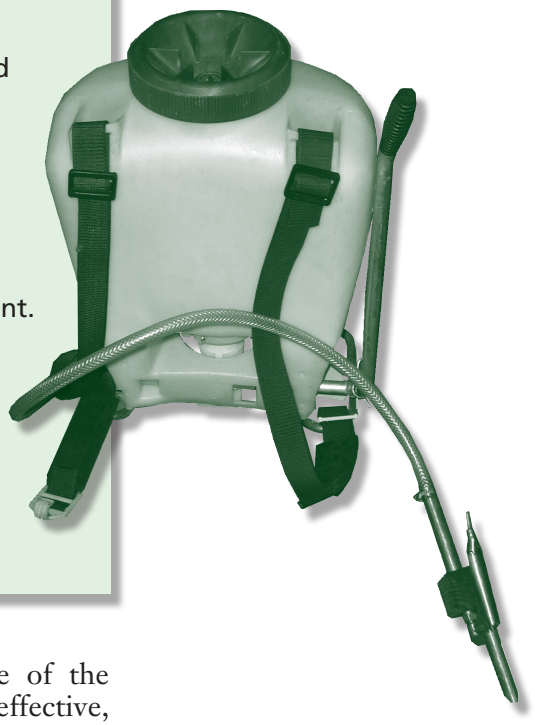
CHAPTER 11

PESTICIDE APPLICATION PROCEDURES

LEARNING OBJECTIVES

After studying this chapter, you should:

- Know how to select the application procedure, equipment, and pesticide formulation appropriate to the situation.
- Know how to use appropriate safety systems (e.g., closed mixing and loading, enclosed cab, pesticide containment).
- Understand the factors (e.g., nozzles, volumes, pressures) that affect calibration.
- Understand the importance of calibrating application equipment.
- Know how to calculate the size of the application area.
- Know how to determine the pesticide application rate.
- Know how to determine the amount of pesticide concentrate and diluent to use.
- Know how to choose appropriate drift reduction practices.

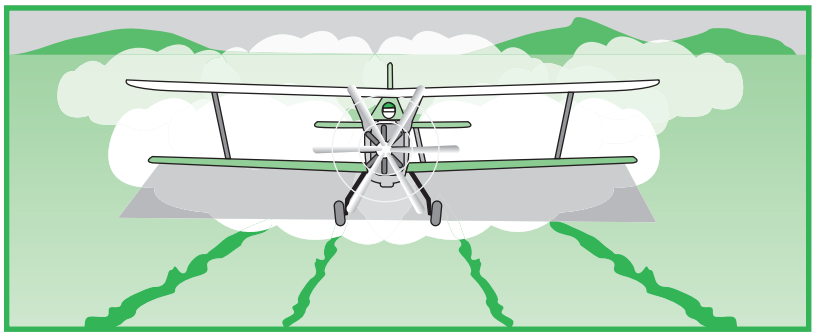


Today's pest management practices require modern equipment to apply a variety of pesticides. Pesticides may be applied as sprays, dusts, granules, gases (vapors), fogs, baits, rubs, or dips. The vast array of equipment on the market must be matched to the pesticide as well as to the size and type of the job to be done. To make an effective, safe, and efficient application, ***read the label first.*** In addition, the equipment must be properly selected, operated, calibrated, and maintained.

APPLICATION METHODS

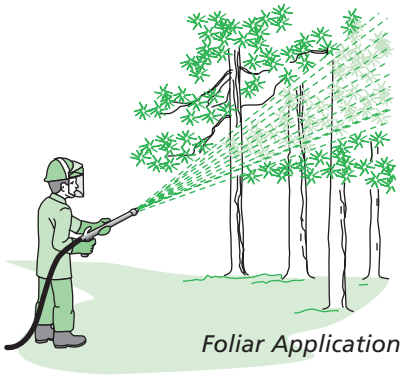
The pesticide application method you choose depends on the nature and habits of the target pest, the characteristics of the target site, the properties of the pesticide, the suitability of the application equipment, and the cost and efficiency of alternative methods. Your choice is often predetermined by one or more of these factors. Following are some common application methods.

Band application involves applying a pesticide in parallel strips or bands such as between rows of crops rather than uniformly over the entire field.



Broadcast application

Crack and crevice application



Foliar Application

Basal application directs herbicides to the lower portions of brush or small trees to control vegetation.

Broadcast application is the uniform application of a pesticide to an entire area or field.

Crack and crevice application is the placement of small amounts of pesticide into cracks and crevices in buildings, such as along baseboards and in cabinets, where insects or other pests commonly hide or enter a structure.

Directed-spray application specifically targets the pests to minimize pesticide contact with non-target plants and animals.

Foliar application directs pesticide to the leafy portions of a plant.

Rope-wick or wiper treatments release pesticides onto a device that is wiped onto weeds taller than the crop, or wiped selectively onto individual weeds in an ornamental planting bed.

Soil application places pesticide directly on or in the soil rather than on a growing plant.

Soil incorporation is the use of tillage, rainfall, or irrigation equipment to move the pesticide into the soil.

Soil injection is the application of a pesticide under pressure beneath the soil surface.

Space treatment is the application of a pesticide in an enclosed area.

Spot treatment is the application of a pesticide to small, distinct areas.

Tree injection is the application of pesticides under the bark of trees.

SAFETY SYSTEMS

Closed systems...

- Increase handler safety.
- Reduce the need for some personal protective equipment.
- Decrease the occurrence of spills.
- Provide a more accurate measurement of pesticide concentrate, which reduces overdosing or underdosing.

Closed mixing and loading systems, enclosed application systems, and pesticide containment systems are excellent investments for pesticide handlers who handle large quantities of pesticides or handle pesticides that are very hazardous to humans or to the environment. These systems may be required for certain pesticides or for pesticide use in or near sensitive areas.

Closed Mixing and Loading Systems

Closed mixing and loading systems are designed to prevent pesticides from coming in contact with handlers or other persons during mixing and loading. The labeling of some pesticides, usually products with a high risk of causing human health effects, may require the use of a closed mixing and loading system.

There are two primary types of closed mixing and loading systems. One type uses mechanical devices to deliver the pesticide from the container to the equipment. The other type uses water-soluble packaging.

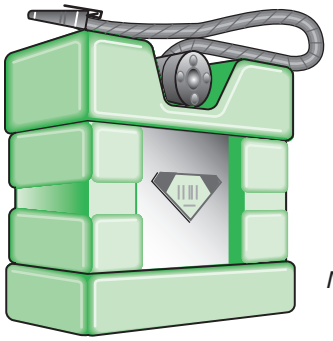
Mechanical Systems

Mechanical systems often consist of a series of interconnected equipment parts that allow for the safe removal of a pesticide from its original container. These systems minimize exposure when rinsing the empty container and transferring the pesticide and rinsate to the application equipment.

Closed mixing and loading systems are often custom-made with

components from several commercial sources. Because pesticide container openings vary in shape and size, no single closed system can be used with all containers. Closed systems are available for containers as small as 2.5 gallons. Mechanical systems are now available to remove the pesticide concentrate from the original container either by gravity or by suction.

A mechanical loading system is often used with **mini-bulk containers.** Mini-bulk containers range in volume from 40 to 600 gallons and are adapted to closed systems. The applicator can use the closed system to attach the mini-bulk tanks to the sprayer without exposure to the chemical. Typically, pump and drive units deliver the product, and a meter allows accurate measuring from the mini-bulk tank to the sprayer. These meters require frequent calibration to be accurate. Mini-bulks must be returned to the dealer for refilling. This process eliminates the need to triple- or pressure-rinse multiple small containers and reduces the volume of used plastic containers.



Mini-bulk tank.

Jack Kelly Clark, Univ. of California Statewide IPM Program

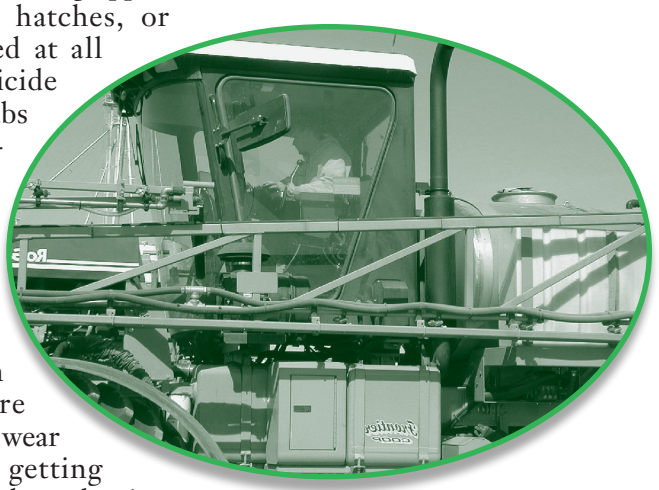
A closed loading system.

Water-soluble Packaging

Water-soluble bags are a simple type of closed mixing and loading system. The premeasured pesticide is contained inside a water-soluble bag or package. The pesticide bag is placed unopened into the mixing tank and dissolves in water or liquid fertilizer. Few manufacturers, however, provide water-soluble bags for small-volume applications.

Enclosed Cabs

An **enclosed cab**—such as a tractor cab, cockpit, or truck/vehicle cab—surrounds the occupant(s) and may prevent exposure to the pesticides being applied as long as any doors, hatches, or windows are kept closed at all times during the pesticide application. Enclosed cabs are considered a supplement to PPE, not a replacement for it. Wear all PPE specified on the label while working inside the enclosed cab. Remember, outside surfaces of the application equipment and cab are contaminated. Be sure to wear appropriate PPE when getting in and out of the cab and conducting maintenance.



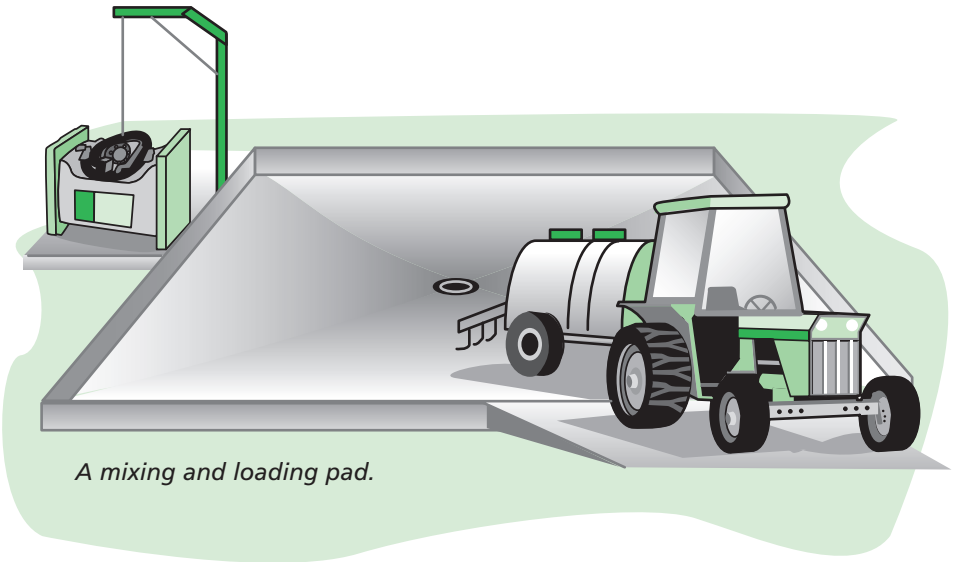
Larry Schulze, University of Nebraska

Enclosed cabs are considered a supplement to PPE, not a replacement for it.

Pesticide Containment Systems

If you often use the same location to mix and load pesticides or clean equipment, **a pesticide containment pad** may be necessary. These pads are designed to contain spills, leaks, overflows, and waste water for reuse by the applicator, or disposal by a commercial waste management contractor. If the spray tank contains pesticides, keep it on the pad. These pads make spills easier to clean up, and they may reduce pesticide waste by allowing the rinse water to be reused. They also help prevent environmental contamination.

Use a permanently installed containment pad for mixing, loading, and equipment cleaning; where large quantities of pesticides are handled or stored; and where large equipment is cleaned. The containment pad must be made of an impermeable material such as sealed concrete, glazed ceramic tile, welded steel, synthetic liners,



A mixing and loading pad.

or no-wax sheeting. Construct a concave pad or one having curbs, berms, or walls high enough to hold the largest amount of spill, leak, or equipment wash water likely to occur at the site. It also must be equipped with a system for removing and recovering spilled, leaked, or released material by either an automatic sump system or a manually operated pump. Smaller portable pads and lightweight trays made of heavy duty plastic may be used when mixing and loading at the application site.

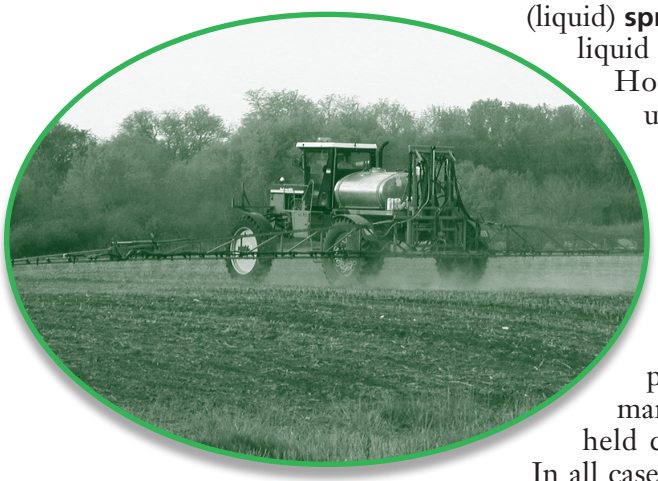
APPLICATION EQUIPMENT

The application equipment or device must apply the pesticide to the intended target at the proper rate. Information on the label specifies the legal application rate and sometimes suggests the appropriate equipment for use with the product. The application equipment can range from an aerosol can to hand equipment to power equipment, including aircraft. The equipment may be carried, towed, or self-propelled.

Sprayers

The most common type of pesticide application equipment is the sprayer—nearly 90 percent of all pesticides are formulated for spraying. A **hydraulic** (liquid) **sprayer** uses water or other liquid carrier for the pesticide. However, in the case of ultra-low volume (ULV) spraying the pesticide is applied directly as formulated. Hydraulic sprayers range from large agricultural sprayers with multiple-nozzle **spray booms** and power sprayers to small manual backpack and hand-held compressed-air sprayers. In all cases, pressure from either a pump or compressed gas or air is used to atomize the spray mix at the nozzle.

Manual sprayers are designed for spot treatments and for areas unsuitable for larger units. They are relatively inexpensive, simple to operate, maneuverable, and easy to clean and store. Adjustable spray guns are commonly used with these units, but spray booms are available on some models.



Larry Schulze, University of Nebraska

A hydraulic sprayer with a spray boom.

Larry Schulze, University of Nebraska

A backpack sprayer is a type of hydraulic sprayer.

The **air-blast** (or mist) **sprayer** uses both water and air as carriers. The pesticide is diluted with water (except in ULV spraying). Spray droplets are formed by the nozzles and delivered to the target by an air stream. Air-blast

sprayers are typically used for disease and insect control on fruit trees, vineyards, vegetables, and Christmas trees.

M.J. Weaver, Virginia Tech Pesticide Programs

An air blast sprayer uses both water and air as carriers.

Sprayer Components

Because sprayers use water or other liquids to dilute and carry a pesticide, a **tank** is necessary to contain the spray mix. Use a tank large enough to eliminate frequent refills but not so large that the weight of the full tank becomes a problem. Choose a tank made of or coated with a material that does not corrode and can be easily cleaned. Corrosion and dirt clog screens and nozzles and increase wear on the equipment. Large tanks require an opening in the bottom to aid in the cleaning and draining. A large top opening is useful for filling, cleaning, and inspecting the tank. The opening must have a watertight cover to prevent spillage. A tank **agitator** is useful for most sprayable formulations but especially for wettable powders or dry flowables. Constant mixing of a pesticide and liquid carrier produces a uniform spray mixture (suspension or solution) resulting in an even application of the chemical.

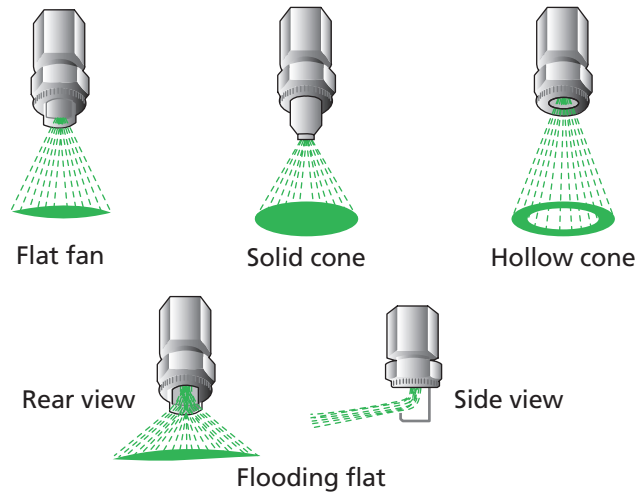
B. Hines, Michigan State University

A large capacity spray tank.

Sprayers require a **pump** to supply the needed pressure and volume to the nozzles and agitator. The pump parts must resist corrosion and be abrasion-resistant, especially when wettable powders or other abrasive formulations are used. Never operate a sprayer pump at speeds or pressures above those recommended by the manufacturer. Some pumps can be damaged if they are operated dry or with a restricted flow at the inlet or outlet. Pumps depend on the spray liquid for lubrication and to prevent overheating.

Nozzles are a very important part of a sprayer. They control the amount of material applied, the formation of the droplets and their size, and the distribution and pattern of the droplets. A nozzle's spray pattern is made up of a wide variety of spray droplet sizes, from very fine to extra coarse. Nozzles are classified on the basis of the spray pattern and the droplet size they produce (see Figure 11.1). The size of the nozzle opening (**orifice**) affects the droplet size and flow rate. A nozzle that primarily produces coarse droplets is usually selected to minimize off-target

Figure 11.1 Nozzle Spray Patterns

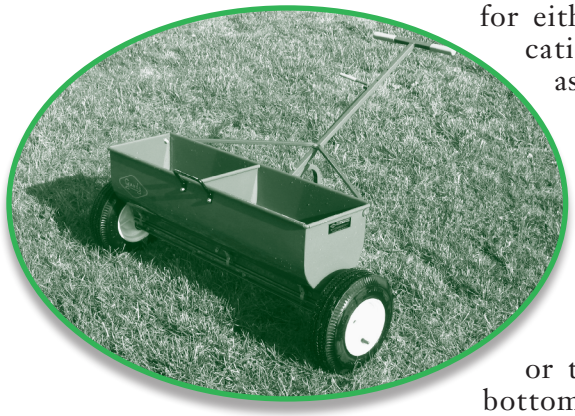


drift. A nozzle that mainly produces fine droplets is required to obtain maximum surface coverage of the target. Base nozzle selection on the target pest, type of application, coverage desired, and potential for drift.

Nozzles are available in various materials including brass, aluminum,

Bob Wolf, Kansas State University

A rotary spreader.



Bob Wolf, Kansas State University

A drop spreader.

plastic, stainless steel, hardened stainless steel, and ceramic. Select the nozzle material appropriate for the pesticide formulation. Never use brass or aluminum tips to apply abrasive materials such as wettable powders and dry flowables, because they wear too fast. Wear destroys the proper working of a nozzle, so replace worn nozzles. To reduce wear, use nozzle tips made of a hard, wear-resistant material such as hardened stainless steel or ceramic. Nozzles made of these materials are more expensive but last longer. Also, be sure you have the correct nozzle screen size for each nozzle.

Granular Applicators

Granular applicators are available for either band or broadcast application. They may be operated as separate units but are often attached to other equipment such as planters or cultivating equipment to combine two or more operations. They usually operate by gravity feed and have an adjustable opening to regulate the flow.

Band applicators use hoses or tubes with deflectors on the bottom. Broadcast applicators use a system of tubes and deflectors or a spinner to spread the granules. The application rate is affected by the ground speed; granule size, shape, and density; field terrain; and even relative humidity and air temperature. When multiple band applicators are used, each individual unit must be calibrated with the specific material to be applied to ensure accurate application.

Rotary and **drop spreaders** are two common types of granular applicators. Rotary spreaders distribute the granules to the front and sides of the spreader, usually by means of a spinning disk or fan. In a drop spreader, an adjustable sliding gate opens holes in the bottom of the hopper and the granules flow out by gravity feed. Drop spreaders are preferred over rotary spreaders when more precise placement of the pesticide is desired.

Other Application Equipment

Additional types of application equipment include:

- Rubs, walk-through sprayers, and dipping vats for controlling pests on animals.
- Bait dispensers for control of rodents, insects, and predators.
- Foggers for indoor pest control and for some insect control outdoors.
- Chemigation systems for greenhouses and field crops.
- Dusters for small-scale disease and insect control.

Jack Kelly Clark, University of California Statewide IPM Program

Rubs are used for applying pesticides to livestock.

Jack Kelly Clark, University of California Statewide IPM Program

Dusters are used to apply dusts in confined areas.

EQUIPMENT CALIBRATION

Calibration is the process of measuring and adjusting the amount of pesticide your equipment applies or delivers to a specific area. The purpose of calibration is to ensure your equipment is applying the correct amount of material uniformly over a given area.

Equipment is manufactured to be adjustable. Charts or tables may be provided to assist the operator in making adjustments to the settings. These recommended settings, however, are only approximate and may not be appropriate for all situations. Therefore, your equipment must be calibrated periodically. This depends on the type of equipment and the frequency of use. The application rate of the sprayer is affected by travel speed, nozzle size, and sprayer pressure.

Equipment is calibrated by making a trial run on some premeasured area and measuring the output. For example, using a hand-held sprayer, spray a premeasured test area with water using the same pressure and techniques (i.e., travel speed and equipment) you would use when applying the pesticide. After spraying the test area, determine how much water was used. This volume can then be used to calculate the amount of water and pesticide needed to cover the intended application area.

The time invested in calibrating your equipment is time well spent. Accurate calibration to determine the application rate under your operating conditions is important for cost, efficiency, and safety.

M.J. Weaver, Virginia Tech Pesticide Programs

Calibrating a backpack sprayer.

Why Calibrate?

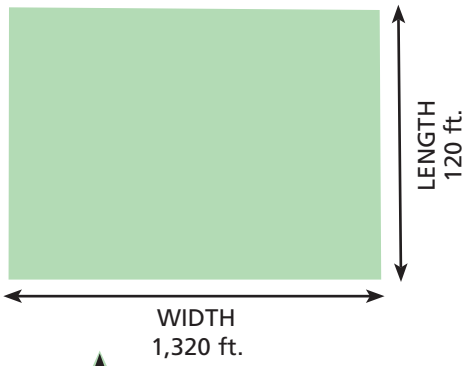
The purpose of calibration is to ensure that your equipment is applying the correct amount of pesticide material uniformly over a given area. Too little pesticide may fail to control the target pest. Too much pesticide is illegal and can result in damage to the treated plant, animal, or surface; can produce illegal residues on treated crops and animals; and can cause adverse effects to the environment and non-target organisms.

CALCULATING AREAS

For precise application, you need to know the size of the area to be treated. The following examples show how to determine the size of rectangular, triangular, and circular areas. See Appendix C—Conversions and Calculations.

Rectangular Areas

You want to apply a pesticide to an area that measures 1,320 feet by 120 feet. What is the area in square feet and in acres?



Area = length x width

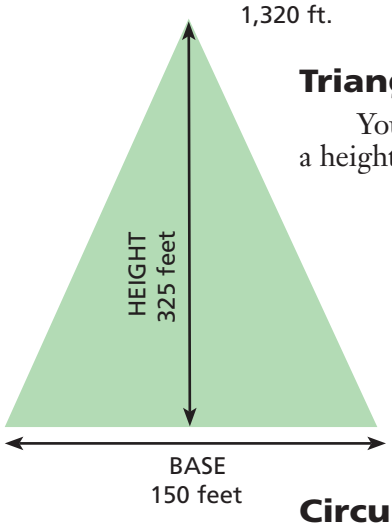
Area in square feet (sq. ft.)
1,320 ft. x 120 ft. = 158,400 sq. ft.

$$\text{Area in acres (A)} = \frac{158{,}400 \text{ sq. ft.}}{43{,}560 \text{ sq. ft./A}} = 3.6 \text{ A}$$

Note: 1 acre (A) = 43,560 sq. ft.

Triangular Areas

You are applying a pesticide to a triangular area that has a base of 325 feet and a height of 150 feet. What is the area?



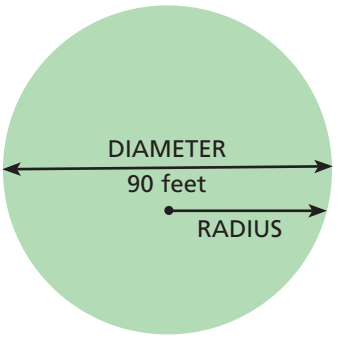
$$\text{Area} = \frac{\text{base x height}}{2}$$

$$\text{Area in square feet} = \frac{325 \text{ ft. x } 150 \text{ ft.}}{2} = 24{,}375 \text{ sq. ft.}$$

$$\text{Area in acres} = \frac{24{,}375 \text{ sq. ft.}}{43{,}560 \text{ sq. ft./A}} = 0.6 \text{ A}$$

Circular Areas

If you have a circular area that has a 90-foot diameter, the radius (r) is 45 ft., what is the area?



Area = $3.14r^2$ ***Note:*** 3.14 (π) is a constant. Radius is 1/2 diameter.

Area in square feet =

$3.14 \times 45^2 = 6{,}358.5$ sq. ft.

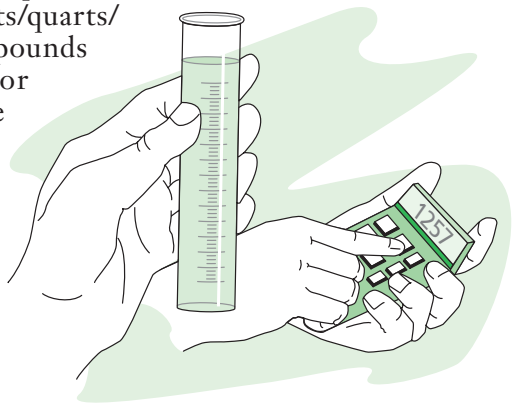
$$\text{Area in acres} = \frac{6{,}358.5 \text{ sq. ft.}}{43{,}560 \text{ sq. ft./A}} = 0.15 \text{ A}$$

CALCULATING THE APPLICATION RATE

Use the volume from your calibration test area to determine the amount of pesticide product and total spray mixture needed for your application area. First, convert your calibrated rate to one based on the area units found on the label. For example, when you calibrated the sprayer it delivered 2 gallons of water over a 250-square-foot test area. But you need to cover a 1,000-square-foot application area (i.e., four times the test area). You would then multiply 2 gallons of water by 4 to determine that you need to use 8 gallons of spray mixture to cover 1,000 square feet. Check the pesticide

label to determine the amount of pesticide to add to the spray mixture. For example, if the label recommends that 4 ounces of a liquid pesticide product be added to give a desired finished spray mixture of 1 gallon (there are 128 fluid ounces in 1 gallon), you add 4 ounces of product to 124 ounces of water. If you needed to apply a total of 8 gallons of spray mixture to cover 1,000 square feet, then you must use a total of 32 ounces (8 times 4 ounces) of pesticide product to 7¾ gallons of water. If the tank capacity of the sprayer is 4 gallons, then you need to fill up the tank twice, using 16 fluid ounces of product each time.

Labels vary how they recommend pesticide application rates. Some examples include ounces of product per 1,000 square feet, pints/quarts/gallons per 100 gallons, pounds of product per acre, or percent product in the tank. Be sure you understand how to calculate the correct amount of pesticide product and diluent needed before making the final mixture.



Calculate the application rate and measure the amount of pesticide needed.

Calculating the Application Rate

You determined from a calibration test that your boom sprayer delivered 10 gallons of water over a one-quarter (0.25) acre test area. You need to apply a pesticide product to a 10-acre field (43,560 square feet = 1 acre). The pesticide label recommends that 4 ounces of liquid product be added to give a desired finished spray mixture of 1 gallon (there are 128 fluid ounces in 1 gallon). How much spray volume and how much product are needed?

Step 1. How much spray mixture is needed for the 10-acre application area? Always use information from the calibration test. In this example, 10 gallons of water was used over a 0.25-acre calibration test area.

$$\frac{10 \text{ gallons}}{0.25 \text{ acre}} = \frac{Y \text{ gallons}}{10 \text{ acres}}$$

Cross multiplication:

$$Y = \frac{(10 \text{ gallons} \times 10 \text{ acres})}{0.25 \text{ acre}} = 400 \text{ gallons of spray mixture needed}$$

Step. 2. How much pesticide product is needed to make up 400 gallons of spray mixture? Use the label rate of 4 oz. product per 1 gal. spray.

400 gallons spray mixture x 4 ounces of liquid pesticide product per gallon = 1,600 ounces of product needed

Step 3. How many gallons of product are needed? Remember, 128 ounces = 1 gallon.

$$\frac{1{,}600 \text{ ounces of product}}{128 \text{ ounces/gallon}} = 12.5 \text{ gallons of product}$$

Final result: To treat 10 acres, you need a total final spray mix of 400 gallons that includes 12.5 gallons of the concentrated product.

TECHNIQUES FOR MINIMIZING DRIFT

Spray drift removes the chemical from the target, depositing the chemical where it is not intended. Application techniques and the equipment used greatly influence the amount of spray drift that occurs. Applicators must evaluate how their equipment is set up because off-target movement is affected by the type of nozzle, nozzle orifice size, sprayer pressure, and the height or distance of the nozzles from the target. It is important to review the pesticide label for specific information on drift reduction techniques or requirements. The applicator must also check weather conditions such as air stability, wind direction, and speed at the time and place of the application and follow all weather-related restrictions on the label.

Bob Wolf, Kansas State University

A wind meter is useful for determining when to spray.

Of the many nozzle types available for applying pesticides, several are specifically designed for reducing drift. Whenever practical, use large capacity (larger orifice) nozzles to minimize drift. The applicator uses the nozzle manufacturer's product guide to determine which nozzle and pressure combinations produce the desired range of spray droplet sizes. Select nozzles to give the largest droplet size that provides adequate coverage at the intended application rate and pressure.

In addition to the size of the nozzle orifice, newer features in nozzle design aid in drift reduction. Some new nozzle designs incorporate air into the spray to form an air-fluid mix. These air-induction nozzles, known as venturi nozzles, form a larger spray droplet, produce fewer fine particles, and provide energy to help transport the droplets to the target. These nozzles, however, require higher spray pressures (40 to 100 psi) to be effective. Even at these higher pressures, venturi nozzles still dramatically reduce the potential for drift.

Operating pressure also affects the droplet size and output volume of the sprayer. Doubling the pressure does not double the flow rate. To double the flow rate, you must increase the pressure four times. Pressure cannot be used to make major changes in application rate, but it can be used to correct minor changes because of nozzle wear. To obtain a uniform spray pattern and to minimize drift, keep the operating pressure within the recommended range for each nozzle tip. Exceeding the recommended pressure range often results in more drift potential. To maintain a proper spray pattern, adjust nozzles according to the manufacturer's recommendations on nozzle spacing and spray angle.

Pat Hipkins, Virginia Tech Pesticide Programs

A demonstration of a method to determine the uniformity of a nozzle spray pattern.

Spray height or distance from the target site is also an important factor in reducing drift. The closer the boom or spray nozzle is kept to the ground or target site, the less chance for drift; however, watch for pattern uniformity. For airblast sprayers, reduce drift by minimizing spraying over the canopy top, using the minimum air speed that can still give good penetration into the canopy, and considering the use of tower sprayers.

Another tool available for minimizing drift is the use of drift control additives. Tests indicate that the use of some drift control additives reduce

downwind drift deposits by 50 to 80 percent. Drift control additives are a specific type of chemical adjuvant. They must be mixed and applied according to label directions to be effective. Research, however, has shown that some products intended to reduce drift, in fact, result in more drift potential. Thoroughly evaluate drift control additives before adopting full use.

Using approved application techniques and adopting new technologies designed to reduce spray drift can improve the performance of spray mixes, benefit the environment, and be more cost-effective. Any one practice used alone may not sufficiently reduce drift. Therefore, incorporate as many drift-reduction techniques as practical into your spray program (Table 11.1).

Table 11.1. Recommended Techniques for Reducing Drift

Recommended Technique	Explanation
Follow label directions for reducing drift.	Read the label and reference the nozzle manufacturer's guide to determine which nozzle and pressure combinations are needed.
Select a nozzle to increase droplet size.	Large droplets are less prone to drift. Use the largest droplets that provide necessary coverage.
Increase nozzle size resulting in higher application volumes.	Larger capacity nozzles can reduce the amount of spray deposited off-target.
Consider using new technologies.	Drift-reduction nozzles (e.g., air-induction, venturi nozzles).
Lower boom height.	The higher the boom height is above the target, the greater the potential for drift. Lowering the boom height a few inches can reduce off-target drift.
Maintain appropriate travel speed.	High travel speeds may result in an unstable boom, high boom positions and increased drift potential.
Keep nozzle close to the target.	When using hand-held equipment, keeping the nozzle close reduces the potential for drift.
Avoid high application ground speeds or major speed changes across the field.	Speed changes may result in pressure adjustments causing droplet size variability. Sudden increases in speed may create high pressure that results in more drift potential.
Avoid applications during times of high wind speeds.	More of the spray volume moves off-target as wind increases. Wind currents can drastically affect spray droplet deposition.
Do not spray in the presence of a temperature inversion.	Temperature inversions prevent the dissipation of spray particles.
Consider using buffer zones/no-spray zones near sensitive areas.	Leave a buffer zone/no-spray zone if sensitive areas are downwind.
Use a drift-control additive when needed.	Drift-control additives increase the average droplet size produced by the nozzles. These additives, must not become your only drift reducing technique. They do not make up for poor spraying practices.

SUMMARY

To choose the appropriate pesticide application method, pesticide users must be aware of the nature of the target sites, pests, and available pesticides. Pesticide users must also be able to evaluate the cost and availability of both pesticide and non-pesticide control methods. This information can help in deciding which type of pesticide application procedure, if any, provides practical and efficient control.

Pesticide users must wear all safety equipment specified on the label during mixing, loading, application, and cleanup. The use of other safety systems also helps prevent pesticide exposures, spills, and environmental contamination. These include closed mixing and loading systems (mechanical systems and water-soluble packaging), enclosed cabs, and pesticide containment systems (containment pads).

Choosing the right application equipment is also an important factor in managing pests successfully. The equipment must be able to deliver the correct amount of pesticide to the intended target. A wide variety of pesticide application equipment is available, each suitable to a particular pest control situation. For example, on a small scale an aerosol can may be used to control household pests, while aircraft may be used to control mosquitoes or forest pests over a broad geographic area.

The most common type of application equipment used in pest management is the hydraulic sprayer. These range from small hand-held or backpack sprayers to large power sprayers. Applicators must understand the parts of the sprayer and how to adjust nozzles, spray volume, and pressure for reducing off-target drift. Spraying under the right weather conditions using proper application procedures can help reduce drift.

Calibrate sprayer and granular application equipment to ensure the correct amount of pesticide is being applied. Before making an application, be sure your equipment is properly calibrated and that you know how to use the label information to calculate the correct amount of pesticide.