# PESTICIDE APPLICATION TECHNOLOGY

## Application Basics

Selection of sprayers and specifically nozzles for a given situation and crop are key to success in pesticide application. However there are some general principles that apply to almost all spraying situations. Following these principles gets you much closer to success in achieving satisfactory and economic control of the problem, regardless of whatever it is that we are trying to control. These major principles are: (1) positive identification of the pest; (2) using the right pesticide; (3) selecting the right equipment, and particularly the right type and size of nozzle for the job; (4) applying the pesticide at the right time; and (5) checking the accuracy of equipment (calibration) periodically to make sure that you are applying the amount recommended on the label.

Nozzles on the sprayer may wear off over time. This will directly affect the application rate of the sprayer as well as the droplet size. Other changes in the operating conditions of the sprayer, such as going from a tilled ground to a no-till ground, or changes in tire pressure may affect the travel speed of the sprayer which again affects the application rate. Therefore, it is highly recommended that a sprayer should be calibrated frequently when application conditions change. Check the Ohio State University Extension publication AEX 520 to learn the steps involved in calibrating a sprayer. This publication is also available on-line (http://ohioline.osu.edu/aex-fact/0520.html).

## PESTICIDE APPLICATION TECHNOLOGY (CONT.)

Some pest control situations such as using systemic pesticides (especially for weed control) may not require a thorough coverage of the target from top to bottom. Some other situations, especially some disease and insect control in crops like soybeans and wheat require a thorough coverage of the target plant from top to bottom. For example, spraying the *right amount* of fungicide on each acre of soybean to treat the crop for stem rot or aphids is not enough to achieve effective control. How uniformly the chemical is deposited on the target plant and how well the chemical reaches the areas of the crop infected by insects and diseases are as important as the amount deposited per acre. Each nozzle produces a unique spray pattern. Some nozzles require precise overlapping of patterns from adjacent nozzles. Setting the proper boom height for a given nozzle spacing is extremely important in achieving proper overlapping. A low boom does not allow proper overlap while a boom set too high causes overdosed areas. Check the nozzle catalog to determine the proper boom height recommended for different nozzle spacings. Other situations that cause improper overlapping and poor uniformity include: clogged nozzles, misaligned nozzles spraying at different directions, and mixing nozzles with different spray angles. These common errors all contribute to uneven distribution of pesticides across the spray swath.

If application is done at the recommended rate, following all the best management strategies associated with application of pesticides, and uniform coverage is established across the field in horizontal plane, most weed control applications will be successful. However, it is more difficult to treat some diseases and insects especially if the problem starts in hidden, hard-to-reach parts of the canopy. For example, flower petals are the sites of primary colonization of Sclerotinia stem rot disease on soybeans. To effectively protect plants against this disease, the application of fungicides must be directed at soybean flower petals, especially in the lower portions of the crop canopy. Flower petals are very close to the stem of the plant and about at two-thirds of the height of the plant. The challenge to reach the flower petals is similar to the challenge to reach soybean rust spores well hidden in lower parts of the plant canopy.

The single most important factor affecting the control of diseases such as Soybean Rust, Soybean Stem Rot, Wheat Stem Rust, and insects such as soybean aphids is to get a **thorough coverage** of the canopy, both horizontally and vertically. Complete coverage of the disease could be even more challenging if the symptoms of the disease are found at later stages of plant growth when the plant is close to having the full canopy. Penetrating droplets inside the canopy of a fully grown plant is a much bigger challenge for us.

### How to achieve the best coverage

There are basically two ways to increase coverage: (1) reduce droplet size; and (2) increase carrier volume (application rate). Large droplets do not provide good coverage and result in waste of chemical. Increasing the application rate may be equally undesirable. It requires frequent refilling of the sprayer tank. This wastes time that may be extremely valuable when there is a short window of opportunity to spray. Ideally, we want to have as many small droplets on the target as possible. However, extremely small droplets have a tendency to drift. Research has shown that there is a rapid decrease in the drift potential of droplets whose diameters are greater than approximately 200 microns. When extremely small droplets are released from the nozzle, they quickly lose the momentum that is needed to push the droplets into the canopy. Also, these extremely small droplets do not last long after they are released from the nozzle. Most of them evaporate within a few seconds.

However, there is a way to utilize most of the droplets that may normally drift: using the air-assist technology. Air flow carries these small droplets into the canopy where they can have a chance to deposit, rather than drift away. In all the spray coverage tests using different sprayers we conducted in Ohio, air-assisted sprayers in general provided the best coverage on artificial targets placed well inside the canopy. This advantage was even more noticeable when we compared the spray deposits on the underside of plant leaves.

We conducted extensive research to determine the influence of spray quality, mechanized canopy movement, air-assisted delivery, and nozzle spray patterns on soybean canopy penetration and deposition, which could aid in selection of efficacious means for delivering pesticides to different parts of the soybean canopy for effective management of diseases and insects that may predominantly reside in hard-to-reach parts of the canopy to control diseases like Sclerotinia stem rot, soybean rust, and insects such as aphids. We compared coverage from several different nozzle/equipment setups: conventional single and double flow pattern (twin jet) nozzles; *low-drift* versions of both nozzle types, nozzles with cone spray pattern, and an air-assisted sprayer fitted with flat-fan nozzles. We had nozzles that produce fine, medium and coarse droplets in our experiments. We looked at coverage at various application rates (10, 15, 20 gal/acre).

Although it is somewhat difficult to draw concrete conclusions from our research for all questions we wanted to address, we have observed significant differences in coverage and deposition obtained from different equipment/nozzles. Following is a list of specific conclusions emerged from this study:

- When using conventional sprayers, nozzles/equipment set up that provide *medium* spray quality (rather than fine or coarse) tend to provide a better penetration of droplets inside canopy and better coverage. Fine-quality sprays should be avoided for treating lower portions of a soybean canopy unless some other form of energy, such as air-assistance, is provided to help move droplets deeper into a canopy.
- Spray hitting the target from two different angles (as in the case of TwinJet nozzles) may produce better coverage if the canopy is not dense (such as spraying for wheat scab and/or wheat stem rust). But, in dense soybean canopy conditions,

flat-fan nozzles with single spray pattern producing medium quality spray tend to provide a better penetration of droplets inside canopy.

- Canopy conditions (tall, dense vs. short, light) and operating conditions (air flow rate, air discharge angle, and proper droplet size) may affect the performance of an air assist sprayer. However, in general, if operated properly, air-assisted sprayers will likely to do a better job with penetration of droplets into canopy and spray coverage than a conventional sprayer.

- Air-assisted sprayers generally provide better deposition and coverage on the underside of leaves, which may be very important to combat some diseases and insects.

- Under dense canopy conditions, flat fan nozzles provided better coverage and penetration into the canopy than the hollow cone nozzle.

- If a twin-pattern nozzle is used, it is best to use some of the new twin-flat pattern nozzles than the conventional TwinJet nozzles because the conventional nozzles tend to produce a higher number of extremely small droplets that tend to evaporate or drift before having a chance to deposit on the target surface.

- Higher spray volumes generally increase spray coverage, which could impact efficacy.

The information related to pesticide application presented here is rather general. More specific and detailed information on the topic discussed in this chapter of the guide can be found in Ohio State University Extension Publication AEX 527-05 “Best Management Practices for Boom Spraying” (http://ohioline.osu.edu/aex-fact/0527.html). There is a wealth of information on the Internet on proper selection and operation of spray equipment for a given crop and growth stages of crops. Do a search using key words such as “spraying/sprayers”, “sprayer calibration”, “nozzles”, “spray equipment”, “spray drift” to obtain more up-to-date and specific information on this topic. Here are again the key general and specific recommendations discussed in this publication:

- Carefully read and follow the specific recommendations given on the fungicide label, and in the nozzle catalogs and sprayer operator’s manual.
- Calibrate the sprayer to make sure that the amount recommended on the label is applied.
- Check the sprayer setup to make sure the amount sprayed is distributed evenly across the spray swath.
- Thorough coverage of weeds on just the top layers of the weeds may be sufficient for adequate control. However, both horizontal and vertical coverage of the plant may be absolutely necessary for some other situations such as diseases and insects that may be hidden inside the dense canopies. Choose the appropriate size and type of nozzles that will provide adequate penetration into the canopy.
- Operate the appropriate nozzles at a pressure that will allow them to produce medium spray quality if no air-assisted sprayer is used.

- Probability of spray drift is much greater when using fine to medium droplets than coarser droplets used for application of some other types of pesticides such as herbicides. Take all the precautions to reduce spray drift. Not only is drift bad from health and environmental aspects, but it is also a waste of expensive fungicides you purchased for treatment of rust.
- For best results, keep the spray volume (application rate) above 15 gpa for ground and 5 gpa for aerial applications.
- Flat-fan nozzles are better than cone nozzles because they produce a much smaller proportion of extremely small, drift-prone droplets.
- Be careful when using twin nozzle/pattern technology. Two nozzles (or spray patterns) angled (one forward, one backward) work better mostly when the canopy is not dense and tall (weeds for example). They are not the best nozzles in tall and dense canopy conditions and when penetration of droplets into the canopy is the key for success. Under such conditions you are better off to use single nozzles spraying down only.
- To improve coverage, if applicable, use directed spraying.
- Air-assisted spraying usually provides better coverage and droplet penetration into the canopy than conventional sprayers when beans reach their full or near-full growth stage. Follow the manufacturer's recommendations for proper setup and operation of the air-assisted sprayers.

- If possible, slow down when spraying. Spray coverage usually is improved at slower speeds. Also, it is proven that the higher the travel speed, the higher the drift.
- Be safe. Wear protective clothing, rubber gloves, and respirators when calibrating the sprayer, doing the actual spraying, and cleaning the equipment.

## NOZZLE TYPES FOR USE ON FIELD CROPS

| Type | Suggested Use | Recommended PSI | Spray Pattern Type |
|---|---|---|---|
| Hollow cone | Most contact insecticides & fungicides; postemergence banding of herbicides | 60 psi & above; below 40 psi if for weed control | Circular - light applications in center, fine droplets |
| Flat fan | Pre-& post emergence herbicide & some insecticides & fungicides | 15-60 psi, not over 40 psi for weed spraying | Fan-like pattern of medium droplets |
| Even-flat | Banding herbicides, insecticides, fungicides | 20 to 40 psi | Uniform coverage across spray pattern, medium droplets |
| Flooding flat | Pre-& postemergence herbicides where drift is hazardous | 10-20 psi for max drift control; below 30 psi otherwise | Fan-like, coarse droplets, numerous enough for weeds |
| Full cone, Raindrop | Pre-plant soil incorporated | 15 to 40 psi | Full cone or hollow cone (with Raindrop). Large droplets. |
| Boomless | Weed & brush control in pastures, fence row & roadsides | 10-30 psi, never over 40 psi | Fan-like, extra wide flat spray pattern with 18 to 33 ft coverage. |

## EVEN-FLAT FAN NOZZLE HEIGHT FOR VARIOUS BAND WIDTHS

| Band Width | Approximate Nozzle Height | |
|---|---|---|
| | 80 Series | 95 Series |
| 8" | 5" | 4" |
| 10" | 6" | 5" |
| 12" | 7" | 6" |
| 14" | 8" | 7" |

*Example:* If you desire a 10 inch band from a nozzle with 80 spray angle, mount nozzle 6" above the surface.

## FLAT-FAN NOZZLE HEIGHT FOR VARIOUS SPRAY PATTERN ANGLES

| Spray Pattern Angle | Nozzle Height above Crop | |
|---|---|---|
| | 20" spacing | 30" spacing |
| 65 | 22" to 24" | 33" to 35" |
| 80 | 17" to 19" | 26" to 28" |
| 110 | 15" to 18" | 20" to 22" |

*Example:* For a spray tip with an 80 degree spray pattern angle and spaced 20" apart, the correct nozzle height above the crop canopy target is 17 to 19 inches.

## RELATIVE WEAR OF NOZZLE MATERIALS*

| Material | Wear Life (years) |
|---|---|
| Brass | 1 |
| Nylon | 3-4 |
| Plastic | 3-5 |
| Stainless Steel | 4-6 |
| Hardened Stainless Steel | 8-10 |
| Ceramic | 10-15 |

* Actual life will depend on usage. Calibrate your spraying system frequently.

# FUNGICIDE APPLICATION TECHNOLOGY FOR HEAD SCAB MANAGEMENT

When applying a fungicide to manage Fusarium head blight or head scab of small grain, the target is the head and not the leaf. Traditional fungicide application techniques suitable for managing foliar diseases do not provide adequate coverage of the heads, and as such, do not provide adequate suppression of head scab and vomitoxin. When a fungicide is applied using nozzles that direct the spray downward, most of the product is deposited on the leaves or the ground and not the head. Hence, specific ground application guidelines have been developed to improve fungicide coverage and efficacy when managing head scab.

**Nozzle Orientation.** Set flat-fan nozzles at a forward angle of 30 or 45 degrees from the horizontal. When applying a fungicide at travel speeds of 6 mph or above, forward-facing nozzles provide better spray deposition and scab management than downward-facing nozzles. An air-assisted spray system can also be used to achieve a forward-oriented spray setup, if the air orifices are angled forward to about 45 degrees. The air stream pushes the heads forward from their vertical position to an angle that improves spray deposition.

**Droplet Size.** Use 80-degree flat-fan nozzles to produce large fine to small medium droplets of 300 to 350 microns. At travel speeds of 6 mph or higher, these droplets are fine enough to provide even distribution of the fungicide on the heads, while at the same time, large enough to minimize spray drift.

**Water Volume.** A spray volume of 10 gpa results in scab and vomitoxin suppression comparable to, or better than, a volume of 20 gpa, with a single set of angled flat-fan nozzles. Coverage with 10 gpa is less than that achieved with 20 gpa, but the amount of fungicide deposited on the head is greater at 10 gpa than at 20 gpa because the fungicide concentration in 10 gpa is double the concentration in 20 gpa.

**Height of the Nozzles above the Canopy.** Angled spray nozzles should be positioned 8 to 10 inches above the grain heads.

It is not necessary to modify the entire boom to achieve the 30 to 45 degree nozzle orientation. Nozzle body adapters, 45-degree nozzle caps, or single-swivel nozzle adapters can be used to generate a forward-angled spray pattern.

Source: http://mawg.cropdisease.com/pdf/AE-1314_Ground_Application_of_Fungicides_REVISED.pdf
http://agbiopubs.sdstate.edu/articles/FS919.pdf

## CALIBRATING GRANULAR APPLICATORS

Application rates and settings for insecticide metering units on planter hoppers are usually given on the chemical label. However, correct rates can be attained only if the application units are calibrated properly because each insecticide flows differently depending on its density, particle size, type of carrier used and relative humidity. Therefore, the setting used for one 15G may not be the same as that needed for another 15G. Follow steps below to calibrate your applicator.

1. Read the label and determine the rate of material you want to apply (for corn rootworms this is usually 1.2 oz. a.i./1000 row ft., or 8 oz of a 15G, or 6 oz. of a 20G formulation/1000 row ft; 4 oz of a 3G at 0.12 oz. a.i./1000 row ft).
2. Fill the insecticide boxes and attach a plastic bag or a calibration tube to each applicator tube.
3. Open the metering units to a beginning setting of the previous year's setting or that suggested on the insecticide label.
4. Measure out 250 feet and operate the planter at planting speed over this distance. Collect the granules.
5. Weigh the amount collected, or use a calibration tube provided by the product manufacturer to determine the weight per 250 row ft.
6. Multiply the amount collected by 4 to determine amount per 1000 row ft. Compare this with the recommended amount per 1000 row ft.
7. Repeat steps 1 through 6 above until the difference between the desired (intended) rate and the measured rate in step 6 is less than 5% of the intended rate.

# CALIBRATION EQUATIONS FOR LIQUID APPLICATIONS

To double nozzle flow rate, pressure must increase four times.

Pressure cannot be used to make major changes in rate, only minor changes due to nozzle wear and other factors.

Doubling the ground speed of a sprayer reduces the gallons per acre (GPA) by a half.

Doubling the effective spray width per nozzle decreases the GPA by one-half.

$$GPA = \frac{GPM \times 5940}{MPH \times W}$$

$$GPM = \frac{GPA \times MPH \times W}{5940}$$

$$OPM = GPM \times 128$$

$$MPH = \frac{\text{feet traveled} \times 60}{\text{sec. to travel} \times 88}$$

GPA = gallons per acre
GPM = gallons per minute
OPM = ounces per minute
MPH = miles per hour
W = nozzle spacing in inches (broadcast spraying)
= band width in inches (band spraying)

## CALIBRATION EQUATIONS FOR LIQUID APPLICATIONS (CONT.)

Some pesticides may be sold in formulations that contain different amounts of the same active ingredient. Therefore, manufacturers may give the rate in terms of active ingredient (a.i.) per acre or 1000 feet of row. To determine the application rate of actual formulated product, use the following formulas:

For dry products:

$$\text{lb product per acre} = \frac{\text{lb a.i. per acre x 100}}{\text{\% a.i. in product}}$$

For Liquid Products:

$$\text{gal of product} = \frac{\text{lb a.i. per acre}}{\text{lb a.i. per gal}}$$

Note: If interested in determining rates in terms of lb or gal per 1000 feet of row, replace acre in equations above with 1000 feet of row.