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Low Volume Pesticide Application Systems for the Greenhouse

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Though high volume (HV) spraying is the most traditional method of applying pesticides in greenhouse and outdoor ornamentals production, it is generally thought to be inefficient for several reasons. There is a high variability of drop size with HV sprays. Due mainly to pesticide labelling, wasteful dosages are often applied. For example, the phrase "spray to run-off" or similar directions are given without regard to spray volume per crop area and means different things to different people. Most HV sprays are applied manually, so distribution will vary with the person making the application. Other problems include the time required to make the application, potential groundwater contamination from excessive run-off, and delayed re-entry into sprayed areas because of wet foliage. Despite these problems, HV, "wet" sprays are considered the best general purpose method of applying pesticides. Various equipment is widely available, relatively inexpensive, and remains the only legal way to apply many pesticides. Also, HV sprays are adaptable to IPM programs because they enable to grower to spot treat. Low volume methods, on the other hand, eliminate many of the disadvantages of conventional HV applications: They take less time, use less water or oil to dilute and carry the pesticide (no run off, faster re-entry), may use less pesticide, and they generate most of the spray volume in small drops.

Spray drop size is important in determining what kind of pesticide deposition and distribution there will be, no matter what the application method used. Often, the spray looks as if it's doing a great job of covering the target area, when, in fact, the spray drops are too large or small to deposit on the target. Most of the volume in HV sprays consist of large drops greater than 100 to 400 microns in diameter (100 micron average diameter particles = 1 mm). Low volume sprayers that produce a 10 micron average diameter particle will deposit an average of 19,000 particles or droplets in 1 cm^2. HV application would deposit only about 19 droplets in 1 cm^2. Small drops can increase pesticide deposition. A number of studies have shown that with certain insecticides, large numbers of small drops cause higher insect mortality than fewer, large drops.

Ready to use aerosols, sometimes called total release aerosols, can actually be considered pre-packaged LV sprayers. Aerosols are available from Whitmire Research Labs, Inc. and other companies for management of whiteflies and other pests. A one pound can be used to treat 3,000 square feet (of covered area) with spray drops approximately 15 microns in diameter. Aerosol technology lends itself well to smaller greenhouses where larger LV equipment would be impractical. Unfortunately, no fungicides are currently available as aerosols. Active ingredients recently formulated as aerosols include biphenthrin (Attain™ also known as the wettable powder, Talstar™), fenoxycarb (Prelude™), acephate (Orthene™), pyrethrum, resmethrin, and methiocarb. Whitmire Research Labs is developing a systemic aerosol from Miles now referred to as NTN.

Table 1 shows a comparison of the various low volume application equipment that is available. High pressure hydraulic sprayers have a similar design to conventional hydraulic sprayers, but they require a much smaller volume of water added to the chemical. The piston or diaphragm pump forces the chemical solution through the nozzle of a hand-held spray gun. The solution exits the nozzle tip at high pressure and produces an extremely fine spray with much smaller droplets than those created by conventional hydraulic sprayers working at 300 to 600 psi. Applications are made by walking through the area aiming the spray produced by a single nozzle ahead and down into the crop. A NC grower has noted that, though application technique is similar to that of HV, wet spraying, the applicator must walk much quicker because the stream is more concentrated. Results with coldfoggers have been mixed. If the pest or pathogen is able to be contacted from above, control has been quite good. Coverage on leaf undersides has been erratic, so pests such as spider mites and whitefly nymphs may not be controlled effectively. Deposition on leaf undersides depends on plant type and how easily leaves can be moved in the spray stream. Very flexible leaves are more likely to bend upward, exposing the leaf underside to the spray stream.

Electrostatic sprayers are similar to high pressure hydraulic sprayers but do not use a high pressure hydraulic pump. These machines produce a fine spray that is electrically charged to achieve better coverage of leaf surfaces and reduce spray drift. The negatively charged particles are attracted to any surface for providing coverage similar, theoretically, to high pressure hydraulic spraying with slightly better deposition on leaf undersides. Air-assisted sprayers, having compressed air supplied to the wand, air-blast the spray onto the crop and are more effective. The only air-assisted electrostatic sprayers now on the market in the United States are produced by ESS - Electrostatic Spraying Systems. Both unattended (similar to mechanical aerosol generators) and hand-held, backpack models are available.

Problems include a "plant position" effect; in other words, deposition is greater and pest control often better on plants nearest the spray nozzle. Studies have shown increased spray deposition on plants using electrostatic sprays, compared to other LV and HV sprays. However, most of this increase appears to be on upper surfaces of leaves near the tops of plants. Thus, despite advances in electrostatic spray technology, distribution within the plant canopy is still uneven. This will vary with the pesticide, crop, spray volume, and person making the application. Some of this variation can be reduced with proper application techniques. Deposition on leaf undersides can be increased and foliage canopy penetration improved by increasing the spray volume. At the higher spray volumes, the time required to make an application may not be much less than that for HV sprays over the same area. However, because the foliage isn't wetted to run-off by the sprays, re-entry can be made right after the greenhouse is properly ventilated.

Thermal pulse-jet foggers use a pulsing jet engine to produce a highly visible fog that can

Table 1. Comparison of low volume spray application equipment.

Type:	High pressure hydraulic	Air-assisted electrostatic	Thermal pulse-jet fogger	Rotary mist applicator	Mechanical aerosol generator	
Example:	Dramm Coldfogger™	ESS Back Pack	Motan Swingfog™ 50	Turbair Fox	Dramm Autofog™ LVH	Dramm Autofog™ SLVH
Spray drop average diameter (microns)	30	40	0.5–50	70–90	0.5–15	0.5–15
Operating pressure (psi)	2800–3000	40–50	4.4–5.9	--------	18.5–28.5	14.2–22.8
Solution tank capacity	12 gal.	2.5 or 4 gal.	1.7 gal.	1 quart	3.7 gal.	1.85 gal.
Flow rate (gal./hour)	0–20	4	3.7–7.1*	1	0.87	0.71
Dispersal (gal./acre)	14.5 max.	4–12	2.5–4.5**	0.5	2.5–6***	0.5–1.1****
Time to treat 100,000 square feet (hours)	1.5–2	2–9	0.5–1	1.5	several***	several****
Formulations that can be applied	Liquids, wettable powders	Liquids, wettable powders	Liquids, wettable powders	Liquids	Liquids, wettable powders	Liquids, wettable powders
Price	$3,200	$1,685	$1,700	$990	$5,000	$4,200
Advantages	•Space sprayer, operates unattended •Spray settles out of the air rapidly; allows prompt re-entry	•Can be used in small houses and to spot treat (20 ft. distance) •Deposition on leaf undersides is above average •Small spray volume and rapid drying allows prompt re-entry	•Provides fastest coverage for large areas (eg. gutter-connected range) •No need for carrier if using water nozzle	•Can be used in small houses and to spot treat (6–15 ft. distance)	•Space sprayer, operates unattended •Deposition on undersides of leaves is above average •Most models have built-in tank agitators and automatic water rinse cycles for easy cleaning	
Disadvantages	•Coverage on leaf undersides is sometimes erratic	•Can encounter a "plant position effect" •Coverage is variable; human applicator effects can cause uneveness is delivery	•Carrier solution may be required by manufacturer •Can encounter a "plant position effect" •Deposition on undersides of leaves slightly less than average	•Few pesticides (eg. Rotospray Resmethrin™) are registered for use •Fan may blow plants over at labelled application distance •Not available from U.S. distributors	•Gummy residue (highly concentrated) can collect on all treated surfaces, including greenhouse structure •Have set maximum coverage areas that cannot be exceeded without reducing effectiveness (see *** and ****)	

*Flow rate varies with nozzle used with the thermal pulse-jet fogger.
**Rate of dispersal varies with nozzle used with the thermal pulse-jet fogger.
***LVH model has a maximum coverage area of 70,000 square feet.
****SLVH model has a maximum coverage area of 25,000 square feet.

stay suspended in the air for up to six hours. Inside the fogger, a gasoline and air mixture explodes in the enclosed resonator, and the explosion rushes out as a jet stream. The chemical solution is injected into the jet stream and is blown apart into billions of tiny particles. These very small drops are able to move long distances from the applicator. With some of the larger units available, drops can travel more than 200 feet. The size of the machine also determines the flow rate of the liquid. Two-and-a-half gallons will cover about 50,000 square feet with a wettable powder and 76,000 square feet with a liquid formulation. Specialized carrier solutions produce a visible fog, eliminate the evaporation of the chemical and ensure uniform particle size. Many manufacturers now provide special water nozzles that eliminate the need for carrier solutions; using water solutions results in less fogging action.

When using foggers to apply residual pesticides, especially wettable powder formulations, it is very important to aim the spray above the plants at about a 30 degree angle. If this is not done, heavy deposition in areas immediately in front of the fogger will result, causing excessive dosage and plant injury. However, when applied from above the crop, the pesticide distribution within the plant canopy and on leaf undersides may be poor. Thus, as with coldfoggers, using thermal pulse-jet applicators with certain pesticide/pest combinations most likely will not be successful. It may be feasible for growers who have expanded metal greenhouse benches to make applications from below the crop, allowing the fog to rise up through the plant canopy. Those who have used this technique report good results.

Rotary mist applicators, originally called controlled droplet applicators (CDA) or rotary atomizers, are not widely available for use in greenhouses in the United States. The type of applicator most widely-used worldwide in greenhouses is the Turbair System. These are portable sprayers that disperse pesticides by directing the flow onto rapidly spinning, notched discs. A fan behind the disc propels the spray toward the target, creating a turbulent air stream. The time to treat a given area will vary with the crop. Workers carry the sprayers through the crop with a walking speed of one pace per second. The spray is aimed ahead about 10 feet, directed at the plants, and moved up and down to ensure proper coverage. Obviously, bedding plants can be treated more rapidly than cut roses, which have much more vertical growth requiring more up and down passes. Pesticide deposition and distribution is quite good. However, foliage canopy penetration and leaf underside coverage varies significantly, depending upon crop type such as roses, bench-grown potted plants or bedding plants on the floor. Most pesticides applied in rotary mist applicators are specially formulated for this use. Only one of these pesticides, Rotospray Resmethrin™, is currently registered for use with this equipment in the United States. Some growers have had success with their own mixtures which they have calibrated to ensure the correct dosage. Any pesticide registered for application as a concentrate spray can be used in rotary mist applicators.

Mechanical aerosol generators, sometimes referred to as ultra-low volume (ULV) sprayers, use pressure supplied by an air compressor to pump air through an air atomizing nozzle that breaks up the spray liquid into super-fine, fog-sized drops. Air is also the method of moving the spray around the greenhouse and onto the foliage. On most large models, a built-in convection fan helps propel the spray drops and circulates air in the greenhouse to disperse the fog, and a timer allows machines to treat large gutter-connected ranges without an operator present. Smaller models are also automatic, but do not have a convection fan. With all of the aerosol generators, much of the spray movement is accomplished by the greenhouse air movement system, i.e. horizontal air flow, overhead convection tubes, and turbulator fans; run these when aerosol generators are used.

Many growers find that integrating two or more types of sprayers is the ideal. A popular combination is a thermal fogger and a high pressure or conventional hydraulic sprayer. The thermal fogger provides fast, broad coverage and the hydraulic sprayer affords easy spot treatment. The specific kind of low-volume sprayer chosen will depend on many factors, including greenhouse size, whether the operation includes many separate houses or one large, interconnected range, and the crops produced. For example, you may have a greenhouse where total release aerosols will be most practical. Others may have a very large, open greenhouse that requires thermal foggers or aerosol generators for best results.

Low volume applications have the potential to significantly reduce the amount of pesticide applied while maintaining good pest control. The basic facts, however, are that technology is well ahead of legality in many cases. Any application method not prohibited on the label can be employed to apply a given pesticide. However, if a specific dilution (for example, 1 pound per 100 gallons) is required, this effectively prevents low-volume applications, which must be made at very high concentrations (10 to 25 times greater than HV sprays) to be effective. Most labels are written in this restrictive way, but changes are occurring. Some pesticide companies are modifying their product labels to allow for low volume application.