12

Seed treatment, dust and granule application

While most pesticides are applied as liquid sprays, the application of dry formulations has one main advantage in that the product requires no dilution or mixing by the user. This is important in areas where the usual diluent, water, is expensive to transport. Nevertheless, the cost of transporting heavy and bulky diluent in the formulated product has to be paid for, and the relative cost of the active ingredient is increased.

Use of dusts has declined, largely because of the drift and inhalation hazards of fine particles less than 30 µm in diameter. Dusts are useful when treating small seedlings during transplanting, and in small buildings where farm produce is stored. Certain dusts, especially sulphur fungicide, are used on a few crops, notably grapevines when humid conditions improve retention of dust on foliage. The main use of dusts is now for seed treatment, although even in this application dusts have been replaced, mainly by particulate suspensions. Small and irregular shaped seeds are often pelleted, so that with a more uniform size they are easy to sow with greater precision (Clayton, 1988). The amount of pesticide applied is related to the pellet size (Dewar *et al.*, 1997).

Granular insecticides are used principally to control soil pests, aphids, stem borers on graminaceous crops and the larval stages of various flies, preferably where there is adequate rainfall or irrigation. They are sometimes added to compost used in peat blocks to raise seedlings such as brassicas (Suett, 1987). An increasing number of herbicides are also formulated as granules, certain of which are used widely in rice in the Far East. In the USA, aerial application of rice herbicides is common. Granules are very often applied by hand, especially in tropical countries, but the amount of active ingredient used is higher than with other application techniques when the granules are broadcast into irrigation water (Table 12.1) (Kiritani, 1974), whereas accurate placement of granules at their appropriate target with precision equipment means that less active ingredient is needed than with other application methods (Walker, 1976).

Table 12.1 Amounts of active ingredient in relation to different formulations used in rice paddy (after Kiritani, 1974)

	Active ingredient in formulation (%)	Active ingredient (kg/ha)
Spray	50	0.5
Dust	2	0.6
Microgranule	3	0.9
Granule	5	1.5

Seed treatment

The 'Rotostat' (Fig. 12.1) has been developed especially for treatment of batches of seed. It can be used to apply dusts, but is more generally used with liquid formulations. Smaller versions have been developed for use in developing countries. Fluidised-bed film coating systems are also used to deposit the pesticide in a thin durable polymer coating (Maude and Suett, 1986; Halmer, 1988). Seed treatment provides a valuable method of protecting young plants with minimal quantities of toxicant (Elsworth and Harris, 1973; Middleton, 1973). Seed treatment is discussed by Jeffs and Tuppen (1986) and Graham-Bryce (1988).

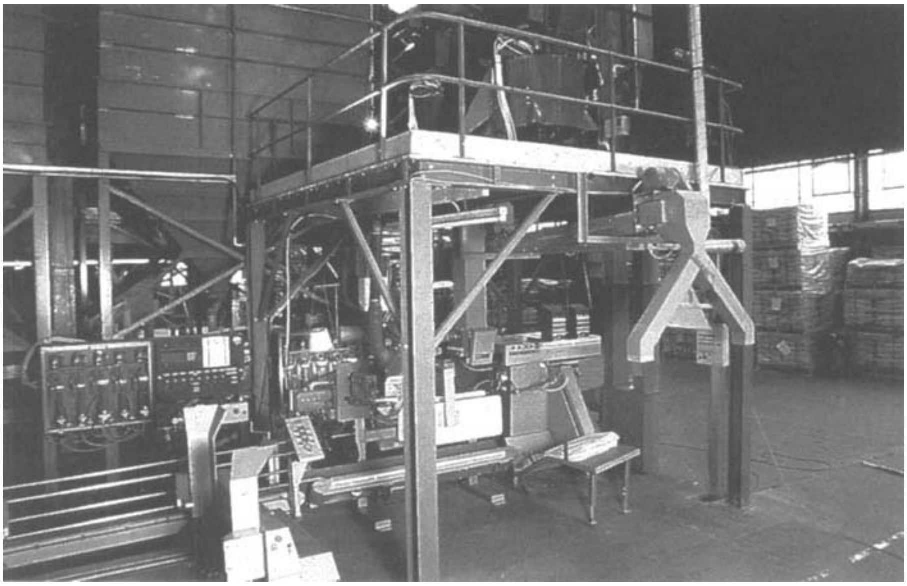
Equipment consists essentially of a hopper, preferably with an agitator, and a metering device to feed particles at a constant rate to the discharge outlet. A blower unit to produce an airstream to convey particles towards the target is essential on a duster, and may be used also on granule applicators, unless granules are allowed to fall by gravity directly from the metering mechanism. Walker (1976) lists the requirements of a good applicator (Table 12.2), and Bruge (1975, 1976) details characteristics of a range of granule applicators (Table 12.3), the main features of which are discussed below.

Features of dust and granule applicators

Hopper design

Ideally, the hopper should have smooth sides sloping down to the outlet, thus conical-shaped hoppers are better than those which are square-box shaped, unless the floor slopes (Fig. 12.2). Conversion of spray tanks to hoppers is unsatisfactory when the floor is level. An agitator is useful to prevent packing of the contents and to ensure an even delivery of the contents directly to the metering device or through a constant-level device. The latter is particularly useful where an agitator damages friable materials, such as attapulgite. Mechanical agitators are linked to the drive shaft of the blower unit. On some machines, air is ducted through the hopper from the blower unit. Certain agitators are less effective when dust particles bind together, as they merely

(a)



(b)

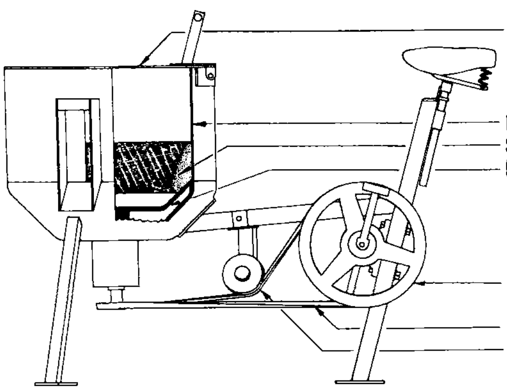


Fig. 12.1 (a) 'Rotostat' seed treatment machine (ICI Agrochemicals – now Zeneca). (b) Low-cost, pedal-powered seed treater.

cut a channel in the dust. Some machines have an auger in the hopper to move the contents to the metering device.

The hopper should have a large opening to facilitate filling; great care is needed to avoid fine particles 'puffing' up when the hopper is filled. Some granule products are now supplied in containers that allow direct transfer, so eliminating operator exposure at this stage. Where granules are not in a closed transfer system, a sieve over the hopper opening is essential to eliminate

Table 12.2 Requirements of a good granule applicator (after Walker, 1976)

(1)	Deliver accurately amount calibrated, either continuous or intermittently
(2)	Spread particles evenly
(3)	Avoid damage by grinding or impaction
(4)	Adequate mixing and feeding of material to metering device
(5)	Easy to use, calibrate, repair and replace worn parts
(6)	Light hand-carried and knapsack versions need to be comfortable to carry on the back
(7)	Robust
(8)	Corrosion, moisture and abrasion proof
(9)	Inexpensive
(10)	Output directly related to distance travelled

foreign matter and large aggregates. A lid must provide a seal to protect the contents from moisture. Ideally, hoppers and components should be made from corrosion-resistant materials, so various types of plastic and light alloys are preferred to ferrous metals, although the latter are cheaper. Granules should never be left in the hopper, otherwise corrosion will occur, so the hopper should be designed to be easily emptied. One knapsack granule

Table 12.3 Three examples of tractor-mounted granule applicators (some data selected from Bruge, 1975)

Manufacturer	Horstine Farmery	Merriau	SMC
Model	'Microband'	Granyl	Bimigrasol
Rows/hopper	2	2	2
Hopper capacity	16 or 35 litres	25 litres	18 litres
Hopper	Polythene	Polythene	Metal sheet
Indicator of level of granules	Yes, translucent hopper	Through translucent hopper	No
Metering device	Grooved rotors in special plastic or aluminium	Rotors with oblique lateral holes	Rubber belt
Method of regulation	By speed, using different sets of pulleys and width of rotor	By variation of speed	Variation of hopper outlet aperture by moving slide with micrometer screw
Drive	By spider wheel or by belt and pulleys	Direct from seeder by chain and sprockets	Direct from seeder or by wheel
Outlet tubing	Transparent plastic	Rubber	Transparent plastic
Internal diameter of outlet (mm)	25	20	20
Adaptability	Fits all seeders	Fits all seeders	Fits all seeders

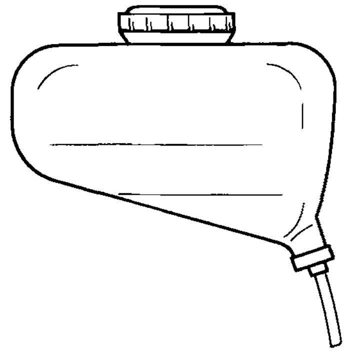


Fig. 12.2 Hopper design.

applicator was designed to incorporate a collapsible hopper to facilitate storage and transport.

Metering system

Various systems of metering dust and granules are used. The amount of product emitted by some machines is adjusted by altering the cross-sectional area of a chute by means of a lever or screw. For most applications the chute must be at least half open. Alternatively, particles drop through one or more holes, the size or number of which can be regulated. Both these systems are liable to block, especially if the particles are hygroscopic. Even collection of a small quantity of particles on the sides of the orifices is liable to reduce their flow and ultimately block the metering system. These systems will not give an accurate delivery unless the forward speed is constant.

Metering is improved by using various types of positive-displacement rotor (Fig. 12.3) which deliver a more or less constant volume of product for each revolution. Output is varied by changing the speed of rotation or capacity of the rotors or both, as on the Horstine Farmery 'Microband' equipment. Great

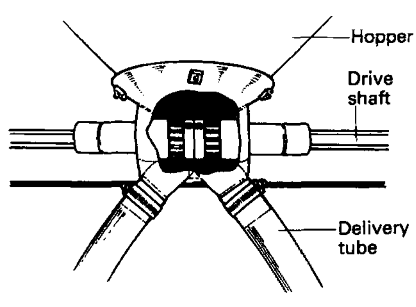


Fig. 12.3 Displacement rotor.

care must be taken in the design and construction of the metering system to avoid it acting as a very efficient grinder or compressor of granules (Amsden, 1970). Variations in size, specific gravity and fluidity characteristics of particles affect the efficiency of the metering system, so each machine requires calibration for a particular product. Farmery (1976) pointed out that the characteristics of a particular product may differ from one season to the next owing to a change in the granule base. Amsden (1970) suggested that the bulk density and flow rate of granules should be given on the label of the granule packaging as a guide to calibration. As some granules contain the most hazardous pesticides, the main development has been in closed transfer systems, such as 'Sure Fill' (Fig. 12.9). In the closed transfer system known as 'Smartbox', metering is controlled with a flow sensing device that allows a precise dosage to be applied, even at very low rates. As with other granule applicators the rate of application is determined by the forward speed of the tractor (Fig. 12.7). Monitoring application continuously and a positive shut-off at the end of rows minimise misapplication and wastage. On many granule applicators a trailing wheel is used to control a positive displacement meter in relation to the forward speed, but on more modern versions ground speed is monitored by radar. The granules are applied in-furrow or in a T-band to protect the roots of the young seedlings.

Calibration under field conditions at the appropriate forward speed is recommended because the flow of granules can be influenced by the amount of vibration caused by passage over uneven ground. Calibration can be done by collecting granules separately from all delivery tubes in suitable receptacles while travelling over 100 m and checking their weight (Bruge, 1975). The amount within each section of the target area has to be considered during calibration, as well as the total amount of product applied per hectare (Table 12.4). Thus, the metering system must provide as even a flow of particles as possible and avoid irregular clumping of particles. This is achieved when rotors have many small cavities to hold the particles, rather than a few larger ones. The speed of rotation can be reduced to minimize attrition of the product. Bruge (1976) emphasised that the moving rotor must be set close to its housing to avoid particles being crushed. On some machines a scraper is positioned at the bottom of the hopper to ensure that the contents in the rotor remain intact. The metering system should not be adjusted to a lower flow rate while particles are present, as packing of the product is liable to jam the unit.

Table 12.4 Amount of formulation required in small areas

Rate (kg/ha)	Area covered by 100 g (m^2)	Rate per m^2(g)
10	100	1.0
15	66.7	1.5
25	40	2.5

Blower unit

Small hand dusters usually have a simple piston or bellows pump. Bellows have been used in knapsack dusters as they are useful for spot treatments, but rotary blowers provide a more even delivery. The fan may be driven by hand through a reduction gear (about 25:1) or by a small engine. Compressed-air cylinders have also been used to discharge small quantities of dust.

Delivery system

Particles drop from the metering unit into a discharge tube connected to a blower unit, if present. When a blower unit is not used, the discharge tube should be mounted as vertically as possible to avoid impeding the fall of particles. If it must be curved, a large radius of curvature is essential. The internal diameter of the tube should be sufficiently large, ideally not less than 2 cm, and uniform throughout its length. Some tubes are divergent at the outlet end, or subdivided to permit treatment of two rows. At the outlet a fish-tail or deflector plate may be fitted to spread the particles. The position of the discharge tube should be fixed, especially when granules are applied in the soil, and the outlet has to be 10–30 mm from the soil at the back of a coulter. Clear plastic tubes are often used as they are less liable to condensation and blockages can be easily seen, but they are sometimes affected by static electricity. Instead of a blower and discharge tube, some machines have a spinner to throw particles over a wide swath.

Examples of equipment

Package applicators

Some dusts and granules are packaged in a container with a series of holes which are exposed on removal of a tape cover. The contents are shaken through the holes, so the quantity emitted will vary depending on the operator and amount remaining in the container. The main advantage is that the contents do not require transferring to other equipment, but the container has to be carefully disposed of after use. Similar 'pepperpot'-type applicators can easily be made by punching holes in the lid of a small tin.

Hand-carried dusters

Various types of bellows dusters are available with capacities from 20 to 500 g. Plastic materials are used now in preference to leather or rubber, which deteriorate more rapidly under hot and humid tropical conditions. They were used to apply sulphur dusts in vineyards, and Mercer (1974) used bellows dusters to treat small plots of groundnuts with fungicide. The design was similar to that described by Swaine (1954) who improvised a bellows duster by cutting a small tin in half and joining the two halves with a piece of car tyre inner tube. A metal handle was soldered to both ends and an outlet tube was fixed to the bottom half of the tin. These dusters were used to apply a puff of dust in the funnel of maize plants for stalk-borer control.

Simple plunger air-pump dusters have a bicycle-type pump, which blows air into a small container. Some have double-action pumps to provide a continuous airstream. The air agitates the contents and expels a small quantity through an orifice. This type of duster was used extensively to treat humans with DDT to prevent an outbreak of typhus in the 1940s. The World Health Organization has a specification for this type of duster (WHO/EQP/4.R2). They are also useful to spot-treat small areas in gardens and around houses for controlling ants and other pests. Similar dusters with a foothold, a cut-off valve to close the dust chamber, and a flexible discharge pipe, have been used to blow a dust into burrows for rodent control. When sufficient dust has been emitted the valve is closed and more air blows in to drive the dust deep into the burrow (Bindra and Singh, 1971). Small dusters with a rotary blower are also made for garden use.

Pest control operators sometimes use a dust applicator, which is very similar in appearance to a compression sprayer. The duster can be pressurised from an air supply through a schrader valve. Dusters with an electrically powered fan are also available. A duster can be improvised by using a loosely woven linen or fabric bag, sock or stocking as a container which is shaken or struck with a stick. The amount applied is extremely variable and most of the dust is wasted.

Hand-carried granule applicators

These have a tube container (approximately 100 cm long, 1–1.5 litres capacity) with a metering outlet operated by a trigger or wrist action rotation of the container (Fig. 12.4). On one machine a small meter is positioned on each side of the outlet. The output of granules depends on the position of the cones, which can be altered by adjusting a connecting-rod. Robinson and Rutherford (1988) found that many applicators which rely on gravity flow are slow, and trigger-operated systems were tiring to operate and more expensive to manufacture. They developed a 'rotary valve' using a wrist-action for granule application in transplanted tobacco. These applicators are particularly useful for spot treatment at the base of individual plants, and have been used in cabbage root fly control and in selective weed control, but are not suitable for burrowing nematode control on bananas for which larger doses are required. Granules are normally left on the soil surface but, by modifying the outlet with a spike, subsurface application is also possible.

Fig. 12.4 Hand-operated granule dispenser.

Shoulder-slung applicator

An applicator, known as a 'horn seeder', consists of a tapered metal discharge tube containing a variable opening which is inserted into the lowest point of a rubberised or neoprene-treated cloth bag. This bag has a zipped opening and is carried by a strap over the operator's shoulder. A swath of up to 7 m can be obtained when the discharge tube is swung from side to side in a figure-of-eight pattern.

Knapsack and chest-mounted dusters and granule applicators

A blower is usually mounted to the side and base of a hopper of 8–10 litres capacity. On hand-operated knapsack versions, a crank handle is situated in front of the body and is connected to a gear-box by a driving chain which is protected by a metal case. This drive is eliminated on some machines by hanging the hopper on the operator's chest, but the front position is less comfortable, restricts the quantity of material which can be carried in the hopper, and may be hazardous if fine particles escape and contaminate the operator's face.

The volume of air emitted by hand-operated machines will depend on the operator, but is at least $0.8\,m^3/min$ at a speed of 14 m/s with the crank handle turned at 96 r.p.m. The discharge tube is normally on the opposite side of the hopper to the gear-case, which must be protected as much as possible from particles liable to cause wear of the gears. Compared with knapsack sprayers, dusters are relatively expensive, owing to the cost of the blower unit.

Most motorised mistblowers described in Chapter 10 can be converted for dust and granule application by removing the spray hose from the tank and inserting a wider tube to feed particles directly down from the hopper through a metering orifice into the airstream (Fig. 12.5). The outlet tube is rotated to stop the flow of material. Machines with a tank having a sloping floor are more easily adapted for application of dry materials. In Japan, a 30 m long plastic tube, carried at each end, has been fitted to these machines. Dusts and microgranules are dispersed through a series of holes along its length. Tabs next to the holes improve distribution (Fig. 12.6) (Takenaga, 1971). Hankawa and Kohguchi (1989) reported that good control of brown planthopper (*Nilapavata lugens*) was obtained using buprofezin or BPMC insecticides applied with this type of applicator fitted to a large capacity fan to increase airflow at each hole.

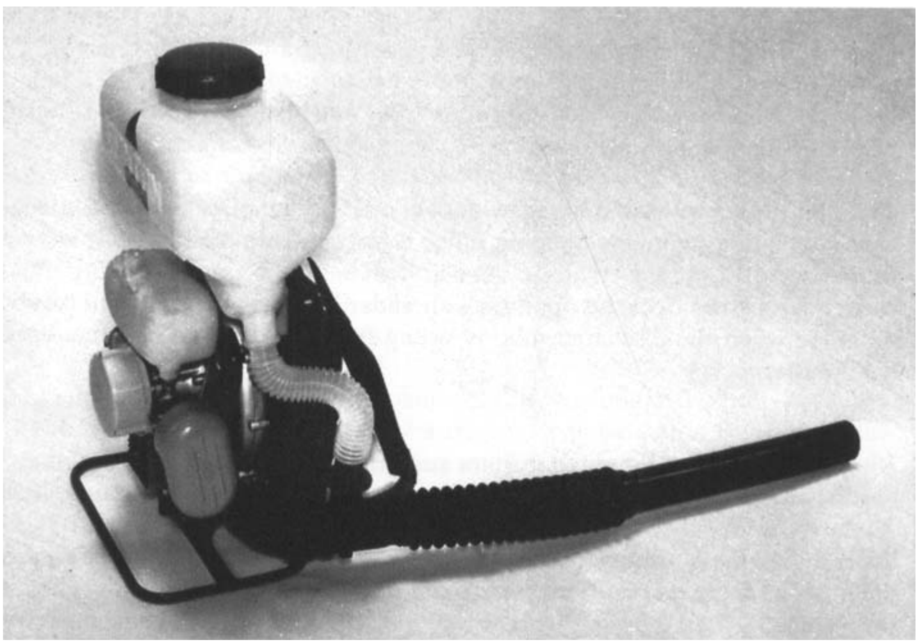
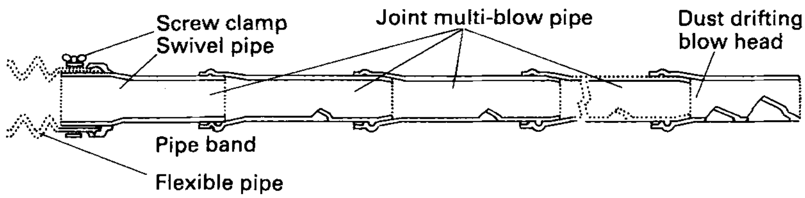


Fig. 12.5 Motorised mistblower converted to direct-air granule application.

Some knapsack equipment is made specifically for granule application with or without an airflow. Machines designed to apply granules by gravity only can sometimes be modified to spot-treat with a measured dose. A knapsack in which a cup is moved by a lever mechanism from the hopper outlet to the

(a)



(b)

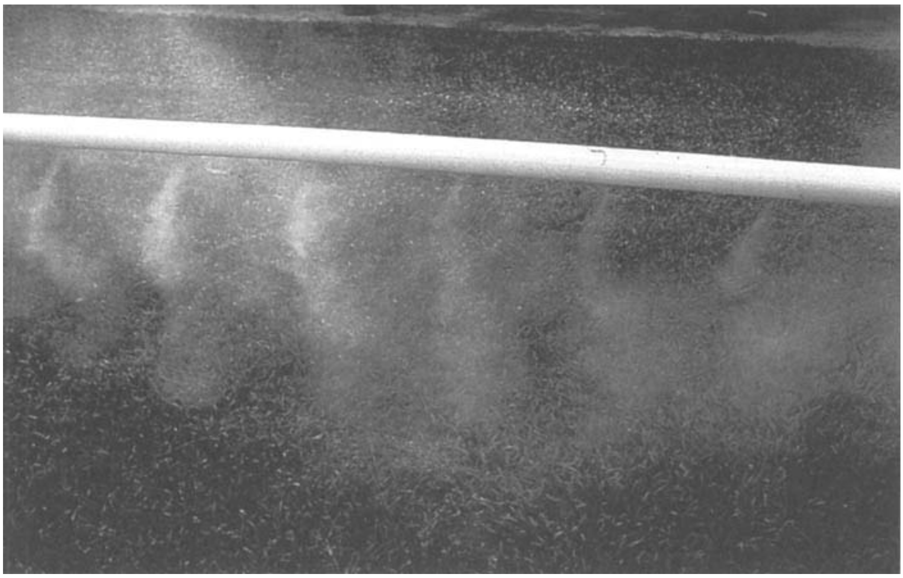


Fig. 12.6 Examples of extension tubes to apply microgranules: (a) detail of rigid tube; (b) flexible lay-flat tube inflated by the airstream applies microgranules over a 30 m swath.

discharge tube each time a dose is applied can be used for spot application on bananas.

Power dusters

Relatively few larger power-operated dusters are manufactured. Some are coupled to the p.t.o. of a tractor to operate a fan with an output of approximately 50 m^3/min. Units with an independent 3–5 hp engine are heavy (> 50 kg), but are sometimes mounted on a two-person stretcher to facilitate transport to areas inaccessible to vehicles. Such units have been used to apply fungicides, especially sulphur dust in vineyards, using machines with twin outlets. In rubber plantations, dust has been projected vertically to a height of up to 24 m under calm conditions.

Tractor-mounted granule applicators

A few machines have been designed with a boom fed from a single blower unit (Palmer, 1970). Some are adapted from fertiliser spreaders and have a spinner, but most have a series of separate units fixed on a horizontal frame (Fig. 12.7) which can be mounted either at the rear or front of a tractor. The containers of granules can now be fitted directly to the hoppers to avoid exposure of the user to the pesticide (Fig. 12.9). Normally, up to four units each with two outlets are used together, but wider booms are possible. Displacement rotors are ideally driven at 0–8 km/h from a rimless spoked land wheel designed to follow the ground contours accurately. A p.t.o. drive replaces the land wheel on high-clearance frames.

Fig. 12.7 'Microband' applicator (Horstine Farmery).

An airflow, provided by a compressor fan driven from the p.t.o. or by a hydraulic motor, increases precision when broadcasting as little as 3 kg/ha (Fig. 12.8). A deflector plate at the discharge tube outlet, if properly angled for a particular granule size and density (Goehlich, 1970), will spread granules over a swath up to 1–2 m wide. Thus an applicator with four hoppers each

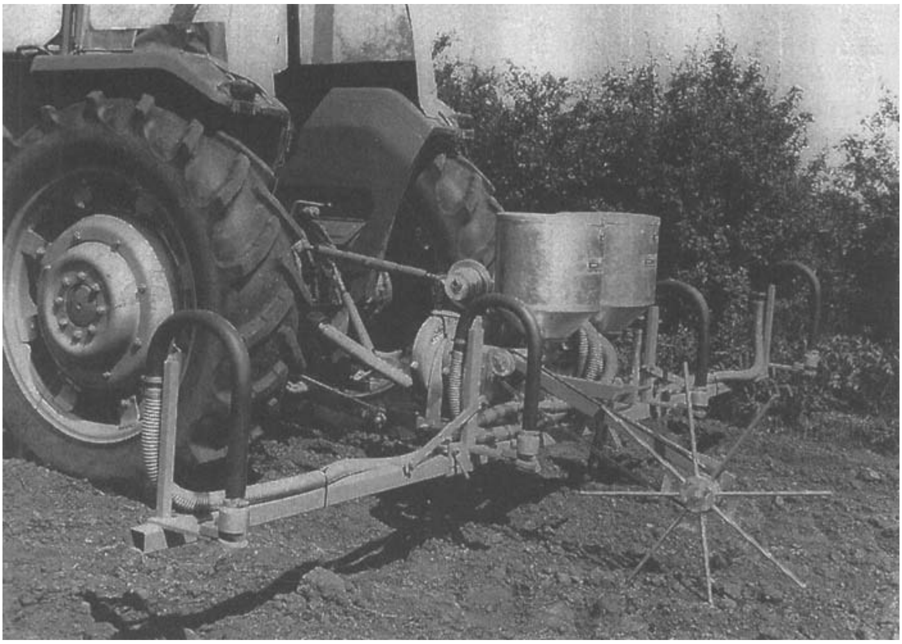


Fig. 12.8 Airflow granule applicator (Horstine Farmery).

Fig. 12.9 'Sure Fill' closed transfer of granules.

carrying up to 30 kg granules can treat up to 40 ha without refilling, and at 8 km/h cover the ground in under 6 h. Farmery (1970) discusses the problems of achieving an even air volume and speed with airflow applicators.

Applicators can be mounted on the tractor alongside seed drills, special coulters, fertiliser applicators and other farm implements, depending on where the granules are needed (Bailey, 1988; Pettifor, 1988). In the 'bow-wave' technique, granules are metered in a 100 mm band on the soil surface in front of a coulter which then mixes them in the soil (Whitehead, 1988). Dunning and Winder (1963) found that the bow-wave technique decreased phytotoxicity.

Some pesticides can be applied as granules placed as an in-seed furrow treatment at the time of sowing. The discharge tube can be positioned close to the coulter for accurate placement of the granules in relation to the seed. Wheatley (1972) studied placement and distribution on the performance of granular formulations of insecticides for carrot-fly control. He concluded that the performance of these granules could not be easily improved by minor modifications of the granule-placement equipment, provided an even distribution along the row is achieved. Granule-application criteria for certain pest-control problems are summarised in Table 12.5 (Wheatley, 1976).

Table 12.5 Dose required for control of cabbage root fly (after Wheatley, 1976)

Application method	Amount of granules	Particle distribution		Dose/plant	
		cm^2 soil/ granule	cm^3 soil/ granule	No. of granules	mg a.i.
Spot surface (15 cm dia.)	0.17–1 g/plant	0.08–0.6	–	340–2100	17–45
Band (5 × 10 cm deep)	0.7–1.2 g/m row	0.09–0.71	0.8–3.6	210–880	10
Broadcast					
surface	45 kg/ha	1.1	–	160	8
mixed to 5 cm depth	30 kg/ha	0.71	3.5	250	2.7

In contrast to 17–45 mg a.i./plant required with spot treatment against cabbage root fly, the dose can be reduced to 10 mg a.i./plant for banding treatments, and to as little as 2.7 mg a.i./plant when granules are broadcast and mixed to a depth of 5 cm. Against aphids, the amount per plant depends on the size of the plant, larger plants requiring a heavier dose to maintain a similar lethal concentration in the sap (Table 12.6). Side dressing of some insecticides is effective later in the season, especially if moisture is sufficient to redistribute the chemical.

A major problem with the development of ground equipment for granular

Table 12.6 Dose required for aphid control with granules on different crops (after Wheatley, 1976)

Crop	Crop density (plants/ha)	Treatment (amount of granules)	Dose/plant	
			Number of granules	mg a.i.
Carrot	500000	Band 7.5 cm × 1 cm (11–25 kg/ha)	32–160	1.1–2.5
Sugar beet	40000	Soil or foliage (5.6–11 kg/ha)	38–880	7–14
Brussels sprouts	10000	Soil or foliage (14–39 kg/ha)	3100–12000	33–190

application has been the lack of fundamental studies on particle distribution and the wide range of granule sizes available, since each manufacturer has sought the cheapest and most easily obtained supply of suitable base carriers. Sand is readily available, but is very abrasive. Heavy carriers are suitable for aerial application to reduce the risk of drift, and for soil application, but lighter and softer carriers such as the clay bentonite, are more suitable for rapid release of herbicides used in rice-weed control. A greater control of particle size within defined limits, namely controlled particle application, is possible with new coating systems.