

EQUIPMENT AND CALIBRATION

Tank-Mixing Precautions

- Read product labels carefully and follow all applicable directions, precautions, and limitations.
- Do not exceed recommended application rates for respective products or maximum allowable application rates for any active ingredient in the tank mix.
- For products packaged in water-soluble packaging, do not tank mix with products containing boron. Also, do not mix in equipment previously used to apply a product mixture containing boron unless the tank and spray equipment have been adequately cleaned. (See Equipment Clean-Out Procedures.)
- Always perform a jar test to ensure the compatibility of products to be tank mixed before mixing a full tank.

Sprayer Agitation

Agitation is an essential design and operational component of the agricultural spray system. Agitation is the hydraulic stirring movement of spray solution. Agitation is necessary to maintain the homogeneous mixture required for uniform performance of the pesticide being applied. Poor agitation usually results in nonuniformity of the pesticide application. This may be most visible as crop injury caused by an excess rate of herbicide when the tank is full or recently refilled. As the tank becomes empty, you may see less control of weeds. The amount of agitation needed for the spray system depends upon the type of agitation being used, the size of the spray tanks, the configuration of the spray tanks, and the type of spray solution being applied. The most common type of agitation system is by-pass agitation where part of the spray pump capacity is used to create agitation inside the spray tanks to maintain a homogenous spray solution.

Spray tank agitation requirements are based on the total size of the spray tanks, the configuration of the spray tanks, and the type of pesticide formulation being applied. The volume of the spray tank agitation also depends on the type of tank agitation system being used. A rule of thumb suggests that about 10 percent of the total tank capacity is needed for sufficient agitation. For example, if the total capacity of two tanks is 300 gallons, then 30 gallons per minute (15 gallons per minute per tank) are needed for adequate agitation when conventional by-pass agitation is used. If the by-pass agitation system has induction jets attached, the total volume required for adequate agitation can be reduced.

In some of the new, very large and irregularly shaped spray tanks, it is more difficult to provide adequate agitation because of the way they are made. These tanks were made to more easily fit the tractor configuration than for spray agitation. More traditional EC, EW and flowable liquid pesticide formulations tend to have lower agitation requirements to maintain a homogenous spray mixture. Some formulation types may be prone to settling, especially if the agitation is inadequate or is stopped. In some situations, you may need to add spray adjuvants. Most agitation problems can be easily corrected with careful design and operation of the agitation system.

Where two or more tanks are used, the agitation system should be designed so that all tanks are agitated continuously once the pesticide is added. The operator must then decide whether to use from both tanks simultaneously or from one tank only. When operating from one tank with a full second tank, two separate pump/control/agitation systems are required to agitate both.

Spray tank agitation systems should include a high-volume spray pump and agitators that are carefully designed and installed. Agitators should be placed in the bottom of the spray tank with jets sweeping towards the ends of the tank so that the tank contents are rolled completely.

Total pump capacity is determined by the agitation requirement and the total nozzle requirement. The pump must have adequate capacity for both needs. If the pump is not large enough, it should be either replaced or a separate pump must be added so that one pump would be delivering the spray boom needs, and one pump would be delivering the agitation system needs.

Sprayer Operation

Agricultural sprayers should be operated so that the required rate of pesticide is delivered to the target site. Do not make applications when conditions are conducive to spray drift, poor spray deposition, or poor target coverage.

- Turn off the spraying system when turning or when booms must be raised to clear obstacles or folded for transport.
- Use check valves in individual nozzle bodies to prevent dripping during turns, transport, or when the sprayer is parked.
- Properly clean the sprayer before transporting, storing, or working in other crops or with other pesticides.

Minimize Drift from Ground Applications

Many variables influence drift from agricultural chemical applications. Focusing on the most important variables provides the applicator the greatest opportunity to minimize off-target movement. Research at Mississippi State University measured the relative importance of variables that influence drift from ground and aerial applications. The tips below are listed in order of importance in reducing drift as found in "Predicting ground boom spray drift" by, D. B. Smith, L. E. Bode and P. D. Gerard, *Trans of ASAE* 43(3):547-553, 2000.

- Maintain the maximum distance possible from the application to sensitive crops or areas downwind of the application by using buffer zones and by choosing times to spray when wind direction is away from sensitive crops and areas.
- Keep the spray release height and the nozzle to the target distance as low as possible to maintain a uniform application pattern from the nozzle for minimum influence of wind and evaporation. Select the proper nozzle type for the application and the nozzle pattern angle. Set the nozzle tip back or forward at approximately 45 degrees to horizontal to minimize height from boom to target.
- Make applications when wind speed is low (3 to 5 mph, but not dead calm indicating an inversion) and direction is away from sensitive crops and areas.

Applicators may benefit from spraying when temperature is low and humidity is high and with pressures no greater than 40 psi when using pattern-producing nozzles. Shielded and hooded sprayers may be used to minimize exposure of the spray to wind; however, one drift study found greater drift due to wind turbulence around a shield.

Aerial Drift Reduction

The tips below for reducing drift from aerial applications are listed in order of importance as found in *Guidelines for Aerial Atomization and Spray Drift Reduction for Mississippi Applicators*, MAFES Information Bulletin 251, by D. B. Smith, M. H. Willcutt, D. L. Valcore, J. W. Barry and M.E. Teske, Nov. 1993).

- Use the largest droplet size compatible with proper coverage required for the mode-of-action of the pesticide being used. The Department of Agriculture and Commerce Bureau of Plant Industry now requires a minimum of 300 micron vmd spray for glyphosate applications by air.

- Maintain the maximum distance possible from the application to sensitive crops or areas downwind of the application by using buffer zones and by choosing times to spray when wind direction is away from sensitive crops and areas.
- Make applications when wind speed is low (3 to 5 mph, but not dead calm indicating an inversion) and direction is away from sensitive crops and areas.

Mississippi regulations require that the outboard nozzles be no more than 70 percent of the wingspan or rotor span. Nozzles placed beyond this boom position contribute to vortex-influenced drift and non-uniform deposition, and they do not increase the effective swath width of the aircraft.

Oklahoma State University Publication E-948, Aerial Pesticide Drift Management, Ron T. Noyes, Dennis Gardisser and Dennis K. Kuhlman, makes this suggestion: “Make applications at a height of 25 to 50 percent of the aircraft wingspan, measured from the top of the canopy to the boom. This will generally equate to a minimum height of 9 to 10 feet to the gear or 10 to 15 feet from boom to target canopy. Flying too low can lead to narrow swaths, non-uniform distribution, and streaking. It may also lead to increased drift potential due to the excessive control surface movements generally associated with ‘wheels in the crop’ flying. Achieve level flight before spraying and turn off the spray system before pulling up. Do not use excessive aircraft speeds. As air speed increases, the amount of particle breakup and ‘rooster tailing’ potential increases. Higher airspeeds also increase the hazards of low altitude flying due to reduced pilot reaction time. Equip the spray boom for immediate/positive shut-off through properly installed bleed lines and well-maintained equipment. Attend educational meetings frequently and read all published information possible to increase your knowledge about factors that contribute to drift.”

Sprayer Clean-Up

Thoroughly clean the sprayer after completion of the application, before repairs and maintenance, and before equipment storage or making other applications. Thorough cleaning will reduce the potential for product residues being dislodged during subsequent applications or worker exposure to pesticide residues and fumes from welding during repairs and maintenance.

At the End of the Day

At the end of each day of spraying, rinse the interior of the tank with clean water and then partially fill the tank. Flush the boom and hoses. This will reduce the buildup of dried pesticide deposits that may accumulate in the application equipment.

Upon Completion of the Application

Follow pesticide label directions for cleaning the sprayer. If no specific cleaning compound or procedure is recommended on the pesticide label, follow the procedure below:

- Drain the mixing and loading system, placing any remaining pesticide solution into the sprayer tank. Thoroughly rinse the mix vat, transfer pump, holding tank, and hoses. Clean this equipment with an appropriate spray tank cleaner. Remove and thoroughly clean all filters and screens on the mixing and loading system. Add all rinse water to the sprayer tank, washing the inside of the tank in the process. Apply rinse water to the application area.
- Fill the sprayer tank half full with clean water, washing the inside of the tank in the process; then apply the rinse water to the application area. Flush the boom with clean water. Loosen and physically remove any visible deposits.
- Fill the tank with clean water and 1 gallon of household ammonia (contains 3 percent active). Anhydrous ammonia may also be used at the same or stronger concentrations for every 100 gallons of water. Flush the hoses, boom, and nozzles with the cleaning solution. Then add more water to fill the tank completely. Circulate the cleaning solution through the tank and hoses for at least 15 minutes. Allowing the cleaning solution to sit 12 to 24 hours will result in better neutralization of pesticide residues. Apply the rinse solution to the application area or labeled cropland for the pesticide used.
- Remove the nozzles and screens and clean separately in a bucket containing cleaning agent and water using a soft-bristle brush.
- Repeat step 2 without the nozzles and strainers installed.
- Rinse the tank, boom, and hoses with clean water.
- Thoroughly clean exterior surfaces of spray equipment with a pressure washer or steam cleaner and with cleaning solutions recommended on the pesticide label.
- If the sprayer will be stored for long periods or during freezing weather, add about 2 to 5 gallons of a 50 percent antifreeze solution, allow it to circulate with the pump, and leave it in the sprayer to reduce damage caused by rust, corrosion, and freezing.
- Store the sprayer in a secure area away from frequent human and animal traffic patterns. Always lower raised components, place transmission in park, lock brakes, remove any keys, and lock cab and storage shed doors when leaving any equipment.

***Note:** If other cleaners are used, consult the cleaner label for rinse water disposal instructions. If no instructions are given, dispose of the rinse water on site or at an approved waste disposal facility.

Carefully read and follow the individual cleaner instructions. Consult your ag dealer, applicator, or pesticide manufacturer’s representative for a list of approved cleaners.

- **CAUTION:** Do not use chlorine bleach with ammonia solutions as dangerous gases will form. Do not clean equipment in an enclosed area. Rinse all metal sprayer components thoroughly after using chlorine or ammonia cleaning solutions to prevent rusting.
- Steam clean aerial spray tanks to remove any caked deposits before performing the above cleanout procedure.
- When a tank mix with other pesticides has been applied, examine all cleanout procedures and follow the most rigorous procedure.
- In addition to this cleanout procedure, follow all pre-cleanout guidelines on subsequently applied products, as per the individual labels.
- Properly dispose of all empty pesticide containers, cleaning solutions, and rinse water in accordance with federal, state, and local regulations and guidelines. Triple or pressure rinse all empty pesticide containers and then render them unusable by puncturing the container.
- One accepted method of cleaning solution and rinse water disposal is to apply the rinse water to the field area previously treated. Do not exceed pesticide label recommendations for application rate when applying rinse water.
- Always wear the proper personal protective equipment while filling, cleaning, or working on sprayers.

Spray Tips for Successful Applications

The success of a crop chemical depends on its proper application as recommended by the chemical manufacturer. Proper selection and operation of spray nozzles are very important steps in accurate chemical application. The volume of spray passing through each nozzle plus the droplet size and spray distribution on the target influence weed control.

There is evidence that spray tips may be the most neglected component in today's farming; yet they are among the most critical of items in proper application of agricultural chemicals. For example, a 10 percent over-application of chemical on a twice-sprayed 1,000-acre farm could represent a loss of \$2,000-\$10,000 based on today's chemical investment of \$10-\$50 per acre. This does not take into account potential crop damage.

Careful cleaning of a clogged spray tip can mean the difference between a clean field and one with weed streaks. Flat spray tips have finely machined openings to control the spray. Damage from improper cleaning can cause both an increased flow rate and poor spray distribution. Be sure to use recommended strainers in your spray system to minimize clogging. If a tip clogs, use a soft-bristled brush or toothpick to clean it—**never** use a metal object. Use extreme care with soft spray tip materials such as plastic.

A wide selection of equipment is available for application of herbicides for weed control. Follow the manufacturer's guidelines for each specific type of equipment. Selection of the proper nozzle for the desired end-use is critical for proper calibration and application. Available nozzle types, spray patterns, and uses are presented in Table 3.

Precalibration check

Be sure that all sprayer components are free of foreign material and function properly. Inspect nozzle tips and internal parts for obvious wear, defects, proper size and type. Check the flow rate of each nozzle using water. Establish the desired operating pressure and check for uniform output, equal fan angle, and uniform appearance of spray pattern. Replace any nozzle tips having 5 percent more or less than the average flow rate of the other nozzles and/or having obviously different fan angles or patterns. If the average flow rate of the old nozzle tips differs from the flow rate of new nozzle tips or catalog flow rates for new nozzle tips by 10 percent or more, consider replacing with new nozzle tips. Check the flow rate of new nozzle tips before spraying.

Nozzle Height and Uniformity

Type and size of nozzle tip, operating pressure, spray formulation, tip spacing along the boom, tip-to-target distance, fan angle, and angle of nozzle tips in relation to vertical can greatly influence the spray swath uniformity. You can see extreme nonuniformity by spraying onto a prepared surface such as concrete or a dust-covered surface. Rotate fan-type tips approximately 5 degrees from being parallel to the boom so that adjacent spray fans do not interfere with each other. Suggested spray tip heights found in catalogs are a good starting point; however, these tip operating heights may or may not produce the maximum uniformity of application. For a more detailed discussion of spray uniformity and height and recommendations for specific nozzle tips, see Extension Publication 1697 *Improving the Uniformity of Ground Applied Broadcast Sprays* by D.B. Smith and M. H. Willcutt. (Specific recommendations for reducing aerial spray drift can be found in MAFES Information Bulletin 251 *Guidelines for Aerial Atomization and Spray Drift Reduction for Mississippi Applicators* by D.B. Smith, M.H. Willcutt, D.L. Valcore, J.W. Barry, and M.E. Teske.)

Use this formula to determine nozzle size:
$$\text{GPM} = \frac{\text{GPA} \times \text{MPH} \times \text{Width}}{5,940}$$

The following web sites may be helpful in selecting nozzles, set-up and calibration of spray equipment:

www.agchem.com	Ag.Chem Equipment Co., Minnetonka, MN55343, 800-760-8800
www.teejet.com	Spraying Systems Co. , Wheaton, IL, 770-552-9292
www.delavanagspray.com	Delavan AgSpray Products, Lexington, TN, 800-621-9357
www.sprayers.com	Sprayer Specialties, Inc. Grimes, IA, 800-351-1587

Always be sure to check the rated operating pressure of nozzles when comparing desired flow to rated flow.

1/128th Acre Calibration for Row- and Boom-Nozzle Sprayers

Calibration of sprayers involves selection of the proper nozzle, spraying pressure, and sprayer speed. See Table 3 for selection of nozzles. There are many ways to determine the right combination of these elements. One practical calibration method is given. For a more in-depth discussion of calibration procedures, see Extension Publication 1006 *Calibration of Ground Spray Equipment*.

The 1/128th acre, baby bottle, and 100-foot methods of calibration are based on spraying 1/128th acre. There are 128 ounces per gallon; therefore, ounces sprayed per 1/128th acre equal gallons sprayed per acre. This procedure results in a treated acre calibration. Broadcast herbicide rates should be added to the volume of water calibrated per treated acre.

1. Determine nozzle spacing or swath width. (Note: if you are making **band** applications and use nozzle spacings, you will figure the gallons of spray per **planted** acre.)
2. Refer to Table 1 on next page for length of calibration course and mark calibration course in the field or 340 ft²/nozzle swath width (feet) course length.
3. Record time required to drive length of calibration course at gear, engine rpm, and implement settings to be used while spraying.
4. Park sprayer, maintain engine rpm used to drive course, and turn on sprayer.
5. Collect all spray from one nozzle for time equal to that required to drive the calibration course.
6. Measure the **ounces** caught. Ounces caught equal gallons per acre of spray applied.
7. Repeat Steps 5 and 6 for several other nozzles.

* **NOTE:** If multiple nozzles are used per row (Figure 4) use the width of area treated by **all nozzles** as the swath width for step 1 and catch the flow from **all nozzles** directed to the row in step 5.

TABLE 1. DISTANCE FOR EACH NOZZLE TO SPRAY 1/128 ACRE.

Effective Swath Width (in)	Course Distance (feet)
6	681
8	510
10	408
12	340
14	292
16	255
18	227
20	204
22	186
24	170
30	136
36	113
38	107
40	102
42	97
48	85

TABLE 2. CALIBRATION LENGTHS FOR BOOMLESS SPRAYERS.

Effective Swath Width (feet)	Course Distance (feet)
15	363
18	302
20	272
22	248
24	227
26	209
28	194
30	182
32	170
34	160
40	136
47	116
50	109
52	105
56	97
60	91

1/8th Acre Calibration for Boomless Sprayers

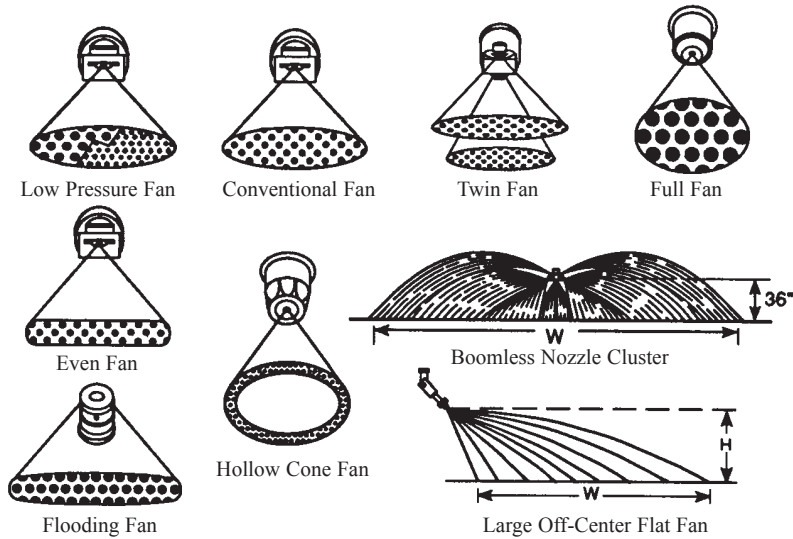
1. Turn on sprayer and measure effective swath width (feet). Note: swath width should be visually assessed when the vehicle is moving at 5 mph with very low wind speed and wind direction is parallel to the direction of travel of the spray vehicle.
2. Refer to Table 2 to determine length of calibration course and mark the calibration course in the field.
3. Record time required to drive course at gear, engine rpm, and implement settings to be used while spraying.
4. Park sprayer, maintain same rpm used to drive course, and turn on sprayer.
5. Catch water in plastic garbage bag for time equal to drive the calibration course.
6. Measure the pints caught. Pints collected equal gallons per acre.

TABLE 3. NOZZLE TYPES, SPRAY PATTERNS AND SUGGESTED USES¹.

Type	Spray Pattern	Pressure (psi)	Suggested Use/Comments
Flat Fan	Fan-like pattern of medium droplets. Not uniform across width.	20-40 (15-40 psi for LP nozzle)	Pre- and postemergence, broadcast booms. Available in low pressure tips that reduce clogging and drift potential. Requires 30% overlap for uniform distribution.
Even Fan	Fan-like pattern. Uniform volume across entire width.	20-40	Pre- and postemergence. Good for banding.
Flooding Fan	Wide, flat pattern of coarse droplet.	10-30	Broadcast booms, chemical-fertilizer mixture, layby. Requires 100% overlap for uniform distribution.
Off-Center Flat Fan (up to OCO8)	Flat-fan pattern. Directed to one side of tip. Swath width 20-144 inches.	20-40	Post-directed, low-profile spraying. Larger drops and increased volume deposited on the toe of pattern. Reasonably uniform deposits are not expected.
Large off-Center Flat Fan	Swath directed to one side from 12 to 33 feet width.	30-40	Herbicide application to ditches and roadsides. Reasonably uniform deposits are not expected.
Cone	Circular, with heavy concentration on outside. Small droplets.	40-60	Complete coverage of foliage. Insecticide, fungicide, and growth regulator applications, and Basagran rigs. Use where slight drifting is not hazardous.
Whirl Chamber (Raindrop tm)	Hollow cone pattern.	5-20	Used on incorporation equipment.
Rotary Atomizers	Flat plane similar to hollow cone. More nearly uniform droplet size.	Device dependent	Low-volume application of herbicides and insecticides.
Boomless Nozzle Cluster	Wide swath (up to 60 feet). Pattern easily distorted by wind. High spray trajectory.	20-40	Pastures and broadcast spraying where obstructions to booms exist. High drift potential. Not suitable for orchard spraying. Reasonably uniform deposits are not expected.

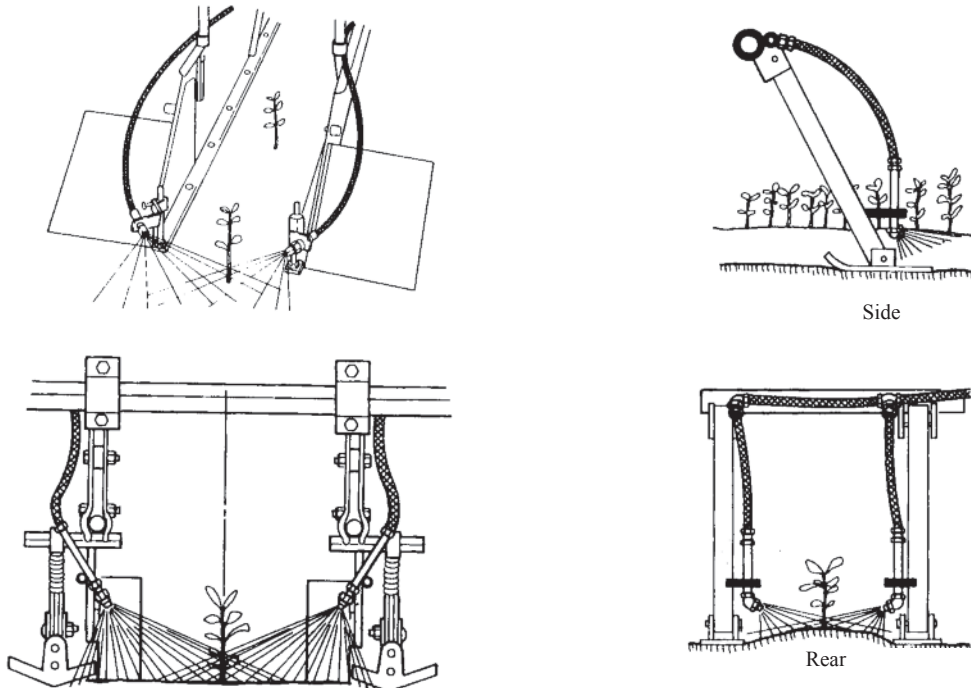
¹Suggested uses are a composite of recommendations from the manufacturer, research, and Extension. Always follow equipment and chemical label.

Nozzle Patterns



Typical Nozzle Settings

Typical nozzle arrangements for weed control applications are shown in Figures 1-5.



Figures 1 and 2. Flat-fan nozzles for post-direct spraying. Mount nozzle on row shield and direct spray down and back to provide desired overlap and band width.

Figure 3. Off-center nozzle for post-direct spraying. Nozzle can be positioned further from the crop than regular flat-fan nozzle.

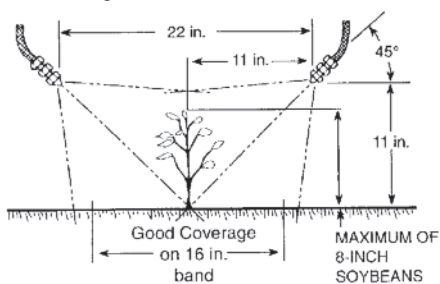


Figure 4. Two-nozzle arrangement for over-the-top applications.

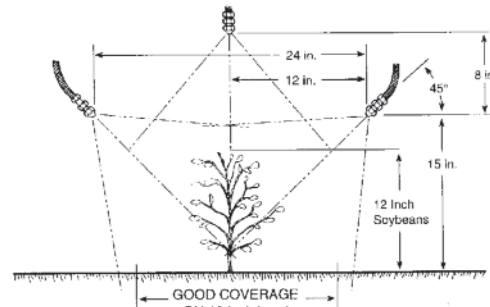


Figure 5. Three-nozzle arrangement for over-the-top applications.

Shielded Sprayers

Shielded sprayers offer a potential to apply herbicides for preplant burn down and in crop post direct with reduced drift and little or no injury to surrounding crops. However, use precautions to prevent drift and resulting crop injury. The shield alone is not enough to permit safe herbicide application when weather conditions are unfavorable. Abide by the normal recommendations for applying herbicides in a manner to reduce drift. Select a nozzle that will produce as large a drop as practical for coverage, spray volume, and control. Lower pressure or extended range nozzles (15 to 20 psi) should be given preference over more conventional nozzles (40 psi) since fine droplet production will be reduced. Set the hood and the nozzles for the lowest position to give adequate coverage of the weeds to be controlled. Angling the nozzles to the rear will usually give better coverage at a lower height as in any post-direct spraying. Never allow a nozzle to spray against the shield or curtain and accumulate to run-off.



Figure 6. Broadcast shielded sprayer operating in “burn-down”



Figure 7. Shielded sprayer in soybeans

Hooded and Shielded Sprayers

Hooded and shielded sprayers offer a potential to apply herbicides for preplant burn down (figure 6 above) and in crop post direct with little or no injury to surrounding crops. A sprayer hood with multiple nozzle configurations is shown in Figure 8. Use precautions to prevent drift and injury to nontarget crops. Do not use when weather conditions are unfavorable for a safe application. During each application, exercise the following precautions:

Set hood and nozzles for the lowest position to give adequate coverage of weeds to be controlled.

Never allow a nozzle to spray against the shield or curtain and accumulate to run-off.

The hood should be operated in contact with the ground and not bounce when using nonselective herbicide in susceptible crops.

Make sure flaps or curtains extend into the furrow for maximum protection when spraying crops in raised beds.

Avoid operating a hooded sprayer on sloping ground.

Maximum operating speed of the tractor and hoods should not be greater than 5 mph with slower speeds preferred for rough or uneven surfaces.

Leave a minimum of an 8-inch band centered over the drill row untreated when using nonselective herbicides.

Avoid spraying weeds that are in direct contact with the crop.

Select low drift, flat fan type nozzles with a 95-degree included spray fan angle that produce medium to large drops suitable for the desired coverage, application, volume, and control.

Always read and follow herbicide label directions.

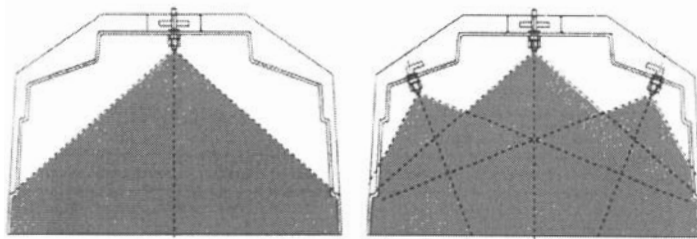


Figure 8. Sprayer hoods with one and three nozzles