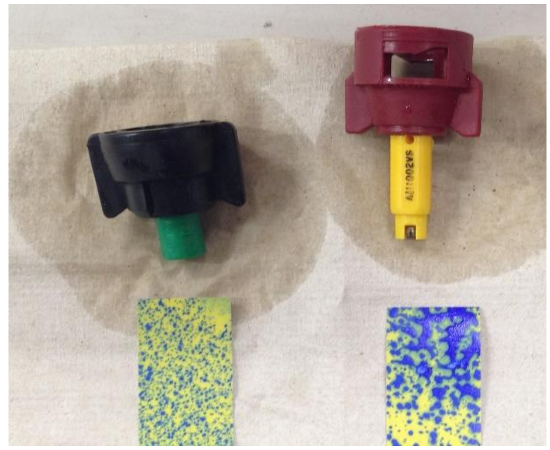
# COMMON INTERCHANGEABLE NOZZLES FOR PERENNIAL CROP CANOPY SPRAYERS



## Interchangeable Nozzle Design and Function

The nozzles on your sprayer can significantly influence the efficacy of your pest management program. They influence how much product is delivered (application rate), the spray pattern on the target crop, and droplet size.

Sprayers with interchangeable nozzles, such as Rear's air blast, Turbo-mist, or Quantum Mist, require the operator to select, or change, the type of nozzle that is installed based on the canopy or field parameters. However, there are several different attributes that commercial nozzles have that can make the selection of a nozzle daunting. Such attributes include nozzle resistance to abrasion, nozzle body design, droplet size produced, and nozzle spray pattern.

### *Resistance to Abrasion or Corrosion*

Resistance to corrosive spray chemistry (composition and solution pH), solution concentration, debris in spray water, and high temperatures are all factors that need to be considered when selecting nozzles. Nozzles can be made from brass, hardened stainless steel, ceramic, nylon, or synthetic ruby or sapphire. The materials are rated by their resistance ratio and the ability of a surface to resist being worn away by friction (Table 1). Higher resistance ratios indicate increased resistance to abrasive materials. Resistance to abrasion relates to how the nozzle material at the orifice is worn away over time, whereas corrosion is general damage to the material (e.g., pitting). Cost of each material type can differ (Table 2).

### *Nozzle Body Design*

The basic interior design of a cone-shape spray nozzle consists of two parts: a disc and a core (or whirl plate). These two components work together to atomize, or break up, a stream of water, thus creating droplets. In older style nozzles, these two parts are separate pieces that are then held together in the nozzle body on the spray boom to form the nozzle tip. A newer nozzle style has those two interior components pre-combined into a single nozzle style, known as a one piece or molded body. Additionally, there are air induction (AI) nozzles which resemble a one piece nozzle but has a hole at the base of the nozzle body. The small hole on the AI nozzle brings air in and injects bubbles into the water stream, thus creating larger, air-filled water droplets.

Table 1. Approximate abrasion resistance ratios of nozzle materials.

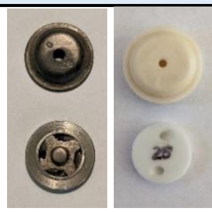
| Nozzle material | Resistance ratio |
|---|---|
| Aluminum | 1 |
| Brass | 1 |
| Polypropylene | 1–2 |
| Steel | 1.5–2 |
| Stainless Steel | 4–6 |
| Hardened Stainless Steel | 10–15 |
| Ceramics | 90–200 |
| Synthetic Ruby or Sapphire | 600–2000 |

*Notes*: The higher the resistance ratio, the more resilient the nozzle is to wear.
*Source*: Adapted from Barber (2009).

Additional details, including images of the different nozzle body designs, are available in Table 2.

When choosing a nozzle style, it is less important to focus on the nozzle itself and more important to consider the droplet size that it can produce.

Table 2. Common interchangeable nozzle types used in orchard and vineyard canopy sprayers. (All photos by Margaret McCoy, Washington State University.)

| **Nozzle description and example** | | **Droplet size** | **Additional information** |
|---|---|---|---|
| **Body style**:<br>disc and core<br><br>**Spray pattern:**<br>hollow or full cone<br><br>**Composition:**<br>multiple types | <br>TeeJet hardened stainless steel and ceramic<br><br><br>HyPro polyacetal | Depends on disc and core combination and is not categorizable by manufacturer.<br><br>Droplets can range from fine to medium (100 to 340 µm); in general, smaller orifices or higher operating pressure produce smaller droplets. | ***Pros***:<br>Industry standard, well known.<br>Ceramic wear less with high use of corrosive chemicals (e.g., sulfur and oil).<br>Almost infinite amount of combinations to create the desired output (gallons per minute [GPM]) from each nozzle.<br><br>***Cons***:<br>Droplet sizes can vary widely.<br>Often the nub on cores is be placed incorrectly. Point nub away from the disc so as not to obstruct the hole.<br>Small identification print on nozzle can be hard to read.<br>Ceramic can crack if nozzle is overtightened.<br><br>**Price range*:**<br>Hardened stainless steel, $3.74–$ 6.49.<br>Ceramic, $6.80–$8.95.<br>Polyacetal, < $2.00. |
| **Body style**:<br>Molded one piece<br><br>**Spray pattern:**<br>hollow or full cone<br><br>**Composition:**<br>ceramic | <br>TeeJet hollow cone<br><br><br>Lurmark full cone | Fine to very fine (60 to 235 µm) and varies based on operating pressure; nozzle color does not necessarily correspond to droplet size classification (Table 3). | ***Pros***:<br>Internal ceramic components wear less quickly with high use of corrosive chemicals.<br>Easy identification because it is color coded and one piece.<br><br>***Cons***:<br>Smaller droplets can drift easily.<br>Sticks out from the nozzle body which may make it vulnerable to damage by objects in the field.<br><br>**Price range*:**<br>$4.09–$5.20. |
| **Body style**:<br>Molded one piece air induction (AI)<br><br>**Spray pattern:**<br>hollow cone<br><br>**Composition:**<br>ceramic | <br>TeeJet air induction hollow cone | Very coarse to extremely coarse (340 to 665 µm). | ***Pros***:<br>Larger droplets can reduce off-target drift.<br>Can be used at higher PSI common for canopy sprays.<br><br>***Cons***:<br>Has a different spray deposition than that produced from a nozzle with finer droplets.<br>Sticks out from the nozzle body which may make it vulnerable to damage by objects in the field.<br><br>**Price range*:**<br>$8.42–$19.01. |

*Nozzles prices sourced from online and various equipment stores in Washington State in 2020. Prices listed are a range of six sources and not a guaranteed price at any one store.

# Droplet Size

Droplet size can vary widely between design of nozzles. The American Society of Agricultural and Biological Engineers (ASABE) developed a droplet size classification system (ASABE S-572.1) which sizes droplets ranging from extremely fine to ultra-coarse to measure and interpret spray quality from tips (Table 3). Categorization of droplet sizes is designated using volume median diameter (VMD) to indicate that half of the spray volume is smaller and the other half larger than the median size droplets. Disc-core nozzles produce a large VMD of droplet sizes, whereas one piece nozzles produces much smaller VMD droplet sizes since the nozzles are produced with more precision. AI nozzles inject air bubbles into droplets, which makes the droplets bigger and thereby less prone to drift. Comparing all nozzle types, AI nozzles produce the biggest droplets. Two different nozzles, for example, one piece and AI, can have the same volume (gallons per minute [GPM]), but very different droplet sizes (VMD). Every time the VMD is halved the number of droplets increase by eight times (i.e., one 400 µm droplet halved becomes eight 200 µm droplets, and those droplets halved become sixty-four 100 µm droplets).

While droplet size can be influenced by operating pressure (as noted in the nozzle catalog of each brand), the primary size is set by nozzle specifications. Droplet size consideration is important as many pesticide labels now include a specific range in droplet sizes under which that specific product can be applied. Either contact or absorbed chemistries work well when applied as smaller droplets. In addition, chemistries that target immobile pests (insects or disease) can also be applied as smaller droplets. Chemistries that are absorbed and translocated by the plant can also be applied as larger droplets. With contact chemistries, application as a large droplet only works if the chemistry is targeting a pest that is mobile and will move to where the product is applied. Larger droplets can also help reduce drift. These generalizations are not meant to be strict suggestions for any chemical application.

# Nozzle Spray Pattern

There are multiple different spray patterns that are delivered from nozzles (Figure 1).

- *Hollow cone pattern*—Nozzles that produce this pattern are often used for canopy sprays. Hollow cone nozzles produce a circular ring pattern (Figure 1A). The hollow cone pattern can assist in canopy spray penetration due to its slight smaller droplet size.
- *Full cone pattern*—Nozzles that produce this pattern can be used for canopy sprays. Full cone nozzles produce a solid cone pattern for a filled-in circle, and they often produce a slightly larger droplet size than a hollow cone (Figure 1B).
- *AI hollow cone pattern*—The small hole in the AI nozzle body sucks air into the nozzle and injects multiple small bubbles into a single water droplet. This results in large droplets that are more likely to "shatter" when hitting a surface (Figure 1C). AI nozzles can be used for many relevant applications situations such as blustery sites where drift can be an issue or if a product needs to spread once it has come in contact with the target.

# Replace Worn or Damaged Nozzles

Manufacturers design nozzles to put out a set pattern and flow rate or volume of water (GPM) at a given pressure rating. Worn, damaged, or clogged nozzles can put out different GPM (Figure 2) or produce a different spray pattern than new nozzles when used at the same pressure (Figure 3).

Visual assessment may sometimes be used to determine if a nozzle is broken, but it is not an appropriate technique to determine if the nozzle is worn. To most individuals, a worn nozzle can look just like a fully functional nozzle (Figure 2). At a minimum, nozzles should be evaluated annually to determine if output is within 10% of the manufacturer's flow rate.

Table 3. Spray droplet categories and associated nozzle color codes and volume median diameter. (Table modified from ASABE [2009].)

| Category classification | Symbol | Color code | Droplet size | Drift potential | Approximate VMD range (µm) |
|---|---|---|---|---|---|
| Very fine | VF | **Red** | Small | High | 60 to 145 |
| Fine | F | **Orange** | | | 145 to 225 |
| Medium | M | **Yellow** | | | 226 to 325 |
| Coarse | C | **Blue** | | | 326 to 400 |
| Very coarse | VC | **Green** | | | 401 to 500 |
| Extremely coarse | EC | **White** | Large | Low | 501 to 650 |

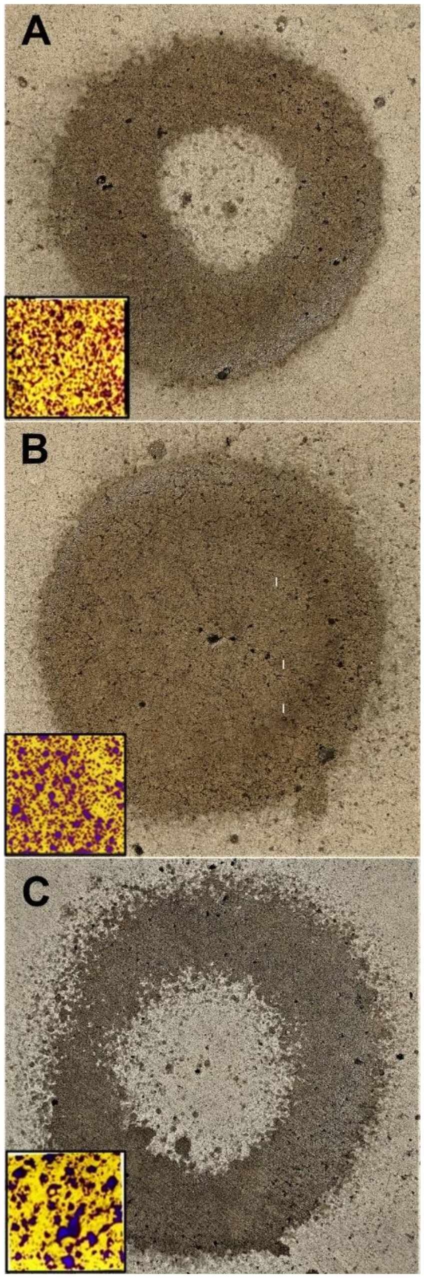



Figure 1. Nozzle spray pattern and droplet deposition for hollow cone (A); full cone (B); and AI hollow cone (C). Images by Margaret McCoy, Washington State University.

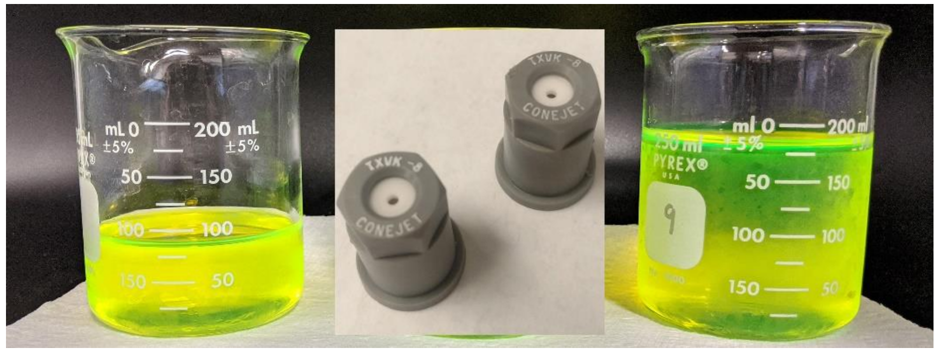



Figure 2. Visually, these nozzle tips (center) look similar. The nozzle on the left is new with the correct GPM. The right nozzle is worn, with greater than 10% higher flow rate than indicated by the manufacturer. Photos by Margaret McCoy, Washington State University.


Figure 3. When testing the new versus worn nozzle, the pattern may show irregular output patterning. The new nozzle (top) compared to a similar nozzle used after one season of heavy sulfur applications (bottom) shows very different output pattern. Photos by Margaret McCoy, Washington State University.

Commercially available tools to measure nozzle output include SpotOn sprayer calibrator or AppliMax spray nozzle calibrator. These can be used during routine sprayer maintenance and calibration. Once the flow rate is known, you can do one of two things: (1) replace only those nozzles with a flow rate that is more than 10% outside of the manufacturer's indicated rate or (2) replace all nozzles at the start of the season. In the first scenario, you will have to repeatedly check the remaining nozzles during the year and replace, as necessary. Replacing all the nozzles at once reduces this extra step.

## Personal Protective Equipment (PPE)

PPE is required whenever checking, adjusting, replacing, or testing nozzles. For specific information on what PPE is required, please read *Pesticides: Safe Handling* (Black 2014b) and *Pesticides: Learning about Labels* (Black 2014a). Or visit your local Extension office.

## Additional Resources

For more details on the process of sprayer calibration see:

- Hoheisel, G.A., L. Khot, M. Moyer, and S. Castagnoli. 2021. Six Steps to Calibrate and Optimize Airblast Sprayers for Orchards and Vineyards. *Pacific Northwest Extension Publication* PNW749. Washington State University.
- Hoheisel, G., and M.M. Moyer, eds. 2020. Pest Management Guide for Grapes in Washington. *Washington State University Extension Publication* EB0762. Washington State University.

Sprayers 101—A website dedicated to sprayer education. Suggested articles include:

- *Airblast Nozzle Materials and Wear*
- *Airblast Nozzle Bodies*
- *The Better Choice: Molded Cone Nozzles*

# References


ASABE (American Society of Agricultural and Biological Engineers). 2009. ASABE S572.1 Droplet Size Classification. American Society of Agricultural and Biological Engineers.

Barber, J. 2009. How to Pre-empt a Significant Profit Drain: Nozzle Wear Causes, Detection and Corrective Action Strategies. White Paper #106. Spraying Systems Co.

Black, C.A. 2014a. Pesticides: Learning about Labels. *Washington State University Extension Publication* FSIPM001E. Washington State University.

Black, C.A. 2014b. Pesticides: Safe Handling. *Washington State University Extension Publication* FSIPM002E. Washington State University.



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