GRANULAR INSECTICIDES FOR APHID CONTROL

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Summary

Granular organophosphorus insecticides for aphid control save time, since there is no water or sprayer problems, no mixing, less drift and they are not as hazardous as sprays. However, granule applicators are needed and these must ensure accurate and even distribution along rows. Granules can either be placed in the root zone or be topdressed over the plants. Systemic chemicals for use with granules must be stable, not phytotoxic, and slightly soluble, enabling slow release from the granule and hence uptake by plants over a longer period. With potatoes, the length of control of aphids is for at least ten weeks after planting.

INSECTICIDES for aphid control are usually marketed as spray formulations but in recent years organophosphorus insecticides on granules have become more common. In many cases good aphid control over a long period has been achieved from one application of granules. It is likely that granules will be more widely used in future since they offer the following advantages over sprays:

- (1) There is no mixing, the chemical is already formulated as 2, 5 or 10% granules.
- (2) There is no water problem and hence no sprayer problems.
- (3) There is a saving of time because of the above advantages, and often only one application of granules is necessary.
- (4) There is less total weight of material to apply per acre.
- (5) There is less drift to adjacent crops.
- (6) There is less risk to the person using granules.

Naturally there are several disadvantages with granules and these are as follows:

- (a) New equipment for applying granules is required.
- (b) More storage space is needed for granules than for spray concentrates.
- (c) There is more handling of drums of granules. It is easier to pump water than it is to lift and carry drums.

Some of these disadvantages can considerably impede experimental work and later commercial use of granules on crops. In particular, granule applicators are essential before much progress can be achieved.

In all experimental work with granules for aphid control, it is important to consider:

- (1) The active ingredient.
- (2) The type and size of the carrier material or granules.
- (3) The granule applicator.
- (4) Placement of the granules.
- (5) The time of application.
- (6) Uptake and translocation of the chemical by plants.
- (7) The aphid control achieved.

Each of these factors will now be discussed.

APHICIDES FOR USE ON GRANULES

Aphicides for this purpose must be stable, not phytotoxic, have good fumigant and systemic action, be only slightly soluble in water, and be slowly released from the granules and absorbed by plants over a long period. Disulfoton and phorate fulfil these requirements and are very useful chemicals for this purpose. Their properties were compared with those of dimethoate and menazon by Burt *et al.* (1965). The molecular weight of disulfoton is 274 and that of phorate is 260.4 and the solubility of these chemicals in water is similar—*i.e.*, 1 part in 40,000 of water. On the other hand, menazon is about three times as soluble as these, and dimethoate is soluble to the extent of 2.5% in water. However, the volatilities of these compounds need to be considered, for this is important in relation to their movement within the soil. Menazon is not volatile, disulfoton and phorate are much more volatile, with phorate being more volatile than disulfoton. In dry soils, therefore, systemic insecticides probably reach the roots of plants only by evaporating into air-filled soil pores and diffusing through them. Even in moist soils, some chemicals, such as phorate and disulfoton, may partition between air and water so that more moves through the air than water. Thus, in judging a compound, its volatility and solubility are both very important. If the chemical is too soluble, then it is rapidly lost by leaching.

TYPE AND SIZE OF GRANULES

Materials that have been used as a carrier for insecticides include attapulgite clay, pumice, expanded mica, bentonite, perlite, sand, Fuller's earth, diatomaceous earth, tobacco, maize and walnut chips, but the most common are attapulgite and pumice granules. It is important to specify the size of granules, since this will determine rate of flow and number of granules per unit area. The amount of fine material and therefore the dust hazard must also be specified. Standard descriptions of granules usually are based on shaking a known quantity of granules on a nest of sieves for a specified time. In a trial at Lincoln by Dr Arlidge, 10% phorate granules (attapulgite clay) when shaken for 5 minutes, separated into the following classes: 29.7% greater than 1 mm (held on 16 B.S. mesh), 68.8% between 0.5 mm and 1 mm (held on 30 B.S. mesh), and 1.5% smaller than 0.5 mm (passing through 30 B.S. mesh). After 10 minutes, the figures were 25.7%, 72.0% and 2.25%, respectively. The other characteristic of granules is their bulk density or weight per cubic foot of granules. Bulk densities vary from 15 lb/cu. ft to 80 lb/cu. ft, but for

attapulgitic clay (15/30 size) it is 32 lb/cu. ft, while for pumice granules it is 29 lb/cu. ft.

GRANULE APPLICATORS

An applicator, particularly for experimental work, should be able to meter granules at rates from 10 to 40 lb per acre, the rate should be able to be altered easily, and be consistent from one delivery tube to another and from day to day. It is preferable that it have a ground-wheel drive as then the application rate will not be altered by changes in forward speed. It is essential that there be an even distribution of granules along the row. This can best be achieved by having a large number of flutes on the rotor. A small number of large capacity flutes give rise to variations in longitudinal distribution. Lindsay and Hale (1963), in tests on three machines, found that Machine A and B with few large flutes gave a distribution for A of +250% and -50% at 27 in. intervals, while for B the figure was $\pm 50\%$ at 30 in. intervals, whereas Machine C with many small flutes varied $\pm 30\%$ at 6 to 9 in. intervals. In similar work, the late M. Cross (pers. comm.) found that the Horstine Farmery unit and the Dale applicator gave satisfactory longitudinal distribution patterns.

PLACEMENT OF GRANULES

The ability of plants to translocate systemic insecticides from the root zone makes application in this position very worth while. Thus with potatoes the granules can be placed on top of and around the seed potato and all along the furrow. As the roots develop they can grow into areas containing the granules. Similarly, with seeds, granules have been successfully placed in the same position as the developing seed. This ensures uptake soon after growth of the seedling and immediate protection, and there has been no phytotoxicity as is usual when these chemicals are coated on the seed. Granules should be useful with seedlings since they are particularly susceptible to insect attack. There is continuous protection with granules, whereas with sprays there is little plant surface to receive and retain insecticide and this necessitates repeated applications. Granules can be applied as a band alongside young or older seedlings, and either as a topdressing over the row or over the whole crop.

TIME OF APPLICATION

The use of granules at the time of planting or sowing is, in general, an "insurance" measure that will prevent an attack that is likely to occur. In some years, the insects may not become economically important, but if this occurs only once every five years then it is obviously worth while to treat every year. If the granules are to be topdressed, then the application can be delayed until the attack is observed, but as far as virus spread is concerned this may be too late.

UPTAKE AND TRANSLOCATION OF THE CHEMICAL BY PLANTS

After being applied at correct rates into the soil, the granules will slowly release the chemical, which is absorbed by the roots and then translocated and stored in the leaves in amounts toxic to aphids. There

TABLE 1: DURATION OF EFFECTIVENESS OF GRANULES FOR APHID CONTROL ON POTATOES, WHEN APPLIED IN THE FURROW AT PLANTING

Trial No.	Days after Planting	Number of Wingless Aphids per 100 Leaf Samples		Rate of Chemical (lb a.i.)
		Untreated Plots	Treated Plots	
1963-4				
1	76	115	9	1.0
2	68	461	18	1.0
3	60	272	21	1.5
1964-5				
4	64	3,326	24	2.0
5	54	2,294	24	1.0
6	65	1,344	11	1.0
7	64	1,927	13	1.0

is a gradual release over a period of time and a continuous uptake by the plants. Leaves that develop first soon become toxic, and in general there is a concentration gradient from highest in the oldest leaves and lowest in the youngest. The root system of the plant will develop and often grows into areas of granules, thus ensuring uptake over a period. This is true of a spaced crop like potatoes, but certainly will not be true of crops such as cereals and peas where seedlings will be competing for the chemical.

Once within the plant, the systemic organophosphorus insecticides are quite selective acting against sap-sucking insects, and having virtually no effect on biological control agents.

Disulfoton and phorate, on absorption by plants, are oxidized immediately into toxic metabolites. The decay rate of these within plants depends on temperature and varies from one plant species to another.

Topdressed granules lodge in leaf axils and adhere to leaf surfaces. Absorption of the chemical through the leaves and stems appears to be the only means whereby the plant can become systemically toxic. However, there is an immediate fumigant effect which is of value in aphid control.

USE OF GRANULES ON CROPS

The situation in New Zealand was reviewed by Smith *et al.* (1964). Their recommendations were that, with low value crops, topical application of low rates of granules should be used. With high value field or 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. Since then much work on potatoes has been completed by Rough and Close (1965). Good control of aphids has been achieved at up to 76 days after planting (Table 1). It was not possible in these trials to determine the total length of protection as the aphids, in all instances, were absent from the untreated plants at the third or fourth time of counting. In Britain, excellent control of aphids on potatoes was still being achieved at 97 days after planting, with both disulfoton at 1 lb a.i. per acre and phorate at 3 lb a.i. per acre (Burt, 1962).

Development work on peas in New Zealand has shown that granules can give good control of aphids at even ten weeks after sowing. Similarly, trials with cereals (Mulholland and Jessep, 1967) have shown that, at 9 weeks after sowing, rates of 0.7 lb, 1.1 lb and 1.8 lb a.i. per acre of disulfoton have given good control of aphids as measured by total numbers of plants infested and by aphid numbers.

Trials with granules are warranted on various brassica crops either applied at sowing or topdressed on more mature plants. In particular, rape seed crops, sown in April, seem to be worth treating with granules at sowing. Granules should also be tested on cauliflower seedling crops, and used again after transplanting. Topical application to brussel sprouts seems worth while.

Carrots are another crop where application of granules with the seed seems warranted. This would apply in particular to early-sown carrots.

In all trials it is important to bear in mind (a) The economics of granules, both in cost of materials and application costs, and (b) That the final product must be either free of residues or that residues be below the figures set for tolerance levels.

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