THE EFFICIENCY OF GRANULAR INSECTICIDES IN CONTROLLING VIRUS DISEASES OF CROPS

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Summary

Granular organophosphorus systemic insecticides gave good control of aphids in carrots, peas, cereals and potatoes and the plants were protected for considerable periods. However, if used as seed dressings they were liable to be phytotoxic and the protection to be of short duration. In many trials, good aphid control prevented the spread of virus diseases. With low value crops, topical application of low rates of a granular insecticide is recommended. With high value field and horticultural crops band or topical application of high rates at sowing, planting or later (to the foliage) is likely to control many aphid and virus problems.

INTRODUCTION

THE POSSIBILITY of controlling virus diseases of field crops by seed treatments was investigated in New Zealand, first in 1959, by the Plant Diseases Division. The materials used as seed dressings were disulfoton and phorate. These have subsequently been developed as granular insecticides to be applied either at sowing or to the young seedlings for the same purpose, namely, aphid and virus control. The initial trials (with disulfoton at the 0.4% rate) showed good systemic activity for 7 to 12 days in turnips, wheat and oats and controlled both the cabbage aphid (*Brevicoryne brassicae*) and the cereal aphid (*Rhopalosiphum padi*). Similar work in England has been described in the *Proceedings of the British Insecticide and Fungicide Conference 1961*, and in general disulfoton and phorate were phytotoxic as seed dressings on sugar beet when applied in amounts sufficient to give long protection against aphids in the field.

Granular organophosphorus systemic insecticides for aphid control should be stable, not phytotoxic, have good systemic action, and be slowly released from their carrier and then be absorbed by the plants. To have wide application they must also be able to move through the soil from the region where they are placed to the roots of the crop, either in solution in the soil moisture or by diffusion in the vapour phase. Recent experiments in England have shown that, of the four granular insecticides commonly applied to the soil for aphid control, all were effective in wet seasons but that in dry seasons menazon and dimethoate were less effective than disulfoton and phorate. This is probably because the first two move less readily in the gaseous phase, but in New Zealand even disulfoton applied at sowing was ineffective under very dry soil conditions.

Treatment with insecticide granules has received increasing attention in recent years and has been found to give long periods of aphid control when applied in the soil with the seed, as a band alongside the seedling, or topdressed over the crop.

Successful control of aphids and virus diseases in field crops has been reported from England particularly on sugar beet yellows virus (Dunning, 1962). The most widely used method is spray application of persistent systemic organophosphorus insecticides, though it was shown that one topdressed application of granular disulfoton or phorate was as effective as two spray applications of demeton-methyl. Seed treatment showed promise only with dimethoate and menazon, both not particularly phytotoxic.

Baywood Chemicals in England have also shown that disulfoton granules topdressed at the rate of 1.25 lb (all rates in active ingredient per acre) gave excellent control of cabbage aphids on brussels sprouts for 6 weeks and this was better than two spray applications.

Excellent work on the relative value of sprays, seed treatment and pellet application of systemic insecticides for cabbage aphid control has been done in California (Andres *et al.*, 1959). They showed that both phorate and disulfoton affected germination of cabbages if applied as a 4% seed dressing but that they both controlled aphids for one month. The period of effectiveness of granules depended on the rate of application— $\frac{1}{2}$ lb, 1 lb, and 2 lb gave control for about 3, 5 and 8 weeks respectively. Disulfoton was more persistent than phorate. They finally concluded that the granules should be placed as near to the plants as possible and that application to the foliage was just as successful as to the soil, but both methods depended on good growth conditions and moisture to assist absorption.

The use of granular systemic insecticides on potatoes (applied in soil at planting) was begun in North America in 1957 (Bacon, 1960), and phorate has become the most popular material, giving good control of aphids, leafhoppers, and flea beetles. Trials were begun in England in 1958 and probably well before this time in Continental Europe. In these two areas, disulfoton seems to be more popular and it is widely used in Europe for aphid and virus control in seed potato production. An experiment in England in 1961 (Burt, 1962) showed that disulfoton and phorate granules gave good control of potato aphids for 97 days after planting, and that menazon and dimethoate were less effective. This was reflected in the virus counts (done on samples grown in 1962), for the percentage of leaf roll on plots treated with disulfoton and phorate was 2.7% and 2.1%, respectively, whereas the percentage in the menazon, dimethoate and untreated plots was 9.1%, 10.4% and 17.9%, respectively. Residue analyses at harvest in 1961 showed that there was 0.15 ppm or less in tubers from treated plots.

METHODS

Between 1959 and 1963, trials have been done on carrots, peas, cereals and potatoes. The primary aim with each crop has been to control aphids and prevent the spread of virus diseases which usually cause much more crop loss than the aphids themselves. The main virus diseases in Canterbury are Barley Yellow Dwarf Virus, Carrot Motley Dwarf Virus, Pea Top Yellows Virus, Potato Leaf Roll Virus, and Cauliflower Mosaic Virus. The materials used were phorate as a 10% granule and disulfoton as a 5% granule.

Application methods were either by mixing with sand and top-dressing over plots of growing plants or by mixing with fertilizer and applying the mixture at sowing or planting time.

Aphids were counted in the field after carefully lifting cereal seedlings with a trowel or examining the undersurface of selected leaves.

RESULTS

CARROTS

Smith *et al.* (1960) first showed that motley dwarf virus could be controlled with granules at $\frac{3}{4}$ and 1½ lb. Mulholland (1963) also described trials using disulfoton and phorate granules at 1½ and 3 lb. Virus incidence was halved and yield increased by 30% in one trial with phorate, and in the other trial the high rate of phorate decreased germination but the low rate and both rates of disulfoton all gave good increases in yield by controlling virus infection. Disulfoton at 1½ lb at sowing appears to be a suitable method for aphid and virus control in early-sown carrots.

PEAS

Phorate (at 4 lb) and disulfoton (at 1 lb) granules were both applied mixed with "Ammophoska" at sowing. Aphids were counted four weeks later and the numbers in 50 samples in one trial and in 40 in another were: Untreated, 10+10, disulfoton 5+1, phorate 3+2. Virus infection in both trials was counted six weeks after sowing and there was 12% primary pea top yellows virus in the untreated plots compared with 9% infection in both the phorate and disulfoton plots. As was expected from the low virus incidence, no yield differences were obtained in these trials nor in similar trials done in 1963-64.

Another trial compared seed treatment (using dimethoate) with disulfoton granules but again there was a low virus incidence (29%) in the untreated plots. Dimethoate 40% seed steeping gave the lowest virus incidence 2%; dimethoate 20% slurry seed treatment and disulfoton 5% granules both showed 10% infection. All materials were applied at 1 lb.

The low incidence of pea top yellows virus in peas in recent seasons suggests that losses may not be very great and that the best method of control may be by increasing the tolerance of pea varieties by plant breeding.

CEREALS

Spring Wheat

Initial trials at Lincoln showed that, although treating oat seed with 1% disulfoton prevented aphid establishment for at least two weeks, all plants eventually became infected with barley yellow dwarf virus (BYDV) after repeated inoculation with infective cereal aphids. One small-scale field trial was carried out in the spring of 1959 using wheat and oats treated with 1% and 0.5% disulfoton. Counts of BYDV infection on October 27 gave the following results for the 1%, 0.5% and untreated plots respectively: Aotea (wheat) 15, 19, and 34%; Hilgendorf (wheat) 17, 16, and 15%; Onward (oats) 33, 37, and 38%; Steel (oats) 31, 49 and 30%. A repeat count in November on the Aotea wheat plots (the most resistant variety to BYDV infection) confirmed the differences

between treatments, which then showed 17, 25, and 41% infection in the 1%, 0.5%, and check plots, respectively.

Because of reports of phytotoxicity to cereal seedlings, seed treatment was not continued and further work on soil and topical application of granular insecticides was commenced. The first successful field trials on BYDV control in wheat using granules was by Coughlan (Department of Agriculture, Hastings) in 1962. With Aotea wheat, granular phorate was drilled with the seed at 1 lb. The incidence of BYDV on January 9, 1963, was 35% in the untreated area and only 15% in the phorate treated area. This trial subsequently showed a 37% increase in yield while another trial on Gabo wheat treated at $\frac{1}{2}$ lb of phorate gave a 25% increase.

Three trials were laid down in 1963 on spring sown wheat using three rates of disulfoton (16, 8, and 4.8 oz). They were at Bulls (Gamenya variety), Masterton (Hilgendorf) and Glen Oroua (Mengavi). The disulfoton was applied as a 5% granule mixed with the fertilizer and drilled with the seed. Aphid counts were made on the plots in October and November, the virus incidence was estimated in December, and yields taken in January.

Table 1 shows that there was little aphid infestation and low virus incidence at the Bulls and Masterton trials but at Glen Oroua there was good aphid control especially at the high rate (1 lb) and a moderate reduction in virus incidence and increase in yield. Better control of aphids and virus would have been achieved if the season had been wetter, there being no rain for over 8 weeks after sowing.

Autumn Wheat

Eight field trials were laid down in Canterbury during the 1963-64 season to study the effectiveness of granular insecticides on cereal aphids and BYDV control. Only one very early sown trial was sufficiently infested with aphids to show any differences between treatments.

This drill trial was sown at Lincoln on April 30. Phorate was applied mixed with the fertilizer at sowing at the rate of $\frac{1}{2}$ lb. Aphid flights gave a uniform infestation by mid-May and subsequent aphid and virus counts are given in Table 2.

This trial showed that even a low rate ($\frac{1}{2}$ lb) of phorate drilled with the seed resulted in a prolonged reduction in aphid infestation but no significant reduction in BYDV or yield increase.

The main objection to application of granular insecticides with the seed at sowing is the waste of material if the aphid flights are delayed or do not occur.

It now appears that, particularly with wheat, there is no need to obtain immediate control of the cereal aphids which bring virus infection into the crop. Thus, the most economical method of application of granular insecticides would be by broadcasting over the crop after the first aphid flight.

OATS

Two trials in July, 1963, tested the relative effectiveness of granular insecticides in controlling *R. padi* in a dense oat crop, about 12 in. high. Disulfoton, phorate and menazon granules were diluted with sand and hand-broadcasted. Aphid counts were done

TABLE 1: CONTROL OF *R. PADI* AND BARLEY YELLOW DWARF VIRUS IN SPRING WHEAT USING DISULFOTON 5% GRANULES AS A SOIL APPLICATION AT SOWING

Treatment (oz./acre)	Bulls			Masterton			Glen Oroua		
	R. padi* 18/10	R. padi* 22/11	BYDV %	R. padi* 25/10	R. padi* 19/11	BYDV %	R. Padi* 18/20	BYDV 22/11	Yield Increase %
Disulfoton 16		8	0	0	0	5	0	73	31
Disulfoton 8		18	9	3	1	5	0	64	40
Disulfoton 4.8		11	3	1	0	5	0	150	48
Control		51	0	3	4	5	27	170	49

* No. aphids per 125 seedlings

TABLE 2: CONTROL OF *R. PADI* AND BARLEY YELLOW DWARF VIRUS IN AUTUMN-SOWN WHEAT WITH PHORATE GRANULES AS A SOIL APPLICATION AT SOWING

Treatment	Aphid Count (R. padi)			BYDV %	Yield (bu./acre)
	Jul. Sampling*	Aug. Sampling*	Sept. Sampling* Netting†		
Phorate ½ lb	0	—	0	26	55
Nil	1	9	25	33	57
Aphid inoculated	12	—	28	68	43

* No. samples infested out of 20

† No. *R. padi* in 400 sweeps

two days after treatment. In one trial, phorate at 0.05, 0.1, 0.2, 0.4, 0.8 and 1.2 lb, achieved efficient control at rates of 0.4 lb and above. The number of samples with aphids out of 15 samples (in the low rate treatments) was: untreated, 14; 0.05, 8; 0.1, 5; 0.2, 2. In the other trial, both disulfoton granules (1 lb) and demethon-methyl ($\frac{1}{4}$ lb as a spray) gave complete control, whereas menazon granules (1 lb) and untreated gave 8 and 10 samples infested, respectively, out of 15.

POTATOES

Trials were begun in 1962 and continued on a much larger scale in 1963. The objects were twofold. First, to find granular materials that, when applied in the soil at planting, would under New Zealand conditions protect potato plants from aphids for six to eight weeks after emergence. Second to demonstrate that effective control of potato aphids also prevented the spread of potato leaf roll virus, an aphid-borne persistent virus which is responsible for the degeneration of seed stocks of the main potato varieties. The first objective has been achieved but data on the spread of leaf roll virus will be available only after virus counts have been done next season.

The great advantage of granules on potatoes is that, apart from the cost of material, there is no application cost (for it is done at planting); and that the plants are protected as soon as they emerge through the soil. This last aspect is particularly important as the plants at this stage are very attractive to aphids and very susceptible to virus infection.

TABLE 3: EFFECTIVENESS OF SOME 5% GRANULAR SYSTEMIC INSECTICIDES, APPLIED AT PLANTING, IN CONTROLLING APHIDS ON POTATOES

	<i>Rate (lb)</i>	<i>Aphid Counts at these Periods after Planting</i>			
TRIAL I		<i>40 days</i>	<i>56 days</i>	<i>76 days</i>	
Untreated		467*	1,133	115	
Disulfoton	½	279	179	24	
Disulfoton	1	167	69	9	
Disulfoton	2	41	2	4	
TRIAL II		<i>33 days</i>	<i>49 days</i>	<i>68 days</i>	<i>87 days</i>
Untreated		639	708	461	10
Disulfoton	½	230	5	33	1
Disulfoton	1	84	0	18	2
Disulfoton	2	15	1	1	0
TRIAL III		<i>49 days</i>		<i>60 days</i>	
		<i>Rep. 1</i>	<i>Rep. 2</i>	<i>Rep. 1</i>	<i>Rep. 2</i>
Untreated		308	295	93	272
Disulfoton	1½	8	11	14	21
Menazon	1½	96	80	54	83
B.77 5%	1½	140	196	118	154

* Numbers of wingless aphids per 100 leaf sample.

The granules were mixed with fertilizer and applied through the fertilizer boxes of the potato planters.

Table 3 shows that the insecticide disulfoton was effective, in all the trials, in controlling aphids on potatoes for several weeks after emergence. The aphids found on plants treated with either the 1½ lb or 2 lb rate were all newly emerged nymphs and would soon be killed. The minimal rate for good aphid control seems to be 1½ lb but further trials will be done on this aspect. In all trials the treated plots seemed to grow better, but the yields were comparable with untreated plots. However, yield differences are expected in the next season when seed from untreated plots will contain more virus than seed from treated plots. Although phorate was not tested in these trials, it is expected (from overseas results) that it would give good control of aphids on potatoes.

The use of granular systemic insecticides on potatoes or any other crops in New Zealand does depend on the development of reliable and accurate applicators for applying small quantities of granules. Several applicators are available and evaluation of these machines will form part of next season's research work.

ACKNOWLEDGEMENTS

Farm Chemicals Co. kindly supplied the phorate, and Henry H. York and Co. Ltd. the disulfoton. The initial trials with seed treatment were done by J. D. Allen, formerly of the Plant Diseases Division. F. McKee (Farm Chemicals Co.) assisted with one of the oat trials.

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