly as the other agents.

The scorching effect of DNOC (Na), on the other hand, was strongly increased by the spreaders and solvents.

It should be recommended that the use of these insecticides should be avoided as admixed to the weed-killing agents when spraying is applied to such sensitive crops as flax and peas, and there ought to be a rather long interval between the spraying against weeds and that against pests, and the spraying against weeds should as far as possible be completed before the spraying against pests.

THE TOXICITY OF CERTAIN WEED KILLERS TO TROUT

J. S. Alabaster, Ministry of Agriculture, Fisheries and Food

Several manufactured weed killers and plant growth regulating substances have been examined for their toxic effect upon rainbow trout (*Salmo gairdnerii*). Their toxicity has been measured as the concentration in which 50% of the test fish die after exposure for 24 and 48 hours (24 hour and 48 hour median tolerance limits) and has been determined by the graphical method of Bliss (1935) from the observed mortality of fish after 24 and 48 hours in each of several concentrations. Where possible, observations have been made at other additional time intervals, such as 6, 12, and 96 hours, and a line relating the logarithm of the median period of survival and the logarithm of the concentration of weed killer fitted by eye to all the data. The 24 and 48 hour median tolerance limits were then read off from this line.

The tests were carried out in 40 l aquaria in which the temperature was maintained at 18°C ± 0.5°C, and the dissolved oxygen concentration kept close to the air saturation value by aeration of the solution with compressed air. The fish were sorted at random into batches of 10 and were acclimatized to these conditions for at least 24 hours. They were kept without food during this period and during the test period which immediately followed. The results are summarized in Table 1. Most of the weed killers consist of more than one substance, but their chemical composition is given as fully as possible.

This note is published by permission of the Ministry of Agriculture, Fisheries and Food.

Reference

BLISS, C. I. (1935). The calculation of the dose mortality curve. Ann. appl. Biol., 22, 134-167.

Table 1

Toxicity of weed killers to rainbow trout

Number	Ingredients	Percentage	Age of fish (Months)	Median tolerance limit p.p.m. 24 hr	48 hr
1	Disodium octoborate tetrahydrate	73.0	15	4200	2750
	(expressed as B_2O_3)	(49.0)			
	Sodium chlorate	25.0			
2	Sodium borate ore				
	(expressed as B_2O_3)	(61.5)	15	2800	1800
3	Disodium tetraborate pentahydrate)	55.0	15	2300	2050
	" " decahydrate)	35.5			
	(expressed as B_2O_3)	(39.2)			
	2,4-D	7.5			
4	Disodium tetraborate pentahydrate	63.2	15	975	925
	" " decahydrate	30.8			
	(expressed as B_2O_3)	(41.4)			
	3-(p-chlorophenyl)-1,1-dimethylurea	4.0			
5	As No. 4 above		3	820	760
6	3-(p-chlorophenyl)-1,1-dimethylurea	80.0	3	180	100
7	Maleic hydrazide				
	as di-ethanolamine salt	25.0	3	85	56
	Alkyl naphthalene sulphonic acid	4.5			
	Water	to 100.0			
8	Phenolic compounds	47.5	3	4.4	3.3
	2,4-D	2.5			
	Oil	4.5			
	Emulsifiers and stabilizers	5.0			
	Water	to 100.0			
9	Neutral aromatic oils	57.0	3	3.0	2.2
	2,4-D	12.5			
	Emulsifiers	8.0			
	Water	to 100.0			