

# Selecting nozzles for fungicide spray applications

Using the right nozzle may save your grass.

**Dennis Shepard, Ph.D.; Michael Agnew, Ph.D.; Mike Fidanza, Ph.D.; John Kaminski, Ph.D.; and Luke Dant, M.S.**

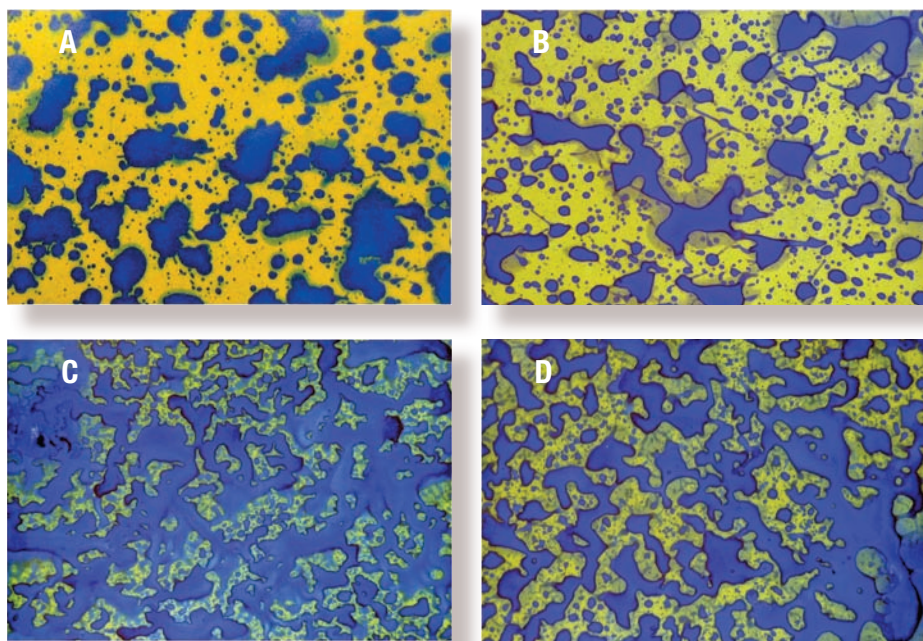
Fungicide spray applications are a key part of a superintendent's turf management program. Fungicide selection, application timing, application water volume and application equipment are important for effective disease control.

Chemical companies have developed products that are active at lower rates for longer periods, are safer for the environment and come in formulations that are easier to apply. Even when these products are applied at the proper interval, disease control can be compromised if fungicides are not applied uniformly over the turfgrass in the proper water volume.

Research conducted in the early 1980s suggests that a general guideline for fungicide applications is a minimum of 44 gallons/acre (411.6 liters/hectare) for contact fungicides and 88 gallons/acre (823.1 liters/hectare) for products that are acropetal penetrants or have a systemic mode of action (1).

Recent research at the University of Maryland demonstrated that 50 gallons/acre (467.7 liters/hectare) worked fine for the contact fungicide Daconil Ultrex (chlorothalonil) and the acropetal penetrant Banner Maxx (propiconazole) (2). This may suggest that the new microemulsion formulations do not require the additional water that older EC or wettable powder formulations needed 25 years ago.

Sprayer technology also has improved over the past several years. Computerized systems now take the guesswork out of speed and spray volume considerations. Sprayer and chemical improvements can be negated if the chemicals are not properly applied to the turf. Even though nozzles are a small part of the overall operation, they are the last piece of



**Figure 1.** Yellow moisture-sensitive paper sprayed with four different nozzles at 50 gallons/acre shows a two-dimensional view of the effective coverage by the nozzles. The sprayed areas are blue, and the dry areas remain yellow. Nozzles that produce smaller droplets improve coverage. A, raindrop (extremely coarse droplet); B, TurfJet, extremely coarse droplet; C, XR TeeJet, medium droplet size; D, air-induction, very coarse droplet.

equipment through which sprays pass before contact with the turf. Several nozzle types are available from various manufacturers, and choosing the right nozzle for various applications will improve product performance. Here we review a nozzle selection project and provide some guidance on nozzle selection.

## What are the issues?

The nozzle selection project began with the question, "What is the best nozzle to use for chemical applications?" In our discussions with superintendents, they indicated that

their primary goal when spraying was to get the job done quickly (see the sidebar, "Syngenta survey"). In order to accomplish this feat, many would reduce their spray water volume to 50 gallons or less with the goal of carrying less water to save time. Unfortunately, the level and duration of dollar spot suppression was unacceptable. This was due in part to nozzle selection. Many of these sprayers were equipped with nozzles that sprayed an extremely coarse droplet size. Thus, fungicide spray coverage was less than optimal, resulting in poor dollar spot control. The pri-

# RESEARCH

## SYNGENTA SURVEY

A survey of 75 golf courses found that application volume to greens averaged 80 gallons/acre (748.3 liters/hectare), with a range from 44 to 110 gallons/acre (411.6-1,028.9 liters/hectare). Of these courses, 23 used XR flat-fan nozzles, 36 used flooding-type nozzles and two used the air-induction nozzle. The others were about equally divided in use of other nozzles.

The survey also asked 66 superintendents about fairway applications. Application volume to fairways averaged 57 gallons/acre (533.2 liters/hectare) with a range of 22 to 88 gallons/acre (205.8-823.1 liters/hectare). Of these, 38 used flooding-type nozzles, 11 used XR flat-fan nozzles and two used the air-induction nozzles.

primary goal of the Syngenta nozzle project was then to determine the best way to maximize the performance of fungicide when applied at 44 gallons/acre (411.6 liters/hectare).

The evolution of this project included a visit to Spraying Systems Co. (TeeJet, Wheaton, Ill.), where we discussed nozzle basics and selection criteria. Spraying Systems provided us with technical literature that is partially reviewed in this article. Nozzles are designed to apply various spray volumes with different droplet sizes. Their design also determines whether the spray is applied in a flat-fan, hollow-cone or full-cone pattern. The target organism, chemical mode of action, wind speed, drift potential and the turf area to be sprayed should all be considered in selecting a nozzle.

### Nozzle basics

The spray nozzles or spray tips determine the amount of chemical applied to an area, uniformity and coverage on the target surface and the potential drift. Nozzles can operate at different pressure ranges, but 30 to 60 pounds/square inch (206.8-413.7 kilopascals) is typical for turf applications. As pressure increases, droplet size decreases, spray volume and drift potential will increase, and nozzles may wear more quickly. An increase in pressure, however, will only provide small increases in volume output. Hence, doubling the spray pressure will not double the output. In fact, the pressure must be quadrupled to double the output from a nozzle. Regardless of pressure, nozzle wear should be monitored routinely because a nozzle that is worn by only 10% can negatively affect coverage.

Two basic types of spray patterns are used on golf courses: flat fan and hollow cone. Flat-fan nozzles are the most common type for boom sprayers, and they are often used when the goal is to coat the turfgrass sur-

face. Depending on how the nozzle is manufactured, spray angles can range from 65 to 110 degrees. Most manufacturers design nozzles that are color-coded according to the universally accepted ISO (International Organization for Standardization) standard color-coding scale. Nozzles are color-coded to identify their gallons-per-minute output at 40 pounds/square inch (275.8 kilopascals). For example, an XR8008 nozzle is white and has an output of 0.80 gallon/minute at an 80-degree angle; a 11004 nozzle is red and has an output of 0.40 gallon/minute (1.5 liters/minute) at an angle of 110 degrees. Most nozzles are marked with a colored band, or the nozzle itself will be a specific color.

In spray nozzle catalogs, performance data are typically provided for spraying water, which weighs 8.34 pounds/U.S. gallon (0.99 kilogram/liter). Liquids denser or heavier than water can form smaller spray angles and reduce flow rates. Liquids less dense or lighter than water can form wider spray angles and increase flow rates. Nozzle manufacturers have conversion charts for solutions heavier or lighter than water.

### Flat-fan spray nozzle

The flat-fan spray nozzle forms a narrow, elliptical, inverted “V” pattern. Spray output is heaviest at the center of the pattern and dissipates toward the outer edge. For most flat-fan spray patterns, a minimum 30% overlap between the nozzles is recommended. Decreasing the pressure will reduce overlap and will probably have a negative impact on coverage.

A 1:1 relationship is best for overlap in that the nozzle spacing should be about the same as the nozzle height above the turf. In general, nozzles with 110-degree fan angles can be used at lower boom heights than 80-degree fan angles. A spray tip with a 110-degree angle spraying at a 10-inch (25.4-centimeter) height will have theoretical spray coverage of 28.5 inches (72.39 centimeters). To get the same coverage with an 80-degree angle spray tip, one would need to raise the boom height to 17 inches (43.18 centimeters). Keeping the boom at a maximum height of 20 inches (50.8 centimeters) from the turf canopy is best for most turf applications. In general, lower boom heights reduce drift and increase coverage.

### Hollow-cone nozzle

The hollow-cone nozzle is more difficult to set up to produce a uniform application. The two basic types of hollow-cone nozzles are one that sprays a fine droplet and one that sprays a coarser droplet. The particle size of the first type can be smaller than a flat-fan spray nozzle. These nozzles are typically used in field crops where sprays are directed onto a plant. Because there is no spray overlap, it is critical to use this nozzle type on

### DROPLET SIZE

| Category         | Symbol | Color code | Approximate VMD (0.5) (microns)* |
|------------------|--------|------------|----------------------------------|
| Very fine        | VF     | red        | <150                             |
| Fine             | F      | orange     | 150-250                          |
| Medium           | M      | yellow     | 250-350                          |
| Coarse           | C      | blue       | 350-450                          |
| Very coarse      | VC     | green      | 450-550                          |
| Extremely coarse | XC     | white      | >550                             |

\*VMD (volume mean diameter) = droplet size where half of the volume has droplets greater than the volume mean diameter, and half the volume has droplets smaller than the volume mean diameter.

Table 1. Droplet size categories.



**Figure 2.** Three-dimensional spray coverage by two nozzles. *Left*, extremely coarse droplets from the TurfJet nozzle; *right*, medium-size droplets from the XR TeeJet nozzle. The blue droplets are spray drops, and the clear droplets are dew. Note that the larger droplets do not spread evenly, but the smaller droplets are evenly distributed on individual leaves.

level surfaces. The other hollow-cone nozzle, the WhirlJet or raindrop nozzle, produces a much larger droplet size in a hollow-cone pattern. Raindrop nozzles were developed to minimize clogging and reduce spray drift, but applications with this nozzle type are generally less uniform, and spray coverage

may be incomplete.

### Droplet size

Choose a flat-fan nozzle that provides the right droplet size to achieve the desired result. Spray droplets are measured in microns (0.001 millimeter or 0.00004 inch). Droplet

sizes are categorized by the American Society of Agricultural and Biological Engineers (ASABE) droplet size classification standard (Table 1). Nozzles produce a range of droplet sizes, but they are classified according to their volume mean diameter (VMD). Most nozzle manufacturers provide color-coded tables that indicate the droplet size for different nozzles at various pressures (Table 2).

Reducing a droplet size by half will result in about eight times more droplets per unit area. For example, applying a fungicide in a water volume of 44 gallons/acre (411.6 liters/hectare) from a nozzle that puts out 800-micron droplets will apply about 88 droplets/square inch (567.7 droplets/square centimeter), whereas a nozzle that produces a 400-micron-sized droplet will result in about 704 droplets/square inch (about 4,542 droplets/square centimeter). It should be noted that the potential for drift increases as droplet size decreases. Droplets smaller than 150 microns have increased potential for drift. Match nozzles to achieve the droplet size and water volume that is needed.

Droplet size can also greatly affect spray coverage. When yellow moisture-sensitive paper is sprayed with different nozzles at 50 gallons/acre (467.7 liters/hectare), the sprayed areas turn blue and the areas that are not touched by water remain yellow (Figure 1). Nozzles that produce smaller droplets improve coverage. This type of demonstration shows the effective coverage on a two-dimensional basis. The photographs show the coverage of an extremely coarse droplet size (left) versus the coverage of a medium droplet size on fair-

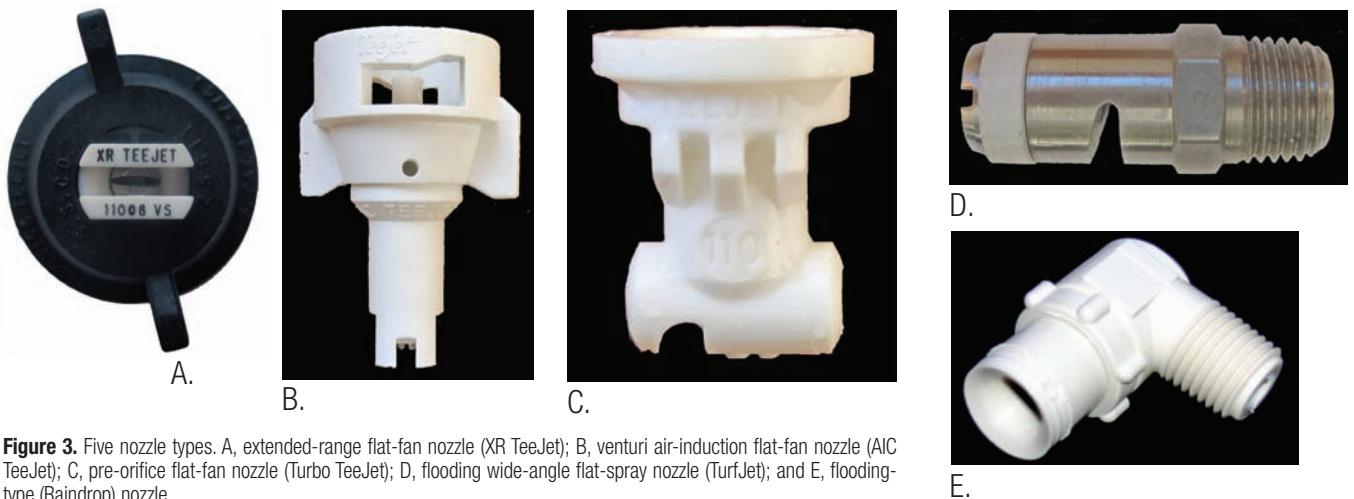
## DROPLET SIZE VS. PRESSURE

### XR Teejet (XR) and XRC TeeJet (XRC)

| Nozzle   | Pounds/square inch |    |    |    |    |    |    |
|----------|--------------------|----|----|----|----|----|----|
|          | 15                 | 20 | 25 | 30 | 40 | 50 | 60 |
| XR8001   | M                  | F  | F  | F  | F  | F  | F  |
| XR80015  | M                  | M  | M  | F  | F  | F  | F  |
| XR8002   | M                  | M  | M  | M  | F  | F  | F  |
| XR8003   | M                  | M  | M  | M  | M  | M  | F  |
| XR8004   | C                  | C  | M  | M  | M  | M  | M  |
| XR8005   | C                  | C  | C  | C  | M  | M  | M  |
| XR8006   | C                  | C  | C  | C  | C  | C  | C  |
| XR8008   | VC                 | VC | VC | C  | C  | C  | C  |
| XR11001  | F                  | F  | F  | F  | F  | VF | VF |
| XR110015 | F                  | F  | F  | F  | F  | F  | F  |
| XR11002  | M                  | F  | F  | F  | F  | F  | F  |
| XR11003  | M                  | M  | M  | F  | F  | F  | F  |
| XR11004  | M                  | M  | M  | M  | M  | F  | F  |
| XR11005  | M                  | M  | M  | M  | M  | M  | F  |
| XR11006  | C                  | C  | M  | M  | M  | M  | M  |
| XR11008  | C                  | C  | C  | C  | C  | M  | M  |

**Table 2.** Droplet size at different pressures.

# RESEARCH



**Figure 3.** Five nozzle types. A, extended-range flat-fan nozzle (XR TeeJet); B, venturi air-induction flat-fan nozzle (AIC TeeJet); C, pre-orifice flat-fan nozzle (Turbo TeeJet); D, flooding wide-angle flat-spray nozzle (TurfJet); and E, flooding-type (Raindrop) nozzle.

way-height creeping bentgrass (Figure 2).

## Target organism or pathogen

Chemical labels list rates, application intervals and recommended spray volumes per unit area for target pathogens. However, one is hard pressed to find a recommendation for droplet size on a label. Droplet size, chemical mode of action and the target pest are key considerations when selecting nozzles. When coverage is critical, such as with contact applications, nozzles with fine to medium droplets should be used to ensure thorough coverage of leaf surfaces. Nozzles that produce coarse to very coarse droplet sizes can be used for products that need to reach the lower turf canopy or the soil surface. These products are either watered in or applied at a higher water volume to move products down into the turf canopy and facilitate uptake by the roots and crowns of the turf.

## Location, location, location

Droplet size and spray volume are important for applications on greens, but applications are less of a problem because the area sprayed is relatively small, the turf is mowed at 0.156 inch (4 millimeters) or less and the leaves are smaller. Fairway applications, however, are more difficult because the grass is higher and a large area must be sprayed in as short a time as possible. Drift is also a consideration. Depending on the product being applied and the target pathogen, the goals are to select a nozzle that will deliver a droplet size that will either cover the foliage or penetrate to the crown; apply a spray volume that will give adequate coverage, especially for contact

products and products that are not watered in after application; and reduce drift.

## Target diseases

Nozzle manufacturers provide tables that list spray volumes per unit area for their nozzles at different pressures and speeds (Table 3). Foliar diseases such as dollar spot and brown patch are suppressed most effectively when fungicides are applied in spray volumes of 1 to 2 gallons/1,000 square feet (40.7-81.5 liters/1,000 square meters). Fungicides targeting root and crown diseases such as summer patch and basal rot anthracnose should be applied in a minimum volume of 2 gallons/1,000 square feet (81.5 liters/1,000 square meters). It is difficult to apply more than 2 gallons/1,000 square feet (81.5 liters/1,000 square meters) through some

nozzles, and these products may need to be watered-in after application. Knowing the mode of action of the products is also critical.

## Nozzle types

Four basic nozzle types are used for most turf applications (Figure 3). Several choices, including various spray angles and ranges of output volume, are associated with each type, depending on the goal of the application. Spray catalogs provide tables with the spray angle and volume output for each nozzle type.

*Extended-range flat-fan nozzles* are widely used because they provide excellent spray distribution over a wide range of pressures. Although drift can be reduced at lower pressures, better coverage is achieved at higher operating pressures. These nozzles produce a fine to coarse droplet size and are rated as excellent and good for contact and systemic fungicide applications, respectively.

*Air-induction nozzles* feature two orifices. A pre-orifice meters liquid flow and a second orifice forms the spray pattern. Between the two orifices, a venturi or air aspirator draws air into the nozzle, where it is mixed with the spray. Air bubbles formed within each droplet shatter on impact and therefore provide better coverage. Air-induction flat-fan nozzles produce a coarse to very coarse droplet size and are rated excellent for systemic applications and good for contact fungicides. They are also excellent nozzles for drift reduction.

*Pre-orifice flat-fan nozzles* reduce operating pressure internally and produce a larger droplet than conventional flat-fan nozzles. The pre-orifice restricts the amount of liq-

## KEYS TO SPRAYING

To increase your chances of spraying success, consider the following questions before you spray.

- What are you spraying for?
- What turf area are you spraying — greens or higher-cut turf?
- For diseases, is the pathogen on the foliage or in the soil?
- What product or products are you spraying, and what is their mode of action?
- What nozzle type and spray volume are you using?
- What is the tolerance for drift?
- What is the weight of the spray solution?
- What is the pressure range of the sprayer?
- What is the boom height and nozzle spacing on the boom?

uid entering the nozzle and creates pressure through the tip. Drift can be 50% less than drift with extended-range flat-fan nozzles. These nozzles are rated very good for both contact and systemic fungicides.

*Flooding wide-angle flat-spray nozzles and raindrop nozzles* produce extremely coarse droplet sizes. They are good choices for reducing drift and for applying products on soil. They are not recommended for general

fungicide applications where complete coverage of the turf is required.

### Golf course nozzle evaluation trials

In 2005, Syngenta, in cooperation with

## WATER VOLUME VS. PRESSURE

| Nozzle                | Pounds/<br>square<br>inch | Capacity<br>1 nozzle |               | Sprayer speed (miles/hour) |    |    |      |      |      |      |      |                           |      |      |      |
|-----------------------|---------------------------|----------------------|---------------|----------------------------|----|----|------|------|------|------|------|---------------------------|------|------|------|
|                       |                           |                      |               | 4                          | 5  | 6  | 8    | 10   | 12   | 15   | 20   | 2                         | 3    | 4    | 5    |
|                       |                           | Gallons/minute       | Ounces/minute | Gallons/acre               |    |    |      |      |      |      |      | Gallons/1,000 square feet |      |      |      |
| AIC11005<br>(50 Mesh) | 30                        | 0.43                 | 55            | 32                         | 26 | 21 | 16.0 | 12.8 | 10.6 | 8.5  | 6.4  | 1.5                       | 0.97 | 0.73 | 0.58 |
|                       | 40                        | 0.50                 | 64            | 37                         | 30 | 25 | 18.6 | 14.9 | 12.4 | 9.9  | 7.4  | 1.7                       | 1.1  | 0.85 | 0.68 |
|                       | 50                        | 0.56                 | 72            | 42                         | 33 | 28 | 21   | 16.6 | 13.9 | 11.1 | 8.3  | 1.9                       | 1.3  | 0.95 | 0.76 |
|                       | 60                        | 0.61                 | 78            | 45                         | 36 | 30 | 23   | 18.1 | 15.1 | 12.1 | 9.1  | 2.1                       | 1.4  | 1.0  | 0.83 |
|                       | 70                        | 0.66                 | 84            | 49                         | 39 | 33 | 25   | 19.6 | 16.3 | 13.1 | 9.8  | 2.2                       | 1.5  | 1.1  | 0.90 |
|                       | 80                        | 0.71                 | 91            | 53                         | 42 | 35 | 26   | 21   | 17.6 | 14.1 | 10.5 | 2.4                       | 1.6  | 1.2  | 0.97 |
|                       | 90                        | 0.75                 | 96            | 56                         | 45 | 37 | 28   | 22   | 18.6 | 14.9 | 11.1 | 2.6                       | 1.7  | 1.3  | 1.0  |
|                       | 100                       | 0.79                 | 101           | 59                         | 47 | 39 | 29   | 23   | 19.6 | 15.6 | 11.7 | 2.7                       | 1.8  | 1.3  | 1.1  |
| AIC11006<br>(50 Mesh) | 30                        | 0.52                 | 67            | 39                         | 31 | 26 | 19.3 | 15.4 | 12.9 | 10.3 | 7.7  | 1.8                       | 1.2  | 0.88 | 0.71 |
|                       | 40                        | 0.60                 | 77            | 45                         | 36 | 30 | 22   | 17.8 | 14.9 | 11.9 | 8.9  | 2.0                       | 1.4  | 1.0  | 0.82 |
|                       | 50                        | 0.67                 | 86            | 50                         | 40 | 33 | 25   | 19.9 | 16.6 | 13.3 | 9.9  | 2.3                       | 1.5  | 1.1  | 0.91 |
|                       | 60                        | 0.73                 | 93            | 54                         | 43 | 36 | 27   | 22   | 18.1 | 14.5 | 10.8 | 2.5                       | 1.7  | 1.2  | 0.99 |
|                       | 70                        | 0.79                 | 101           | 59                         | 47 | 39 | 29   | 23   | 19.6 | 15.6 | 11.7 | 2.7                       | 1.8  | 1.3  | 1.1  |
|                       | 80                        | 0.85                 | 109           | 63                         | 50 | 42 | 32   | 25   | 21   | 16.8 | 12.6 | 2.9                       | 1.9  | 1.4  | 1.2  |
|                       | 90                        | 0.90                 | 115           | 67                         | 53 | 45 | 33   | 27   | 22   | 17.8 | 13.4 | 3.1                       | 2.0  | 1.5  | 1.2  |
|                       | 100                       | 0.95                 | 122           | 71                         | 56 | 47 | 35   | 28   | 24   | 18.8 | 14.1 | 3.2                       | 2.2  | 1.6  | 1.3  |
| AIC11008<br>(50 Mesh) | 30                        | 0.69                 | 88            | 51                         | 41 | 34 | 26   | 20   | 17.1 | 13.7 | 10.2 | 2.3                       | 1.6  | 1.2  | 0.94 |
|                       | 40                        | 0.80                 | 102           | 59                         | 48 | 40 | 30   | 24   | 19.8 | 15.8 | 11.9 | 2.7                       | 1.8  | 1.4  | 1.1  |
|                       | 50                        | 0.89                 | 114           | 66                         | 53 | 44 | 33   | 26   | 22   | 17.6 | 13.2 | 3.0                       | 2.0  | 1.5  | 1.2  |
|                       | 60                        | 0.98                 | 125           | 73                         | 58 | 49 | 36   | 29   | 24   | 19.4 | 14.6 | 3.3                       | 2.2  | 1.7  | 1.3  |
|                       | 70                        | 1.06                 | 136           | 79                         | 63 | 52 | 39   | 31   | 26   | 21   | 15.7 | 3.6                       | 2.4  | 1.8  | 1.4  |
|                       | 80                        | 1.13                 | 145           | 84                         | 67 | 56 | 42   | 34   | 28   | 22   | 16.8 | 3.8                       | 2.6  | 1.9  | 1.5  |
|                       | 90                        | 1.20                 | 154           | 89                         | 71 | 59 | 45   | 36   | 30   | 24   | 17.8 | 4.1                       | 2.7  | 2.0  | 1.6  |
|                       | 100                       | 1.26                 | 161           | 94                         | 75 | 62 | 47   | 37   | 31   | 25   | 18.7 | 4.3                       | 2.9  | 2.1  | 1.7  |
| AIC11010              | 30                        | 0.87                 | 111           | 65                         | 52 | 43 | 32   | 26   | 22   | 17.2 | 12.9 | 3.0                       | 2.0  | 1.5  | 1.2  |
|                       | 40                        | 1.00                 | 128           | 74                         | 59 | 50 | 37   | 30   | 25   | 19.8 | 14.9 | 3.4                       | 2.3  | 1.7  | 1.4  |
|                       | 50                        | 1.12                 | 143           | 83                         | 67 | 55 | 42   | 33   | 28   | 22   | 16.6 | 3.8                       | 2.5  | 1.9  | 1.5  |
|                       | 60                        | 1.22                 | 156           | 91                         | 72 | 60 | 45   | 36   | 30   | 24   | 18.1 | 4.1                       | 2.8  | 2.1  | 1.7  |
|                       | 70                        | 1.32                 | 169           | 98                         | 78 | 65 | 49   | 39   | 33   | 26   | 19.6 | 4.5                       | 3.0  | 2.2  | 1.8  |
|                       | 80                        | 1.41                 | 180           | 105                        | 84 | 70 | 52   | 42   | 35   | 28   | 21   | 4.8                       | 3.2  | 2.4  | 1.9  |
|                       | 90                        | 1.50                 | 192           | 111                        | 89 | 74 | 56   | 45   | 37   | 30   | 22   | 5.1                       | 3.4  | 2.6  | 2.0  |
|                       | 100                       | 1.58                 | 202           | 117                        | 94 | 78 | 59   | 47   | 39   | 31   | 23   | 5.4                       | 3.6  | 2.7  | 2.1  |

Table 3. Water volume amounts from different nozzles at different pressures. Optimal spacing between nozzles is 20 inches (50.8 centimeters).

# RESEARCH

Michael Fidanza, Ph.D., Penn State University (Reading), and John Kaminski, Ph.D., University of Connecticut (Storrs), initiated the first phase of the nozzle evaluation program on the golf course. The goals were to verify preliminary findings and to determine the proper nozzle for the application of Daconil Ultrex (contact fungicide), Banner Maxx (acropetal penetrant) and the combination of the two when applied at 44 gallons of water carrier per acre (411.6 liters/hectare). The nozzles being tested all spray a flat-fan pattern, and the droplet sizes range from fine to extremely coarse.

Although this is an ongoing study, early observations suggest that, in this study, the nozzle that was used was more important than the fungicide. Whichever fungicide was sprayed through a nozzle emitting a fine to coarse spray droplet was the best one for controlling dollar spot and brown patch. In contrast, the fungicide that was applied with a nozzle that sprayed an extremely coarse droplet, regardless of spray pattern, provided the worst control. (For more tips, see the sidebar, "Keys to spraying.")

Figure 4 is from a trial conducted on a creeping bentgrass driving range in southeastern Pennsylvania. Fungicides were applied at the low recommended label rates so as to allow some disease to develop within the plots. All fungicides, regardless of nozzle type, reduced dollar spot when compared to the untreated control plots. In all cases, fungicides applied

## THE RESEARCH

says . . .

- **In an attempt** to apply fungicides quickly, superintendents may be choosing the wrong nozzle and getting inadequate spray coverage.
- **Spray nozzles determine** the amount of chemical applied to an area, uniformity and coverage on the target, and potential drift.
- **The nozzle type** may vary according to the target disease or organism, the location being sprayed, the amount of overlap desired and the desired droplet size.
- **Preliminary results show** that using the wrong nozzle for fungicide applications decreases the efficacy of the application.

with nozzles that emitted a fine or medium droplet size provided the best disease control. When fungicides were applied through a nozzle that emitted an extremely coarse droplet size, there was less disease control. This is an example of several observations recorded in 2005.

### Conclusions

Syngenta is continuing to conduct research with nozzles and application volumes for various products. Several university trials are currently in progress in Pennsylvania and Connecticut to further investigate nozzle selection and effective fungicide application strategies on turfgrass. Studies testing other fungicides are being planned. Furthermore, everyone involved is gathering information from on-site visits and from audience feedback at technical presentations.

We have determined that nozzles are often

an overlooked piece of the puzzle when problems with product performance arise. The most common factors involved in product failure that we see are spray volumes that are too low and spray droplets that are too large to provide the complete coverage needed to control certain diseases. When multiple products are sprayed, clogged nozzles can be a problem, which can be reduced by using an in-line screen or changing the nozzle type.

We are not recommending that superintendents change their spray program if they are getting positive results, but we want to make sure they realize that options are available for nozzle selection. Superintendents should ask for nozzle information from the manufacturer or supplier.

#### Funding

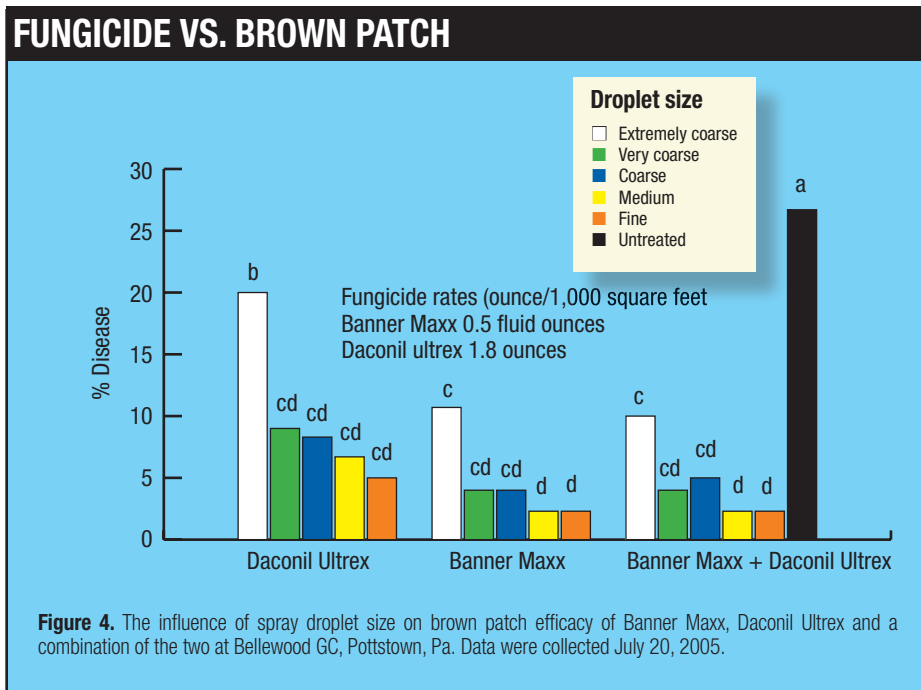
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**Figure 4.** The influence of spray droplet size on brown patch efficacy of Banner Maxx, Daconil Ultrex and a combination of the two at Bellewood GC, Pottstown, Pa. Data were collected July 20, 2005.

Dennis Shepard (dennis.shepard@syngenta.com) and Michael Agnew are technical managers for Syngenta Professional Products in Greensboro, N.C. Michael Fidanza is an associate professor of horticulture at Penn State University, Reading; John Kaminski is an assistant professor in turfgrass pathology at the University of Connecticut, Storrs; and Luke Dant is a recent graduate of Iowa State University, Ames, and is currently working for Syngenta.