

PROSPECTS FOR ALTERNATIVE CHEMICAL METHODS OF GRASS-GRUB CONTROL

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Summary

Treatments alternative to DDT for grass-grub control are required because of:

- (a) Residues in produce
- (b) Development of DDT resistance
- (c) Soil factors which restrict effectiveness of DDT in some areas.

The ideal insecticide for this purpose, which is broken down in the grazing animal but which is stable in soil, has yet to be discovered. The properties of alternative insecticides at present available may be exploited by considering treatment of bare soil when re-seeding takes place or by attacking the adult beetle stage. Data are presented which challenge the necessity of long-term soil residual action, provided high enough initial kill is obtained.

INTRODUCTION

IN THIS PAPER an attempt is made to review the present prospects of developing an insecticide treatment alternative to DDT for grass-grub control.

The reasons for seeking an alternative treatment may be summarized as follows.

Residues: The danger to our overseas markets, North America in particular, from pesticide residues in farm produce can hardly be over emphasized. The recent legislation restricting DDT usage to granular formulations is a reflection of the prime importance of this aspect. Only time can tell how effective these measures will be in maintaining DDT residues at an acceptable level.

Resistance: There is now definite evidence that grass-grubs in some areas have developed a degree of resistance to DDT that renders normal rates of use ineffective. Although these resistant strains appear to be restricted to a few areas at present, by comparison with the development of resistance in other insects, it must be expected that the problem will increase in severity from year to year.

Soils: It seems clear that the poor control reported from some areas is due to some soil factor restricting the penetration of DDT, or rendering it inactive in other ways. This could be a general effect applicable to a wide range of insecticides, but promising alternatives should obviously be tested in such cases.

The residue problem is perhaps of overriding importance, and will certainly be an important factor in selecting an insecticide alternative to DDT.

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A "residue safe" material is one that is metabolized in the animal body to harmless end products when and if it can be detected in significant amounts.

At the same time, if a material is to be used in the same manner as DDT—that is, applied over the surface of pasture to control grubs beneath the soil surface—it must exhibit sufficient stability in the soil environment to be taken down to the level in which the grubs are present. There is no doubt that this is chemically a very difficult problem. Nothing less is being asked than that the insecticide should be broken down in one biochemical system, the grazing animal, but that it should be relatively stable in another biochemical system, the soil.

It is clear, therefore, that the ideal chemical for grass-grub control may be some way off; and for the present it may be necessary to consider the use of materials which are less than perfect, but which nevertheless have something to offer in overcoming the problems of residues, resistance or soil factors.

In developing new materials to their fullest potential, it may be necessary to depart from the established method of using DDT to treat existing infestations of grubs or to "proof" pasture against attack by use on a routine basis.

METHODS OF ATTACK

The various possible ways of attacking grass-grub with conventional insecticides may be listed as follows:

(1) APPLICATION OVER PASTURE WHEN GRUBS ARE PRESENT

This has been almost the only procedure attempted to date. It is important from the practical point of view, as the farmer can treat when he knows that grubs are present and can see damage. It should be remembered, however, that considerable damage to the pasture and loss of plant growth may already have occurred.

Granular formulations appear to be the most suitable for this type of treatment, as they have the great advantages of minimum drift and foliar contamination.

It seems to have been generally assumed that materials such as DDT with long-term residual action in soil are essential if more than one season's control is to be achieved.

This is not necessarily so, provided a high enough initial kill is obtained, as is shown later.

(2) TREATMENT OF BARE SOIL WHEN PASTURE IS SEEDED

Such a treatment is naturally limited to those pasture areas which are cultivated and re-seeded from time to time. Highly persistent materials to give as many years' protection as possible are necessary, together with an insurance attitude on the part of the farmer.

There may well be a place here for certain materials such as heptachlor, which are highly effective against grass-grub and very persistent, but which have a lower residue tolerance than DDT and therefore cannot be considered seriously for use on established pasture.

It is important to check that such materials are not taken up by pasture plant species from the soil and translocated to the foliar parts before soil treatment is endorsed.

Methods of application to bare soil need some investigation. Broadcast application of granules followed by surface cultivation seems to be the best. Drilling in is not likely to be satisfactory because of the inadequate distribution.

(3) INTRODUCTION BENEATH PASTURE SWARD BY MECHANICAL MEANS

This is a theoretical possibility and has received some discussion. The practical problems of obtaining adequate distribution seem to rule it out.

(4) ATTACK ON THE ADULT BEETLE

In the adult stage, the grass-grub spends at least part of its time above ground and should therefore be more accessible to attack with insecticides. This possibility has received very little attention so far, but may hold distinct prospects for the future. Preventive insurance action will obviously be involved, but it should be remembered that infestations of grass-grubs tend to occur in the same place, year after year, and will often continue to do so unless the cycle is broken somewhere.

For effective reduction in subsequent larval populations, treatment against the adults must be highly effective and sufficiently early to suppress egg laying.

INSECTICIDE TESTING

Between thirty and 40 different insecticide chemicals have been examined for activity against grass-grub larvae, by one method or another, over the past three years. Table 1 gives a brief classification of this effort.

In laboratory and pot tests, quite a number of materials have shown high toxicity to grass-grub larvae, but when tested in the field these materials may show very little activity. An example is fenthion.

TABLE 1: CLASSIFICATION OF INSECTICIDE TESTS AGAINST GRASS-GRUB UP TO APRIL, 1964

<i>Test Method</i>	<i>No. of Materials Examined</i>	<i>Chemical Categories of Insecticides Tested</i>
Laboratory — contact effect by topical application	18	7 chlorinated hydrocarbons 9 organophosphates 2 carbamates
Glassehouse — treatment of soil*	34	11 chlorinated hydrocarbons 19 organophosphates 4 carbamates
Field — replicated plot trials on pasture	at least 24 including	7 chlorinated hydrocarbons 14 organophosphates 3 carbamates

* For description of test method see: Fenemore, P. G., 1963: *Proc. 16th N.Z. Weed Control Conf.*, pp. 123-6.

Conversely, a material which is known to persist in soil for long periods may show comparatively low toxicity in the laboratory, but prove effective in the field. DDT comes into this category.

It is therefore necessary to include studies of the stability of toxicants in soil in any screening programme for grass-grub insecticides and this is now being done.

PROSPECTIVE TOXICANTS

None of the materials tested so far combines the desirable properties of immediate effectiveness against grubs present with long-term soil residual action, but without significant residue risk.

The two chlorinated hydrocarbon insecticides heptachlor and "Telodrin" have shown outstanding activity against grass-grubs (including DDT-resistant strains) and have long residual life, but toxicity and residue problems probably rule them out for pasture

TABLE 2: SUMMARY OF FIELD TRIAL RESULTS WITH HEPTACHLOR AND "TELODRIN"

TRIAL 1: Treated May 3, 1962 (DDT-resistant strain). Method of application — sprayed on and watered in.

Treatment (lb a.i./ac)	Mean No. Grubs per sq. ft			
	July, 1962	Sep., 1962	Apr., 1963	Apr., 1964
Heptachlor 2	5.6	1.8	0.0	0.2
DDT 2	25.5	8.1	31.1	53.1
Diazinon 2	1.3	0.3	1.3	13.8
Diazinon 4	0.4	0.0	0.7	3.7
Untreated	29.9	11.8	32.4	80.0
	*8.6	4.2	12.4	26.1
	**11.4	5.6	16.4	34.7

TRIAL 2: WAVERLEY: Treated Mar. 13, 1962 (primarily *Pyronota* sp.). Method of application — sprayed during rain.

Treatment (lb a.i./ac)	Mean No. Grubs per sq. ft			
	May, 1962	Jul., 1962	Apr., 1963	May, 1964
Heptachlor 2	8.5	5.2	0.3	0
DDT 2	27.3	15.9	4.6	7.8
Untreated	42.1	40.1	22.9	27.2
	*9.1	8.1	9.1	
	**12.1	11.8	12.1	

TRIAL 3: OMATA: Treated April 24, 1963. Method of application — heptachlor and DDT as granule, "Telodrin" sprayed during rain.

Treatment (lb a.i./ac)	Mean No. Grubs per sq. ft	
	Jul., 1963	May, 1964
Heptachlor 2	10.7	0
Heptachlor 1	11.6	0.5
"Telodrin" 0.5	1.3	0
"Telodrin" 0.25	2.5	0
DDT 2	17.1	18.3
Untreated	14.2	13.0
	*6.6	*8.7
	**8.8	**12.3

TRIAL 4 — HALKETT: Treated May 2, 1963. Method of application — granules.

Treatment (lb a.i./ac)	Mean No. Grubs per sq. ft		
	Aug., 1963	Oct., 1963	May, 1964
Heptachlor 2	20.4	9.8	0.4
Heptachlor 1	21.6	6.8	0.4
"Telodrin" 0.5	14.4	2.4	0.2
"Telodrin" 0.25	16.5	2.2	0.2
DDT 2	26.4	16.8	2.4
Untreated	38.1	15.8	3.8
	*8.4	*5.6	*2.0
	**11.1	**7.4	**2.7

treatment. However, they could find a place in treatment of bare soil. Results from a number of field trials in which these insecticides were compared with DDT are given in Table 2.

Heptachlor would be recommended at 2 lb active ingredient per acre for bare soil treatment. Studies are now in progress to determine whether uptake from the soil occurs in significant amounts by pasture species.

"Telodrin" is by far the most active material that has been tested to date against grass-grub in pot tests and field trials. Its minimum effective rate of use has not yet been determined accurately, but it is certainly in terms of a few ounces of active ingredient per acre. Unfortunately, the very high mammalian toxicity of "Telodrin", both oral and skin intake (close to that of parathion), could almost certainly rule it out of further consideration. Also, it appears to be highly toxic to worms.

Of the "residue safe" materials, the most promising to date is diazinon. This has been granted a nil withholding period in granular form, which means that stock need not be removed from the paddock even when treatment is being made. Unfortunately, the cost of the active ingredient is a factor limiting the rate of use which it is practical to recommend.

It would be desirable to have a material with somewhat greater soil stability than diazinon for consistent performance under different conditions.

DISCUSSION

There is little doubt that the ultimate aim in most pest control operations must be to get away from highly persistent residual insecticides of the chlorinated hydrocarbon type wherever possible. There is increasing evidence of the accumulation of these highly stable toxicants in the environment, and there can now be few individuals in the civilized world who are free from traces of DDT in their body fat. Our knowledge of what happens finally to these materials after application to plants or soil is limited.

There has been a tendency to assume that for several seasons' control of grass-grub it is necessary to render the soil toxic by the use of long-term residual insecticides. However, the results of a trial laid down in Riwaka in 1962 indicate that this is not the case, at least in some circumstances.

In this trial, diazinon sprayed on and washed in by irrigation equipment gave an initial mortality of nearly 100%. A high level of control has now continued for three generations of grass-grub but bio-assays of soil made from mid-1963 onwards have failed to

demonstrate any residual toxicity. The explanation of this effect lies almost certainly in the behaviour of the adult beetles. It has been shown with other related species of scarabs that the vast majority of the females are mated and lay their eggs almost exactly where they emerge from the soil. The same pattern of behaviour on the part of grass-grub adults would account for the effects observed.

This example shows that several seasons' control may be achieved by the use of relatively non-persistent insecticides, but it is essential to be able to produce consistently a very high initial mortality if this approach is to be of general application. It is not yet possible to do this.

Similarly, if control is to be achieved by attacking the adult beetle, a high level of mortality must be produced if the effect on grub populations is to be more than temporary.

Although reliable techniques still have to be developed, these two lines of attack would seem to hold the best prospects of being able to control grass-grub without recourse to chlorinated hydrocarbon insecticides.