Calibrations and Conversions

Proper sprayer calibration is vital to assure successful application of herbicides, insecticides and fungicides. Constant observation of sprayer operating conditions and frequent calibration of the equipment are necessary to avoid problems.

Machine Sprayer Calibration
The first step is to determine the speed that the sprayer will be traveling in the field in feet per minute. Equipment speedometers are not always accurate. Therefore, a distance should be measured, traveled and timed in seconds. This should be done when field conditions are normal.

Multiply sprayer speed by nozzle spacing to determine the area sprayed per minute by each nozzle.

\[
\text{Speed} = \frac{\text{distance (feet)}}{\text{time (sec.)}} \times 60 \text{ sec./min.}
\]

\[
\text{Area acres/minute} = \text{speed} \times \text{feet/minute} \times \text{nozzle spacing (inches)} \times \frac{1 \text{ foot}}{12 \text{ inches}} \times \frac{1 \text{ acre}}{43,560 \text{ sq. ft.}}
\]

Collect the spray output from each nozzle for a set period of time (some fraction of a minute), and determine the average volume per nozzle per minute. Consider replacing individual nozzles that vary more than 5% from the average of all nozzles.

\[
\text{Output gal./minute} = \frac{\text{volume (fl. oz.)}}{\text{time (sec.)}} \times 60 \text{ sec./min} \times \frac{1 \text{ gal.}}{128 \text{ fl. oz.}}
\]

\[
\text{Output gal./minute} = \frac{\text{volume (ml)}}{\text{time (sec.)}} \times 60 \text{ sec./min} \times \frac{1 \text{ gal.}}{3,785 \text{ ml}}
\]

Then, divide the average nozzle output by the area sprayed gallons per acre.

\[
\text{gal./acre} = \frac{\text{gal./minute}}{\text{acre/minute}}
\]

Hand Sprayer Calibration
Hand sprayers are usually used for applying chemicals to small areas. Hand sprayers may be calibrated as follows: determine the square feet in an area, measure the output of the handgun for one minute, and calculate how fast the measured area should be covered. Then mix enough chemical to cover the area and apply all of the chemical to the area as evenly as possible.

\[
\text{Example:} \text{ You measure an area 21 feet by 21 feet. This is approximately 1/100 acre. Your handgun puts out one gallon in one minute and the chemical should be applied at the rate of 25 gallons per acre. In this case: 1/100 acre = .01 ac.}
\]

\[
\text{Gallons} = 25 \text{ GPA} \times .01 \text{ ac.} = .25 \text{ gallons}
\]
If the area should be covered with one quart of spray and your handgun puts out one gallon per minute, you should cover the area in:

\[\frac{0.25 \text{ gal.}}{0.5 \text{ gal./min.}} = 0.5 \text{ minutes or 30 seconds}\]

**How Much Chemical to Put in the Tank**

To determine the amount of pesticide to add to the spray tank, you need to know the recommended rate of pesticide, the capacity of the spray tank and the calibrated output of the sprayer.

The recommended application rate is usually indicated as pounds per acre for wettable powders, and pints, quarts or gallons per acre for liquids. The recommendation can also be given as pounds of active ingredient (lb. AI) per acre rather than the amount of total product per acre. The active ingredient must be converted to actual product.

Be sure your spray tank has accurate markings on the side so you can determine the amount of spray mix remaining in the tank. This is needed so you don’t add more or less chemical than is needed. Be sure to place your sprayer on level ground so an accurate reading can be made.

Most pesticides are sold as formulations in which the active ingredient (AI) is combined with a carrier of water, oil or an inert material. Once you’ve chosen the chemical and the formulation, you must determine the amount of spray mix needed for the application. This will depend on the tank size, the spray volume per acre, the acres to cover and the required application rate given on the product label.

**Liquid Application Example**

A liquid recommendation calls for 0.5 pound of active ingredient (AI) per acre. The pesticide contains 4 pounds (AI) per gallon formulation. The sprayer being used has a 500-gallon tank and is calibrated at 8 gallons per acre. How much product should be added to the spray tank?

**Step 1.** Determine the number of acres that can be sprayed with each tankful.

\[
\begin{align*}
\text{Tank capacity} & \ (\text{gallons per tank}) & 500 \\
\text{Spray rate} & \ (\text{gallons per acre}) & 8 \\
\end{align*}
\]

\[\frac{500}{8} = 62.5 \text{ acres per tankful}\]

**Step 2.** Determine the amount of product needed per acre by dividing the recommended AI per acre by the concentration of the formulation.

\[\frac{0.5 \text{ lb. AI per acre}}{4 \text{ lb. AI per gallon}} = .125 \text{ gallon}\]

or 1 pint per acre

One pint of product is needed for each “acre’s worth” of water in the tank to apply 0.5 pound of active ingredient (AI) per acre.
Step 3. Determine the amount of pesticide to add to each tankful. Each tankful will cover 62.5 acres (Step 1), and 1 pint of product per acre (Step 2) is needed. Add 62.5 pints (62.5 acres x 1 pint per acre = 62.5 pints) of pesticide to each tank. This is equal to 7 gallons and 6.5 pints of chemical.

**Dry Application Example**

A dry product recommendation calls for 2 pounds of active ingredient (AI) per acre. The product is an 80 percent dry flowable. The sprayer is calibrated for 9 GPA and the tank holds 540 gallons. How much product should be added to the spray tank?

**Step 1.** Determine the number of acres that can be sprayed with each tankful.

- **Tank capacity (gallons per tank)** 540
- **Spray rate (gallons per acre)** 9

\[
\frac{540}{9} = 60 \text{ acres per tankful}
\]

**Step 2.** Determine the pounds of product needed per acre. Because not all of the material in the bag is active ingredient, more than 2 pounds of the product must be added to each “acre’s worth” of water in the tank. How much more? The calculation is: divide the percentage of active ingredient (80) into the total (100) and multiply by the active ingredient needed per acre. This gives the pounds of product to add to the tank for each acre covered.

\[
\frac{2 \text{ lb. AI per acre} \times 100}{80} = 2.5 \text{ lb. of product per acre}
\]

Two and one half pounds of product are needed for each “acre's worth” of water in the tank to apply 2 pounds of active ingredient per acre.

**Step 3.** Determine the amount of pesticide to add to each tankful. Each tankful will cover 60 acres (Step 1) and 2.5 pounds of product per acre is needed (Step 2). Add 150 pounds (60 acres x 2.5 pounds per acre = 150 pounds) of product to each tank.

**Adjuvants**

(Spreaders – Sticker, Surfactant, Etc.)

The manufacturer may recommend a small amount of adjuvant be added in addition to the regular chemical. This recommendation is often given as “percent concentration.”

If an adjuvant at a 0.25 percent concentration by volume is recommended, how much should be added to a 500-gallon tank?
Solution:
1 percent of 100 gallons = 1 gallon
NOTE: 1 percent = 0.01
(100 gal. x 0.01 = 1 gal.)
0.25 percent = 0.0025
0.0025 of 100 gallons = .25 gallons or 1 quart

You will need 1 quart per 100 gallons, or 5 quarts for 500 gallons (.25 x 5 = 5 qts.)

Pesticide Mixing and Loading Checklist
With all the pressures of the growing season, don’t overlook safety precautions when handling pesticides. If you mix pesticides often, consider building a pesticide mixing and loading facility with a spill containment pad. If not using a pad, do not mix and load in the same place each time to avoid buildups of contamination from splashes and spills. Cleanup all spills according to label directions.

The following checklist is a reminder to take the time to handle pesticides carefully when mixing and loading them.

General Handling Recommendations
• Read the label carefully and take notice of personal safety and environmental precautions.
• Remember that labels may change from year to year, so re-read the label instructions whenever you purchase new containers.
• Mix only what is required for the area to be sprayed so that you will not have leftover chemicals. Never exceed labeled rates.
• Maintain a distance of at least 100 feet between the mixing and loading site and wellheads, ditches, streams or other water sources.
• Mix wettable powders with water in a bucket to form a slurry before adding to the spray tank.

The Right Mix
Use the W-A-L-E method when mixing different formulations together in the tank:
1. To the diluent (usually water):
2. add Wettable powders and water-dispersible granules,
3. Agitate the mix thoroughly,
4. add Liquids, surfactants and flowables,
5. add Emulsifiable concentrates last.

Compatibility Testing
When mixing two or more products, always check the label for any warnings about incompatibility. Use the “jar test” to determine if the components of a pesticide mixture are chemically and physically compatible.
1. Use a clear glass quart jar.
2. Add 1 pint of water from the same water source that you will be using for tank mixes.
3. Add the pesticides in correct proportions in the W-A-L-E order. For liquid formulations, use a teaspoon measure for each pint/100 gallons of final spray mixture. For dry formulations, use a tablespoon for each pound/100 gallons of final spray mixture.
4. Once you have mixed all of the components and thoroughly shaken the jar, allow it to stand for 15 to 60 minutes (longer time is better).
5. If the contents heat up or form clumps, scum or other solids, they are not compatible.

6. If the mix is not compatible and you did not use a compatibility agent on the first test, repeat the process with a proportionate amount of a compatibility agent. If the mix is compatible, add pesticides to the spray tank in the same order that they were added in the test.

**Warning:** Chemical compatibility does not guarantee that the mixture will perform as expected. Combinations of some active ingredients can cause plant damage or phytotoxicity. In some cases, mixing chemicals together may cancel their effectiveness; in other cases, the effectiveness of some products may increase when they are applied together. Consider applying the mixture at the labeled rate to a test area in the field. Look for any damage or control failures. You have a compatible mix if no adverse effects are observed.

**Equivalents for Liquid Measure (volume)**

<table>
<thead>
<tr>
<th>Gallons</th>
<th>Quarts</th>
<th>Pints</th>
<th>Fluid Ounces</th>
<th>Cupfuls</th>
<th>Tablespoonful</th>
<th>Teaspoonful</th>
<th>Milliliters</th>
<th>Liters</th>
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<td>0.001</td>
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**Equivalents for Dry Measure and Weight**

**Dry Measure**
3 level teaspoonfuls = 1 level tablespoonful
16 level tablespoonfuls = 1 cupful
2 cupfuls = 1 pint
2 pints = 1 quart

**Weight**

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<thead>
<tr>
<th>Pounds/Ounces</th>
<th>Metric</th>
</tr>
</thead>
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<tr>
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<td>100 kilograms (kg)</td>
</tr>
<tr>
<td>100 pounds</td>
<td>45.349 kilograms</td>
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<tr>
<td>2.204 pounds</td>
<td>1 kilogram</td>
</tr>
<tr>
<td>1.102 pounds</td>
<td>.500 grams</td>
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<tr>
<td>1 pound/16 ounces</td>
<td>.453.5900 grams</td>
</tr>
<tr>
<td>8 ounces</td>
<td>.226.78 grams</td>
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<td>4 ounces</td>
<td>.113.39 grams</td>
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<tr>
<td>3.527 ounces</td>
<td>110 grams</td>
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<td>2 ounces</td>
<td>.56.70 grams</td>
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<td>1 ounce</td>
<td>.28.35 grams</td>
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<tr>
<td>3/4 ounce</td>
<td>.21.25 grams</td>
</tr>
<tr>
<td>1/2 ounce</td>
<td>.14.17 grams</td>
</tr>
<tr>
<td>1/4 ounce</td>
<td>.7.08 grams</td>
</tr>
</tbody>
</table>
1/8 ounce ............................ 3.54 grams
1/16 ounce .......................... 1.77 grams
1/32 ounce .......................... 885 milligrams
1/64 ounce .......................... 442 milligrams
1/128 ounce ........................ 221 milligrams

Ounces-to-Grams

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<th>Ounces</th>
<th>Grams</th>
</tr>
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<td>14.75</td>
</tr>
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<td>1/32</td>
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</tr>
<tr>
<td>1/4</td>
<td>7.087</td>
</tr>
</tbody>
</table>

Metric System Conversion Table

Liquid Capacity
1 fluid ounce (fl. oz.) ........................ = 30 milliliters (ml)
1 pint (pt.) = 16 fl. oz. ........................ = 473 ml
1 quart (qt.) .............................. = 946 ml
1 gallon (gal.) ......................... = 3,785 ml
1 liter .................................... = 1,000 ml
1 milliliter (ml) ....................... = 1 cubic centimeter (cc)

Dry Material Capacity
1 ounce (avoirdupois) ........................ = 28.4 grams (g)
1 pound (lb.) ................................ = 453.6 g
1 kilogram (kg) ............................ = 1,000 g = 2.2 lb.

Volume
1 cubic inch (in.³) ....................... = 16.4 milliliters (ml)
1 cubic foot (ft.³) ...................... = 7.48 gal. = 28.3 liters (l)
1 bushel (bu) ............................. = 1.24 ft.³ = 35.2 liters
1 cubic yard (yd.³) ..................... = 21.7 bu = 765 liters
Linear
1 inch (in.) ................................................. = 2.54 centimeters (cm.)
1 foot (ft.) ................................................ = 30.48 cm.
1 yard (yd.) ............................................... = 91.44 cm.
1 meter (m) ............................................... = 100 cm

Area
1 square inch (in.²) ..................................... = 6.45 square centimeters (cm.²)
1 square foot (ft.²) ...................................... = 0.09 square meter (m²)
1 square yard (yd.²) .................................... = 0.84 square meter (m²)
1 acre (a) ................................................... = 0.40 hectare (ha)
1 square mile (M²) ..................................... = 2.59 square kilometer (km.²)

Miscellaneous Conversions Used in Fertilizer Calculations
1 millimeter or cubic centimeter of water weighs 1 gram
1 liter of water weighs 1 kilogram
1 gallon of water weighs 8.34 pounds

1 part per million (ppm) = 0.0001 percent
1 part per million = 1 milligram/liter
1 part per million = 0.013 ounces in 100 gallons of water

1 percent = 10,000 ppm
1 percent = 10 grams per liter
1 percent = 10,000 grams per kilogram
1 percent = 1.33 ounces by weight per gallon of water
1 percent = 8.34 pounds per 100 gallons of water
0.1 percent = 1,000 ppm = 1,000 milligrams per liter
0.01 percent = 100 ppm = 100 milligrams per liter
0.001 percent = 100 ppm = 10 milligrams per liter
0.0001 percent = 100 ppm = 1 milligram per liter

Approximate Weight-Volume Measurements for Making Small Volumes of Water-Soluble Fertilizers
1 cup = 8 oz. or 0.5 lb. of fertilizer
2 cups = 1 lb. of fertilizer
1 tablespoon = 0.5 oz. of fertilizer
2 tablespoons = 1 oz. of fertilizer

Useful Conversions
1 ton/acre = 20.8 grams/square foot
100 lbs./acre = 0.2296 lbs./100 square feet
1 ton/acre = 1 lb./21.78 square feet
grams/square foot x 96 = lbs./acre
1 gram/square foot = 96 lbs./acre
lbs./square foot x 43,560 = lbs./acre
1 lb./acre = 0.0104 g/square foot
100 square feet = 1/435.6 or 0.002296 acres
100 lbs./acre = 0.2296 lbs./100 square feet
Weight Conversions From lbs./A to Weight/100 sq. ft.

<table>
<thead>
<tr>
<th>lbs./acre</th>
<th>amount applied/100 sq. ft.</th>
<th>lbs./acre</th>
<th>amount applied/100 sq. ft.</th>
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</thead>
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<tr>
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<td>1 lb 10 oz.</td>
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<tr>
<td>200</td>
<td>7.4 oz.</td>
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<td>1 lb 13 oz.</td>
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<td>11.1 oz.</td>
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<td>2 lb 1 oz.</td>
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<td>14.8 oz.</td>
<td>1000</td>
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<tr>
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</tr>
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Percent to Ratio Conversion

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<th>Ratio</th>
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</tr>
<tr>
<td>1.5%</td>
<td>1:67</td>
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<td>1:100</td>
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<tr>
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Temperature Conversion

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NOTES:
1) To convert temperature in degrees from Centigrade (Celsius) to temperature in degrees Fahrenheit: Multiply Centigrade temperature by 1.8 and add 32.
2) To convert temperature in degrees Fahrenheit to temperature in degrees Centigrade (Celsius): Subtract 32 and multiply by 0.55.
Optimizing and Measuring Spray Coverage

Kurt Becker, Dramm Corporation

One of the least preferred and most time consuming jobs in the greenhouse is the application of pesticides for the control of disease and insects, unfortunately it is also one of the most important. By using common sense and a few simple techniques, this arduous task can become easier and more effective, though probably not any more popular. This article will provide some of these techniques and hopefully some common sense as well.

Choose Your Weapon.
There are many different ways to spray your crop. From the hand-pump sprayer to the automatic low-volume applicator, each machine has its strengths and its weaknesses and each has its place in the greenhouse. Typically the sprayer world is divided into two camps: high volume and low volume. These titles refer to the amount of water applied as a carrier. High volume sprays are generally wet, employ particles larger than 100µ (microns), and are targeted or directed sprays. Low volume sprays are generally much drier sprays and use smaller particles. They can be either targeted or space treatment sprays. Each of these sprayers has its use in effective pest management. High volume hydraulic sprayers are effective spot treatment tools, they are useful when the chemical being applied needs more water to be effective and they are well suited to controlling certain pests. Targeted low volume sprayers are most often faster than standard hydraulic sprayers as they use less water as a carrier. They employ smaller particles and often cover more surface area at greater distances. In comparison to space treatment low volume sprayers they are more flexible, offering the ability to treat areas selectively. They can often be used in shade houses and outdoors with no wind. Thermal foggers are the fastest method of chemical application. They have the ability to treat large areas and great distances as much as 50 times faster than traditional methods. They create ultra-fine particles (10-20µ) that can remain airborne for several hours, enveloping the plants in a fog and covering both upper and lower leaf surfaces. Automatic aerosol generators work similarly, creating billions of micro-particles (5-10µ) but they do this more slowly. Their advantage is that their operation is automatic. No operator is needed during the application. But, because no one is there to direct the spray, proper machine placement and air movement are critical to ensure maximum coverage. Both the thermal foggers and the automatic aerosol generators must be used in enclosed spaces and cannot be used selectively.

Your equipment choice may be based on the crop, the crop stage, the pest, the size of area to be treated, the timing of spray, the time needed to apply and the type of chemical being used. Here is where common sense enters. Obviously it will take a great deal of time to spray one acre of bedding plants with a two gallon hand-pump sprayer. Conversely it may be overkill to use your Dramm Autofog to treat the same area when your only unwanted guests are five aphids in the corner of the greenhouse. No one sprayer will do every job. For best results, growers should own several types of spray equipment. Growers should view their sprayers as tools in a tool box, each has its individual use. A flat-head screwdriver will work great on flat head screws, it may do okay on some Phillips head screws but it makes a lousy hammer.

Size Matters.
Droplet particle size is an important consideration when applying pesticides. Standard hydraulic sprays vary in coarseness from 100µ to 500µ. While the term low volume refers to the amount of solution applied to a given area, targeted low volume sprays are typically less than 100 µ with aerosol low volume sprays generally below 25 µ. Generally the finer the spray and the smaller the particle size the more surface area that spray will cover. Because the mathematical relationship between particle size and volume is a cubic one, reducing the particle size by 50% increases the number of droplets available to cover plant surfaces by approximately 800%. For example: reducing the particle size of a spray droplet from 100µ to 50µ, each 100µ droplet yields 8 - 50µ droplets. These 8 droplets are able to cover a much greater area that the one 100µ droplet. This relationship explains the efficacy of low volume sprays in their ability to cover large areas with less water. For example one 100µ particle can be separated into 1,005 ten micron particles. Imagine you are an...
Aphid; a droplet of pesticide solution measuring 100µ will seem like a small boulder while 1,005 droplets will seem like gravel under your feet. As an aphid you can walk around the boulder but you are unable to avoid the gravel.

Additionally particle size is also an important consideration in controlling run-off. The smaller the particle, the less effect gravity has on it. This combined with reduced volumes of water means less run-off. This is not to say that only low volume sprays are effective. Particle size has a great effect on hydraulic sprays as well. Again, the difference between a 200µ droplet and one 50% of its size is that there will be 8 times as many 100µ droplets. Additionally, a 100µ droplet is smaller and has less mass. This allows the droplet to be more affected by the turbulence of the spray and less by the spray’s forward inertia (the tendency to travel in a straight line). The more swirling in the spray the greater the under leaf coverage. While the science behind these techniques may be complicated the results are not. Smaller particle sizes mean more area covered with less water and less run-off.

Train Yourself.
Taking time to learn how to use each sprayer in your arsenal will affect your performance greatly. For instance, there is a big difference in spray technique when using a Dramm Heavy Duty Sprayer when compared to a Dramm Coldfogger. Both use hydraulic pumps but one is a standard high volume machine and the other is a low volume machine. Each is operated by aiming at the crop, but the size, quantity and velocity of the droplets is different for each unit. By learning the characteristics of each machine in your arsenal, you can maximize their effectiveness.

In addition to learning about your equipment, practice using each machine. Fill your equipment with water and go out, not with the aim of killing bugs, but with the goal of getting the best coverage. Try different techniques and angles of attack. The most common technique mistake that we see regularly is that people spray too close to the plant. This gets the plants wetter than needed, wasting chemical, and it limits the circulation of fine droplets to the underside of the leaves. Additionally by spraying at greater distances, your angle of attack naturally changes to a more lateral angle. This is often the best way to get better under leaf coverage.

Measure Your Results.
By using several commercially available tools it is possible to gauge your spray coverage with each type of equipment. Fluorescent dyes sold by Day-Glo Color Corporation of Cleveland, Ohio (216/391-7070) or Hydrosensitive Paper available from The Dramm Corporation of Manitowoc, WI (800/258-0848) are excellent tools for determining spray coverage. By using a dye in your tank or by paper-clipping small pieces of hydrosensitive paper throughout the crop it is possible to see where you are effective and where your technique needs help.

In general the dye is best for ultra-low volume sprays as the spray droplets are often too small to register on the hydrosensitive paper, but these can be messy. For best viewing use a black light with the Blaze Orange dye. When training with hydraulic or targeted low-volume equipment the hydrosensitive paper is a less colorful way of determining coverage. It will yield excellent results and requires less cleaning.

Time Yourself.
With any sprayer being used you should know the output rate. By combining this with the volume of solution you are going to use in a given area you can even your pesticide coverage throughout the house. For example, if you know that you are going to apply 40 gallons of a high volume spray to a greenhouse and you know the output rate is 1 gallon per minute (gpm), you know that it will take 40 minutes to empty the tank. Therefore at 10 minutes you should have completed 1/4 of the area to be treated, at 20 minutes 1/2 of the area should be finished. Too often either too much or too little solution will be left near the end of the greenhouse. This means that the end of the house will either get blasted or not get enough coverage. By metering your application speed you will ensure more even coverage throughout the entire greenhouse. Keep a clock handy.
**Time Your Application.**
With REI and Worker Protection Standards, timing is less of an issue than in the past. However, the timing of the chemical application can make a big difference in the efficacy. Ultra-low volume sprays during the heat of the day are not possible because of the need to close the greenhouse and turn off all ventilation. Hydraulic sprays in the mid-day sun may cause burning of the crop because of large droplet evaporation. Keep in mind the various factors that limit your spray applications and consider them when choosing the equipment, chemical and time of application.

**Check Nozzle Accuracy.**
With many of the other factors in proper chemical application dependent on accurate nozzle output and particle size, it is very important to regularly check your nozzles for accuracy and replace them when worn. If your nozzles are worn, your output is not what you would expect. Over time, nozzles wear due to abrasion and erosion, increasing the size of the nozzle orifice. This will change the output, the spray pressure and the particle size. For instance, imagine that you are applying 20 gallons to an area and you are metering your application speed (see above). Your sprayer usually applies 1 gpm, but because of nozzle wear it is now spraying 1.5 gpm. It won’t take long before you are rushing to finish as you realize that you don’t have enough solution left to complete the rest of the house. Remember that your particle size has also changed as a result of this nozzle wear and may affect your spray coverage.

Keep in mind that chemical application is only one part of a good integrated pest management program. By controlling other factors in the greenhouse and combining them with effective spray application management you will be able to keep greenhouse pests and diseases under control.

1 Micron (µ) - a unit of measurement equal to 0.0001 cm or 0.000039 in. 100 µ is the width of a human hair.