PRINCIPLES OF DISTRIBUTION OF GRANULAR INSECTICIDES

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Summary

This paper, based partly on theory and partly on observations, discusses briefly various problems which arise when granular insecticide is broadcast so as to achieve the most uniform deposition of insecticide and low retention on pasture.

GRANULAR INSECTICIDE is broadcast unevenly from several causes: the pattern of spread across the swath is never perfect and may be fluctuating; material may be fed at a rate disproportionate to ground speed; lapping may be too wide or erratic. In addition, when small areas of ground are considered, there is a variation in deposit caused by the small number of particles available for each area. Such detailed unevenness of spread is inherent in granular application, and is important in determining the number of granules required per square foot and therefore their size. (All materials are given in terms of active ingredient.)

TABLE 1: PROPERTIES OF TYPICAL SAMPLES OF SOME MATERIALS AT PRESENT USED IN N.Z.

	Mean Mass of Granules (mg)	Rate Normally Applied (lb/ac)	No. of Granules per sq. ft	Approx. Mean Terminal Falling Speed in Air (ft/sec)
DDT prills 20%	0.9	10	110	20
DDT granules 30%	0.25	6.7	250	12
DDT coated on "Ammophos" 2%	3.5	100	300	25
DDT/superphosphate all granulated	20	224	130	35
Diazinon granules 5%	0.4	20	500	15

VARIATION IN INSECTICIDAL DEPOSIT FROM STATISTICAL CAUSES

Small circles of uniform size may be considered at the surface of the ground above every insect so that each is affected by insecticide deposited within the circle but not outside. Granules broadcast evenly over the area will not fall equally in all such circles but in varying number according to Poisson's distribution. The more granules there are, the more uniformly they will fall, as indicated in Table 2.

TABLE 2: VARIATION IN INSECTICIDAL DOSAGE ARISING FROM LIMITED NUMBER OF GRANULES

<i>Average No. of Granules, supposed of Uniform size and Composition, affecting each Insect</i>				<i>% of Insects receiving $\frac{1}{2}$ Mean Dose of Insecticide or More</i>				<i>% of Insects receiving $\frac{1}{2}$ Mean Dose of Insecticide or More</i>			
2					59	.....	.....	.....	.....	73	
5					71	.....	.....	.....	.....	87	
10					79	.....	.....	.....	.....	94	
20					87	.....	.....	.....	.....	99	
40					94	.....	.....	.....	.....	100	

The important soil insects in New Zealand are not very mobile in their larval stages and are unlikely to be affected by insecticide more than 2 to 3 in. away. Insecticide must be placed within a circle of area only about 0.1 sq. ft if it is to control such insects located at the centre of the circle. Hence as few as 10 granules may be available to act on an insect, even though spreading has been done as evenly as possible.

The importance of variation in particle size within a sample may be appreciated by supposing that insecticide is spread so perfectly that 10 granules are placed within lethal range of each insect. Variation in dosage can be estimated by weighing granules drawn at random from the sample in groups of 10, and assuming that all have the same composition. One hundred groups of ten DDT prills of 20% were weighed with the results given in Table 3.

TABLE 3: VARIATION IN WEIGHT OF GROUPS OF TEN DDT PRILLS

4 groups with weight under 4.3 mg ($\frac{1}{2}$ mean wt)	
25 groups with weight under 7.5 mg	
25 groups with weight 7.6–8.3 mg	
25 groups with weight 8.4–10.4 mg	
25 groups with weight over 10.5 mg	
Mean weight	8.6 mg

It can be shown that with this product variation in insecticidal dosage among insects caused by varying size of granules is rather less than variation in dosage caused by fluctuating numbers of granules deposited near each insect. These effects may be combined by regarding the granules of uniform size, but reduced in number by a factor which is calculated from the particle size range, or, more exactly, from the range of quantity of insecticide in the granules. DDT prills of the size range indicated in Table 3 would act as though they were 40% fewer but of uniform size. The impregnated granules of 30% have a wide particle size range and should be reduced in number by over 50% to obtain a uniform size equivalent.

Commercially available materials, even when broadcast evenly in the normal sense of the word, will give an insecticidal deposition fluctuating within small areas of 0.1 sq. ft, corresponding to as few as 6 particles in Table 2, whereby one-tenth of the treated area is to be regarded as receiving insecticide at less than half the mean rate.

Variation in deposition from these statistical causes becomes relatively greater in those regions where deposition is generally light. Loss of insecticidal performance from these causes, although not serious, is probably as large as should be tolerated, and would not allow any further reduction in the weight of concentrate materials applied per acre. Present products represent a good compromise between cost and performance. Materials of rather narrower size range would be an advance provided they do not present insuperable problems in application because of their uniform ballistic properties.

SPINNER SPREADERS

Spinning discs provide the only means of achieving a wide swath with compact ground-based equipment and continue to be much used for spreading granular insecticide, especially where it is sown without fertilizer.

Skill is needed both in the design and operation of such equipment. If material is fed near the centre of the spinner, so that it is trapped and flung out against vanes, rather than being hit away by impact, its throw may be directed to give a satisfactory swath. On such a spinner, granules move outward in logarithmic spirals, leaving the disc after $\frac{1}{2}$ to $\frac{3}{4}$ of a rotation of the disc with a radial velocity about half the tangential. Radial velocity of granules on the spinner depends on friction—in the absence of friction being equal theoretically to tangential velocity. Granules with low friction, or which roll easily, come off the spinner more quickly than those which are more sticky or angular. The pattern of throw is also very dependent on just where material falls on to the spinner.

The problem of getting material to leave the spinner at the right place may be solved by providing adjustment of the position where it is fed on to the spinner. This scheme assumes the operator is capable of adjusting the machine correctly, which will probably be done visually rather than by measuring samples collected.

In operation, spinner spreaders are subject to tilting and side shocks which affect the pattern of spread.

Spinners designed for spreading lime or powdered fertilizer are likely to throw granular material largely to one side. If spreading is done round and round rather than back and forth, and is done at a sufficiently close lap interval, the spread may be tolerably good. Many of the modern bulk spreaders have twin spinners oppositely rotating so that throw must be equal to either side. Machines of this type which have been tested throw granules well out either side but leave very little behind. Lapping must be done close enough for granular material to be thrown into the wheel tracks on the next round.

FEED OF GRANULAR MATERIAL TO SPREADERS

Insecticides can be formulated into free-flowing granules which flow at a constant rate through calibrated openings. The flow rate varies approximately with the square of area of the opening, so that the size of opening is critical; it must be capable of accurate adjustment and remain constant in operation. The rate of flow of granular material through an opening does not increase with greater loading of material above unless it is able to force the opening wider.

Trickle feeding assumes known forward speed over the ground. It has proved satisfactory for aeroplanes, for tractors carrying

light spreaders, and for trucks on flat ground. It is unacceptable for trucks on sloping ground encumbered by heavy loads of fertilizer. Equipment to feed small quantities of granular insecticide in proportion to ground covered has not been developed. Bulk spreaders operating on slopes either use fertilizer/insecticide mixtures, or, if the equipment is considered suitable, insecticide tipped on top of the load. Spreaders of the type which peel the whole depth of the load off at the rear as it is slowly moved back on the wide moving belt which occupies the floor, appear to have done a satisfactory job of spreading the composite load, even though sampling of the feed to the spinners has shown that mixing is imperfect.

Some popular makes of spreader for power take-off operation on tractors employ a spinner disc on the middle region of which the load rests, feed being regulated by the clearance between the disc and a sleeve above. This feature has merit for superphosphate but is very destructive of granular material. Various other kinds of feed mechanism are hard on granules, breaking or powdering them. Disintegration of the granules is apparent when they are spread alone through such devices, but when they are mixed with a larger quantity of powdered fertilizer is greatly reduced. It is not apparent to the eye whether the degree of powdering of insecticidal granules is tolerable in such cases.

No improvement in abrasion resistance of insecticidal granules can be expected in the near future, for manufacturers are under pressure to improve dispersibility in order to achieve more rapid insect control in the lighter rainfall districts. The requirements of abrasion resistance are strongly in conflict with those of dispersibility.

It is probable that, if lower insecticidal residues are required, greater use must be made of trickle feed.

SPREADING FROM AEROPLANES

Material dropped straight from an aeroplane hopper comes under the influence of air currents caused by the aeroplane. These currents have a greater effect and for a longer time on light particles than on heavy ones; in consequence, light material is spread over a wider swath than heavy material. Once a particle is free of turbulent air in the wake of the aeroplane, its further path in still air can be calculated if its initial speed and direction are assumed, and if its terminal falling speed is known.

Particles with a terminal falling speed of 20 ft/sec attain a vertical direction after falling 50 ft. There is no further widening of swath on falling further unless there is sidewind to carry the lighter particles further than the heavy ones. In calm air the swath is no more than 20 ft wide if the very light deposit at the edges is neglected; with heavier granules the effective swath is even narrower.

Spreaders are used to give lateral velocity to granules leaving the aeroplane, usually by means of ducts carrying slipstream outwards. These ducts should be directed about 20° aft of abeam for furthest throw. Heavy particles are accelerated in the ducts less than light ones, but nevertheless spread further because of their greater ability to keep moving after release.

The heavier granules are, therefore, the greater the advantage is of using a spreader.

Theory also indicates a small increase in swath width with increase in flying speed.

The best spreaders not only widen the swath, but also give a gradual falling off in intensity of deposit at the edges. This gives a considerable width of ground which is partly covered in consecutive passes, so that errors of lapping will not be so serious as with a swath pattern which falls off rapidly at the edges.