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Sprayer Nozzle Tip Selection

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Nearly all farms have a field sprayer. One of the important skills farmers should learn is how to select nozzle spray tips that are matched to the requirements of the pesticide application. There are several general types of spray tips used in agriculture: flat fan, flood, hollow cone, solid cone, even-spray, raindrop, and various drift reduction tips. Flat fan spray tips and even-spray tips are the two most popular with farmers who do their own chemical application. Hollow cone, solid cone, and flood spray tips have their place as well. Drift reduction spray tips use various methods to increase droplet size but will not be discussed in this fact sheet.

Achieving Application Uniformity

Regardless of the spray nozzle selected, certain basic nozzle selection and spray management techniques will help achieve the results desired. With one exception, (Band Spraying, see below) uniform distribution is achieved by overlapping the outer edges of the individual spray patterns. By correct spacing of the nozzles along the boom and running the correct boom height above the spray surface, one can achieve the recommended spray pattern overlap for uniform application. The required amount of overlap will depend on the nozzle tip design. Manufacturer recommendations range from 30% to 100% overlap, depending on the spray tip. Because the recommended overlap may change from one design to the next, one should always refer to the manufacture's information for correct tip height and spray overlap when changing spray tips on the boom.

Spray Drift Management

Consider two spray droplets, one has twice the diameter of the other. The larger droplet will contain eight times the volume and therefore will have eight times the weight of the smaller droplet. Larger and heavier droplets fall through the air more quickly than smaller droplets and therefore have less tendency to be carried off-target by the wind. This off-target movement is known as drift.

Smaller spray droplets have greater surface area per unit volume as compared to larger diameter droplets and therefore can experience greater moisture evaporation while in the air. As a droplet evaporates, it gets smaller and lighter and is even more subject to drift.

All spray tips will operate over a range of pressures. When operated below the recommended pressure range, the spray tip will not develop a full spray pattern. When operated above the recommended pressure range, the tip will produce a large percentage of very small droplets which can result in particle drift and poor deposition patterns. When operated near the lower end of the recommended pressure range, a nozzle will produce larger droplets and therefore particle drift is reduced. For better penetration into a crop canopy and/or more thorough coverage with more (but smaller) droplets, the operator may choose a spray tip which applies the recommended volume per acre nearer the higher end of recommended pressures for the spray tip.

Flat Fan Nozzles

A flat fan spray tip gets its name from the shape of the spray pattern it produces, which resembles a hand-held folding fan or an inverted "V". Standard flat fan spray tips are designed to produce a narrow elliptical spray pattern for broadcast (full coverage) application. Deposition of spray is heaviest in the center of the spray pattern, (directly under the spray tip) and graduates to nothing at the outer edges. When properly spaced along the boom and with the boom at the proper height above the spray surface, flat fan spray tips apply a uniform spray pattern and are widely used in agricultural applications for applying pre-plant incorporated, pre-emergent and post emergent pesticides for weed, insect and disease control.

Some spray tips are designed to operate over a broader range of pressures than the standard flat fan tips. These are commonly referred to as Extended Range spray tips. Because of the broader range of operating pressures, extended range spray tips can be used in more situations and are becoming more popular choices for general farm use.

Other designs, used mainly to apply insecticides or fungicides to standing crops, are made with two orifices per spray tip. Because they are essentially two smaller orifices working in tandem which tend to produce smaller droplet sizes and because the spray streams are angled differently, one can achieve more thorough coverage and better penetration into the crop canopy.

Band Spraying

A special type of flat fan spray tip has been designed for banded spray operations. In banded spray operations, only a portion of the total land area receives a chemical application, leaving untreated strips. In applications where the band will be sprayed with only one nozzle, the nozzle must apply a uniform amount of spray over the entire width of the band. Manufacturers have designed spray tips specifically for this

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purpose called even-spray tips. Because of the very different spray patterns produced, one should be careful not to confuse flat fan and even-spray nozzle tips when equipping a sprayer for band versus broadcast applications.

Hollow Cone and Full Cone Nozzles

These spray tips have a round orifice which produces a cone-shaped spray pattern. Both solid cone and hollow cone designs are available. These are used mainly in air blast spray systems for use in orchards and vineyards.

Flood Nozzles

Flood jet (a.k.a., flooding or flood) nozzles are used for broadcast application of chemicals. This system is popular with commercial applicators because the recommended nozzle spacing is typically 40 or 60 inches, thus requiring large diameter orifices which are less prone to plugging than the smaller orifices used in flat fan nozzles with 20 to 30 inch nozzle spacing. These nozzles also produce relatively larger droplet sizes, resulting is less spray drift than typical flat fan designs. The larger droplet sizes also are less affected by higher ground speeds and therefore maintain acceptable deposition patterns when used on high-speed commercial spray rigs.

Selecting Spray Tips

When selecting a spray tip for a given application, three factors must be considered. The material the tip is made of, the size of orifice needed, and the spray angle.

All spray tips wear out eventually and must be replaced. The actual life of a spray tip depends on the abrasiveness and corrosiveness of the spray solution. If a tip is made from a soft material, e.g., brass, the tip life can be very short indeed. Polymer spray tips provide better wear life than brass, and have good chemical resistance but, as with brass, polymer tips can be easily damaged by improper cleaning techniques. Stainless steel tips have better durability than those made of brass or polymer. Stainless steel provides good wear and excellent chemical resistance and is not as subject to mechanical damage. One can buy tips made entirely of stainless steel or polymer tips with a stainless steel orifice insert. Hardened stainless steel, as one could imagine, has improved wear life over regular stainless steel. Ceramic orifices are the hardest, and therefore the longest-wearing (and most expensive) tips.

As with any type of orifice, the output per minute through a spray tip depends on the operating pressure and the size of the opening. When selecting spray tips, one needs to consider: the desired volume of spray output per acre, the intended operating pressure, the travel speed of the sprayer through the field, and the nozzle spacing on the boom.

Spray tip manufacturers have charts that list the output per acre for each spray tip design and orifice size. Once the nozzle spacing and the travel speed are known, one can study these charts to find the tip(s) that will apply the required volume of spray solution per acre. When more than one tip is capable of applying the desired volume per acre, the selection for which specific tip to use is then made, based on the operating pressure one wants to run in consideration for coverage versus spray drift potential.

Alternatively, when selecting a spray tip, one could calculate the output, in Gallons Per Minute (GPM) per spray nozzle that is needed for a given application using the formula, listed in Figure 1–Selecting Nozzles. For example: To apply 15 Gallons Per Acre (GPA) while traveling 6 Miles Per Hour (MPH) with a nozzle spacing of 30 inches (W), the calculation would be:

GPM/nozzle = GPA x MPH x W / 5940
= 15 GPA x 6 MPH x 30" / 5940
= 0.45

Once the required GPM/nozzle is known, one could refer to the manufacture's information to select a tip that matches the output criteria at the desired operating pressure. A Delavan 110-6 will have an output of 0.42 GPM at 20 Pounds per Square Inch (PSI) and 0.47 GPM at 25 PSI. This tip will have the desired output somewhere between these two operating pressures and could be used in this application.

To estimate the correct pressure for an output of 0.45 GPM, use the Equation in Figure 1–Correcting Pressure, (substituting GPM for GPA).

PSI required = (GPM desired/GPM initial)^2 x PSI initial
= (0.45 GPM/0.47 GPM)^2 x 25 PSI
= (0.957)^2 x 25 PSI
= 0.916 x 25 PSI
= 23 PSI

Manufacturers offer several choices of spray angles. Flat fan designs typically always come in both 80 and 110 degree spray angles. 65 and 73 degree spray angles are available in many spray tip designs as well. The recommended nozzle spacing and tip height above the surface to be sprayed is dictated by the spray angle.

Within a given class of spray tips, the orifice size determines the spray volume output at a given pressure. The spray tip industry uses a standard pressure of 40 PSI when designing the output capacity of flat fan spray tips. For example: Consider TeeJet spray tips with 8004 in the name. The “80" designates the spray angle, 80 degrees. The output capacity at 40 PSI would be 0.4 GPM. A Delavan 80-4 will produce the same results. Likewise, a TeeJet 11004 and Delavan 110-4 will both produce a 110 degree spray angle with an output capacity of 0.4 GPM.

For flood nozzles, the industry uses a standard pressure of 10 PSI when designating the spray output. For example: a

Figure 1. Calibrating a Sprayer

Selecting Nozzles
GPM/nozzle = GPA x MPH x W / 5940

Catch Test
GPM/nozzle = 7.5 / seconds per pint (16 fl oz)

Calculating Output
GPA = (5940 x GPM/Nozzle) / (MPH x W)

Correcting Pressure
PSI required = (GPA desired / GPA initial) ^{2} x PSI initial

Result of Pressure Change
New GPA = (New PSI / initial PSI) x initial GPA

Calculating True Ground Speed
MPH = 68.2 / seconds / 100 feet

Key to Abbreviations
GPM = Gallons Per Minute MPH = Mile Per Hour
GPA = Gallons Per Acre PSI = Pounds per Square Inch
W = Width between nozzles in inches

TeeJet TK-3 will output 0.3 GPM at 10 PSI, as will a Delavan D3.

Example of Sprayer Tip Selection: A producer wants to broadcast a pre-plant incorporated herbicide. Drift reduction is more important in this situation than closely spaced droplet deposition. The producer wants the tips to last for many days of spraying without concern for wear and need for replacement. He therefore chooses a stainless steel orifice, because of its longer life than brass or polymer. The sprayer is set up on a 20 inch nozzle spacing. He wants to apply 20 GPA with a field speed of 5 MPH.

The producer finds an 80 degree, extended range nozzle in the TeeJet catalog (XR8005VS) that is listed as applying 21 GPA while traveling 5 MPH at 20 PSI on a 20 inch spacing.

This nozzle would be a close fit to the original design criteria when operated at 20 PSI and 5 MPH. Many times a farmer will simply calibrate the sprayer at 20 PSI and 5 MPH and use this spray tip without further adjustments.

However, after consideration of field size and sprayer tank volume, this farmer decides 20 GPA would be much more convenient than 21 GPA because at 20 GPA the saddle tanks should run nearly empty at the end of every 6 rounds with the sprayer. This puts the farmer on the same end of the field as the nurse tank and chemical storage each time it needs to be refilled. There are two ways to apply the design goal of 20 GPA using this nozzle.

If the spray rig travel speed could be increased to 5.25 MPH instead of the original 5 MPH these spray tips would produce an output of 20 GPA. (To reduce the volume by five percent, increase travel speed by five percent).

The book shows this nozzle can operate as low as 15 PSI. At 15 PSI the output would be 18.4 GPA. The farmer therefore knows he can achieve the desired 20 GPA by operating somewhat below 20 PSI but well above the minimum recommended pressure of 15 PSI.

Using the equation for Correcting Pressure from Figure 1, one can calculate the pressure required to adjust the output per acre.

$$\begin{aligned}\text{PSI required} &= (\text{GPA desired}/\text{GPA initial})^2 \text{ x PSI initial}\\ &= (20\text{ GPA}/21\text{ GPA})^2 \text{ X } 20 \text{ PSI}\\ &= (0.95)^2 \text{ X } 20\text{ PSI}\\ &= (0.903) \text{ X } 20 \text{ PSI}\\ &= 18 \text{ PSI}\end{aligned}$$

This spray tip design should apply 20 GPA at a 5 MPH field speed when operated at 18 PSI.

For more information on selecting sprayer nozzle tips see NebGuide G89-955 Nozzles - Selection and Sizing http://www.ianr.unl.edu/pubs/farmpower/g955.htm

For more information on drift, see NebGuide G90-1001 Spray Drift of Pesticides http://www.ianr.unl.edu/pubs/pesticides/g1001.htm

For more information on sprayer calibration, see NebGuide G88-865 Fine Tuning a Sprayer Using the Ounce Calibration Method. http://www.ianr.unl.edu/pubs/farmpower/g865.htm