Backpack Sprayers

Modified for Small Farm Crop Protection
Rutgers Snyder Research & Extension Farm Staff
Edited by John Grande and Jack Rabin

Companion Handouts for the Backpack Sprayer Videos
Materials List
Sprayer Calibration
Rate Calculation
Choosing Nozzles
Product Measuring Supply List

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# Backpack Sprayers

## Video 2 Companion Handout

### Materials List – Spraywand Conversion to TeeJet System

No endorsement is implied for products and manufacturers listed here. Resources are listed for informational purposes only.

<table>
<thead>
<tr>
<th>Part Description – catalog No.</th>
<th>Supplier Sources</th>
<th>List Price (2012)</th>
</tr>
</thead>
<tbody>
<tr>
<td>* 3/8” ID rubber chemical resistant spray hose</td>
<td>Multiple</td>
<td></td>
</tr>
<tr>
<td>** CF pressure regulating valve – 11/16” straight thread (other available) 14.5 psi – Yellow 21 psi – Red 29 psi – Blue</td>
<td>Gate CFV Solutions (772) 202-7783 Purchase the 11/16” straight thread <a href="http://www.gatecfv.com">http://www.gatecfv.com</a></td>
<td>$19.95 each</td>
</tr>
<tr>
<td>TeeJet strainer &amp; check valve 50 mesh – 4193-PP Specify matching psi</td>
<td>**** TeeJet Spraying Systems</td>
<td></td>
</tr>
<tr>
<td>4” barbed swivel – 11990-61</td>
<td>TeeJet Spraying Systems</td>
<td>$17.66</td>
</tr>
<tr>
<td>Valve handle - 4727</td>
<td>TeeJet Spraying Systems</td>
<td>$12.32</td>
</tr>
<tr>
<td>*** Trigger valve – brass – 6466 (alternate trigger valve – plastic – B22650-PP-1/4)</td>
<td>TeeJet Spraying Systems</td>
<td>$52.71</td>
</tr>
<tr>
<td>** 24” brass curved extension – 6671-24”</td>
<td>TeeJet Spraying Systems</td>
<td>$18.07</td>
</tr>
<tr>
<td>Quick TeeJet 11/16” nozzle body – QJT-NYB</td>
<td>TeeJet Spraying Systems</td>
<td>$5.25</td>
</tr>
<tr>
<td>Turbo FloodJet – TF-VS2 or VS3</td>
<td>TeeJet Spraying Systems</td>
<td>$13.56</td>
</tr>
<tr>
<td>TeeJet spray tips many available</td>
<td>TeeJet Spraying Systems</td>
<td></td>
</tr>
<tr>
<td>Gasket – nylon – CP8635-NY</td>
<td>TeeJet Spraying Systems</td>
<td>$1.54</td>
</tr>
<tr>
<td>Rubber seal gasket – CP18999-EPR</td>
<td>TeeJet Spraying Systems</td>
<td>$1.11</td>
</tr>
<tr>
<td>Quick TeeJet caps – 25600-NYR</td>
<td>TeeJet Spraying System</td>
<td>$1.22</td>
</tr>
<tr>
<td>MeterJet spray gun for dose spot treatments</td>
<td>TeeJet Spraying Systems</td>
<td>$150.21</td>
</tr>
</tbody>
</table>

* Replace hose only if existing OEM hose inadequate  
** Gate CFV Solutions (Global Agricultural Technology and Engineering), 100 Sebastian Industrial Place, Sebastian, FL 32958 USA, 772-202-7783; http://gatecfv.com/  
*** Brass trigger valve can be substituted with plastic to save money for light duty use  
**** TeeJet Spraying Systems, 124A West Harrisburg St., Dillsburg, PA 17019 717-432-7222 www.teejet.com
Sprayer Characteristics

Our comparison testing determined that sprayer designs with the following four characteristics worked better than others:

1) Sprayers with large internally mounted piston pumps are more efficient. An internally mounted pump that leaks is much better than an externally mounted pump that leaks, reducing your exposure to pesticides.

2) Leveraging pump handle designs reduce arm fatigue operating the pump.

3) Lightweight tank design and carrier system to reduce overall weight.

4) Large fill spouts offset to the side to allow for easier filling and pouring out of products along with a pickup handle in the middle of the sprayer which is a nice addition to handling a fairly heavy item when filled with solution.

Model Availability Updates

Gate pressure regulating valve manufacturer source changed to Gate CFV, www.gatecfv.com, April 2015.

Worldwide manufacturing of sprayer brands and models changes over time.

As of 2013, the Shindaiwa SP415 shown on the videos, and a very efficient backpack sprayer in our evaluations, is no longer sold.

Jacto model SP416 is a new model in 2013, with similar specifications and performance as the Shindaiwa SP415. The Jacto SP416 has a new trigger valve that accepts the 24-inch TeeJet brass extension shown in our materials list. Adding TeeJet trigger valve and valve handle, while not a necessary accessory, enables use of the TeeJet barbed swivel, improving the spraywand balance and user comfort.

H.D. Hudson offers a sprayer, model 93594 Regulator™ Bak-Pak® Poly 4 gal, which is similar in features to the Jacto SP 416 but requires complete spray wand replacement for TeeJet conversion. Also offered is a good quality rechargeable battery powered backpack sprayer, NeverPump® Bak-Pak® Sprayer Model 13854.

Updated April 2015, J. Grande, J. Rabin

http://snyderfarm.rutgers.edu/Backpack-Sprayers-Video2.html
Backpack Sprayers

Video 4 Companion Handout

Backpack Sprayers Apply Products Accurately with Proper Calibration

Calibration

This instruction assumes your backpack sprayer is set up with a CF valve as shown in the companion videos, and utilizes a TeeJet nozzle with gallons per minute (GPM) specified in the products catalog.

Three factors are required to be determined for calibration:
1. Maintaining constant spray volume
2. Maintaining spray width and holding boom at constant height
3. Maintaining constant walking travel speed

1. Using a CF valve with TeeJet nozzles maintains constant spray volume, greatly simplifying calibration. You may extract the nozzle GPM specification from the TeeJet catalog to use in the calibration formula provided here. However, we recommend that you measure the nozzle GPM using the following method provided rather than depending on the spray nozzle catalog. Your measured conditions may provide a different flow rate accounting for variation, worn, or defective spray nozzle tips.

2. The effective nozzle spray width is the next component of calibration. Walk with a constant height above the target to maintain uniform width. The spray tip catalog specifies some effective nozzle width calibration information (typically 20” or 30”), but your width may not be listed in the catalog. So determining your width, and using it in the formula provided here, assures your width is customized to your specific application, such as spraying the width of a bed, or width between rows.

3. Practice and record a constant walking speed. Let’s begin with your walking speed.

Practice your walking MPH travel speed

Mark off 100 feet on the uneven ground you will be spraying. Practice walking a constant speed. With practice, your time in seconds to travel 100 ft. can accurately be paced to match 1st column times, and your walking speed in MPH can be read from the 2nd column.
Seconds/100 ft.    MPH
45              1.5
34              2.0
27              2.5
23              3.0
19              3.5
17              4.0
15              4.4
14              5.0

**Effective Spray Width**

Each nozzle type is manufactured with a spray angle and recommended spray height which provides a known width listed in the catalog. 20” or 30” widths are common for 110 degree nozzles. Hold the boom at a constant comfortable height and measure the width, leaving edges for spray overlap.

**Measure GPM nozzle output for accuracy**

Manufacturers provide specified output flow rate at a given pressure for each nozzle type and size for easy lookup in product catalogs. For accuracy, you will need the following to measure the flow rate: measuring container (units of fluid ounces); sprayer with CF valve and chosen nozzle; stopwatch.

1) Half-fill the sprayer with water (and a colorant)
2) Pump the sprayer; Release the hand trigger and timer
3) Hold a measuring container under a nozzle **for 1 minute**, collecting its output
4) Determine the volume and record it
5) Convert the flow rate to gallons per minute by the following equation:

   **GPM nozzle = output in fluid ounces ÷ 128**
   Example: 32 fluid ounces caught in 1 min is a flow of 0.25 GPM (32 ÷ 128)

If you build a spray boom with more than one nozzle, repeat steps 3 and 4 and measure output for each nozzle. Calculate the total sprayer output by adding the output for the nozzles. Most nozzles will have a slightly different output, but the variance should not exceed +/- 10 percent. Replace worn or faulty nozzles if the output is 10 percent more or less than the manufacturer’s specifications and repeat steps 3 and 4.
Calculate sprayer output gallons per acre (GPA)

GPA =
(Nozzle GPM x 5,940) ÷ (MPH x W spray width)

GPA = the sprayer output in **gallons per acre**
GPM nozzle = the actual nozzle flow rate in **gallons per minute**
MPH = your walking speed - the sprayer - in **miles per hour**
W spray width = the nozzle spacing in inches
5,940 in the equation = a constant value needed for conversion of mixed units (feet, miles, and acres; minute and hour).

Calculate sprayer output gallons per 1,000 sq. ft.

Gal per 1,000 sq. ft. =
(Nozzle GPM x 136) ÷ (MPH x W spray width)

For determining the total spray volume gallons needed for treating areas
136 in the equation = a constant value needed for conversion of mixed units (feet, miles, and acres; minute and hour).
Backpack Sprayers

Video 4 & 7 Companion Handout

**Video 4 - Backpack sprayers apply products accurately with proper calibration**
**Video 7 - Measuring small quantities safely**

**Calculate product mixing rate per spray gallon**
Products have legal recommended application rates. Determine the product mixing rate (in pounds, ounces, or fluid ounces per gallon) with water in the backpack sprayer tank using this equation:

\[
\text{Product Mixing Rate} = \frac{AR}{GPA} \quad \text{where}
\]
- \(AR\) = product Application Rate in pounds, ounces, or fluid ounces per acre
- \(GPA\) = the sprayer output in gallons per acre

**Typical Example: Treat crop rows on plastic mulch**
10 single rows of a crop on plastic mulch 250 feet long
A crop protection product recommended application rate of 1 pint (16 oz.) per acre
Walking practiced at 2.5 MPH
TeeJet nozzle with 0.2 GPM output flow with 20 psi CF valve and 20” width
We have all the information needed

**Sprayer output GPA**

\[
\begin{align*}
\text{Sprayer output GPA} &= \frac{(\text{Nozzle GPM} \times 5,940)}{(\text{MPH} \times \text{W spray width})} \\
&= \frac{(0.2 \text{ GPM} \times 5,940)}{(2.5 \text{ MPH} \times 20’’)} = 1,188 \div 50 = 23.8 \text{ gallons per acre}
\end{align*}
\]

**Treated Area**

\[
\text{Treated Area} = 10 \text{ rows} \times 250 \text{ feet} \times 20’’ \text{ width} = 10 \times 250 \times 1.6’ = \sim 4,000 \text{ sq. feet}
\]

**Sprayer output GP 1,000 sq. ft.**

\[
\begin{align*}
\text{Sprayer output GP 1,000 sq. ft.} &= \frac{(\text{Nozzle GPM} \times 136)}{(\text{MPH} \times \text{W spray width})} \\
&= \frac{(0.2 \text{ GPM} \times 136)}{(2.5 \text{ MPH} \times 20’’)} = 27.2 \div 50 = 0.55 \text{ gallons per 1,000 sq. ft.}
\end{align*}
\]

\[
= 4,000 \text{ sq. ft. at 0.55 gal per = 2.2 gallons total spray volume}
\]

**Mixing Rate**

\[
\begin{align*}
\text{Mixing Rate} &= \frac{AR}{GPA} \\
&= 16 \text{ oz./A} \div 23.8 \text{ gallons/A} = 0.67 \text{ ounces per gallon spray mix}
\end{align*}
\]

Note: Product application rates specified in pounds, ounces, or fluid ounces per 1,000 square feet need to be converted to pounds, ounces, or fluid ounces per acre before performing the calculation above. Multiply pounds per 1,000 square feet by 44 to convert to pounds per acre.
Choosing spray nozzles

By Thomas Reed, Spraying Systems Co., Wheaton, Ill.

Nozzles are the unsung heroes of the spraying industry. Despite their small size, they regulate the spray flow, droplet size and spray pattern. Proper selection and operation of spray nozzles are important steps in precise application.

Flow regulation is extremely important because it affects the application rate. The nozzles are designed so that the pressure must increase four times in order to double the flow rate through an orifice. Therefore, orifice (nozzle opening) size and spray pressure are key features affecting the flow rate through nozzles. You can vary these factors by selecting a different nozzle size or adjusting the pressure.

Viscosity (the ability of a liquid to flow), liquid density and surface tension are additional factors affecting flow rate. However, it’s more difficult to change these characteristics unless you add adjuvants to the tank solution.

Droplet size varies due to pressure, climatic conditions and nozzle size. The size may be affected by the spray angle and the spray pattern shape (nozzle design). Increasing pressure at the nozzle decreases droplet size in a conventional system. Increasing the spray angle of the tip also decreases droplet size. As nozzle (orifice) size increases, there is a corresponding increase in droplet size.

Nozzle spray patterns are comprised of three basic shapes—flat-spray, hollow-cone and full-cone patterns. The characteristics of each spray pattern favor certain chemical applications.

![Flat-spray nozzle](image)

**Flat-spray nozzle**
Spray droplets from a flat-spray tip form a fan-shaped pattern as they leave the orifice. The edges of the pattern have a lower spray volume, so patterns of adjacent nozzles must overlap to obtain uniform coverage along the spray boom. Proper overlap is one-third on each edge of the spray pattern. Look in nozzle manufacturers’ catalogs for tables that provide data on the spray tip height required to achieve proper overlap.

Flat-spray tips are commonly available in 65°, 73°, 80°, and 110° spray angles. Wider-angle nozzles produce smaller droplets, but they can be spaced farther apart on the spray boom or operated closer to the target. Narrow-angle spray tips produce a more penetrating spray and are less susceptible to clogging. Flat-spray tip characteristics make them ideal for broadcast applications of herbicides when uniformity is critical. Typical operating pressure should be 30 to 60 psi for the most uniform coverage. Lower pressure will reduce drift, but it also may cause less uniformity along the boom.

Specialty types of flat-spray tips are also available to turf managers. A new type of nozzle called the extended-range flat-spray tip was designed to provide better spray distribution over a range of...
Spray nozzles

Spraying pressures from 15 to 60 psi. At low pressures you can uniformly apply systemic herbicides with reduced drift risks. You can use higher pressures for contact herbicide applications.

The twin-orifice flat-spray is designed for applications requiring thorough spray coverage and good spray penetration. The spray tip has two orifices that direct one flat-spray pattern 30° forward and the second spray pattern 30° to the rear. By atomizing with two orifices, the droplet size is smaller than an equivalent-capacity standard flat-spray tip. The smaller droplets increase coverage potential and make the nozzle suitable for applying systemic herbicides. Typical operating pressure is 30 to 60 psi.

Another type of flat-spray nozzle is the LP or low-pressure flat-spray tip. This nozzle operates at lower pressures (15 to 40 psi). Larger orifices and lower pressures provide larger droplets that reduce drift and minimize clogging. This makes the tip especially well-suited for applying systemic herbicides in sensitive areas.

Flooding nozzles

The flooding nozzle produces a wide, flat spray pattern when the liquid atomizes as it leaves the edge of the nozzle. The wide spray angle (110 to 130°) allows wider nozzle spacings and lower boom heights in broadcast applications. Both the wider spacings, which allow a larger orifice, and the round shape of the orifice make the nozzle less susceptible to clogging.

Spray horns are the higher spray volumes that typically occur at the edges of the spray pattern. These heavy edges require you to double overlap adjacent spray patterns to optimize broadcast uniformity. Angling the nozzles at 45° also improves the uniformity of coverage. Typical operating pressure is 10 to 25 psi.

Wide-angle full-cone nozzles

The wide-angle full-cone nozzle produces large droplets that are distributed uniformly in a full-cone pattern. The uniform spray pattern is maintained over a pressure range of 10 to 40 psi. You can use the wide, 120° spray angle on up to 40-in. spacings, as with the flooding nozzle.

The droplets from the full-cone tip are larger than other tip styles of equal capacity at similar pressures. This nozzle is well-suited for soil-applied and systemic herbicides. You achieve maximum drift control at pressures of 15 to 20 psi. To optimize broadcast uniformity, overlap spray patterns 30 to 50 percent on each edge with the nozzles angled back at a 30 to 45° angle from the vertical.

Hollow-cone nozzles

A hollow-cone nozzle produces a spray pattern with the liquid concentrated on the outside of a conical pattern. The typical spray distribution is saddle-shaped with less liquid in the center of the distribution, tapering off rapidly at the edges. For this reason, the hollow-cone nozzle is not well-suited for broadcast applications because proper overlap is difficult to achieve.

Hollow-cone nozzles generally produce the smallest droplets of any nozzle type. You generally would use a hollow-cone nozzle to apply insecticides, fungicides or growth regulators where penetration and coverage are critical.

Spray drift can be high because of the many small droplets produced at the typical operating pressure of 40 psi and above.

Boomless nozzles

In some areas, the terrain or obstructions make it difficult or impossible for you to operate a boom sprayer. Typically you would use the boomless or cluster nozzle in these situations. This compact nozzle assembly mounts at the rear of the sprayer and can deliver a spray swath 30- to 60-ft. wide, depending on pressure and capacity. The nozzle assembly, consisting of up to five separate nozzles, produces a wide flat-spray pattern. Atomization is as fine as possible in relation to the distance the spray must travel to the outside edges of the swath. You can use angle mounting to allow a lower nozzle height, therefore decreasing the effect of wind driftage while maintaining the swath width. Spray distribution is not as uniform as with a boom sprayer; however, double-overlapping swaths can compensate for this to some degree. Keep in mind that this doubles the application rate and increases spraying time.

Spray tip materials

Nozzle tips are available in a variety of materials, including hardened stainless steel, stainless steel, thermoplastic and brass. They show the following qualities:

- **Hardened stainless steel** is the most wear-resistant material and, though expensive, it is probably your best long-term investment.
- **Stainless steel** nozzles have excellent corrosion and abrasion resistance.
- **Thermoplastic** tips have good abrasion resistance, but swelling can occur with some chemicals. You also can easily damage them when cleaning clogged orifices.
- **Brass** tips are relatively inexpensive but wear rapidly with abrasive mixtures, and some liquid fertilizers corrode brass tips.

The abrasion and erosion of orifice material is determined by four factors: the orifice shape and size, spraying pressure (velocity), spray liquid (abrasive media) and nozzle material.

Applicators introduce other variables that affect wear life, such as changes in chemical sprayed, pressure changes, differences in water quality (suspended solids) and tip maintenance methods (tip cleaning). All of the variables suggest that it is extremely difficult to predict the useful life of a spray tip.

Illustration credit: Author.

**Spraying Systems Co.**

North Ave. at Schmale Rd. • P.O. Box 7900
Wheaton, Illinois 60189-7900 USA
Backpack Sprayers

Video 7 Companion Handout

Supplies for safely measuring small quantities of crop protection chemicals

Measure and transfer crop protection materials from large product containers into backpack sprayers using syringes and extension tubing.

Nasco Farm & Ranch Supplies

Syringes, plastic, small size 10 cc; 10/box, product no. C13044N

Syringes, plastic, mid size, 60 cc, 10/box, product no. C16791N

Extension tubes, 18” plastic disposable, 25/bag, product no. C08273N