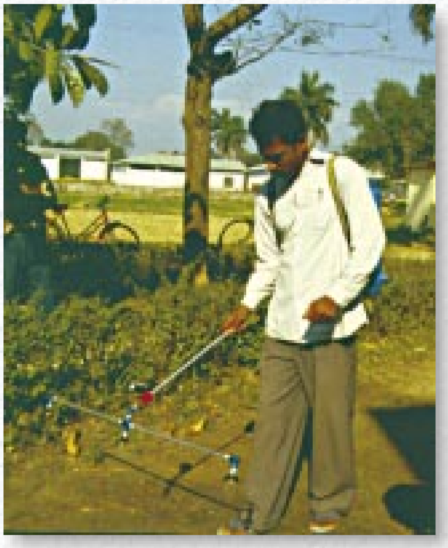
Herbicide Application Using a Knapsack Sprayer



Andrew Miller and Robin Bellinder

Rice Wheat

Rice-Wheat Consortium for the Indo-Gangetic Plains

Herbicide Application Using a Knapsack Sprayer

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The initial support from the Asian Development Bank and International Fund for Agricultural Development provided the groundwork for establishment of the RWC in 1994 and formalizing the collaborations between the NARS, IARCs and ARIs. The NARS-driven strategic ecoregional research initiatives with financial support from the Governments of the Netherlands, Sweden, Switzerland, Australia and the US Agency for International Development and the World Bank have grown over the years into a dynamic agenda of resource conservation technologies appropriate to different transects of the Indo-Gangetic Plains. The on-going successes in scaling-up resource conservation technologies for enhancing productivity and sustainability of the rice-wheat systems are beginning to create a revolution and favourably benefit large areas and more numbers of farm families.

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III. Miscellaneous

16. RWC-PRISM User Manual for Data Entry & Updating and Focal Point Management, 2001

1. Introduction

Knapsack sprayers are indispensable agricultural tools. Understanding how to use them is essential for the successful application of agricultural chemicals, especially selective postemergence herbicides. Herbicide efficacy and crop tolerance depend upon inherent species sensitivity to a herbicide and the size of the weed or crop at application. With many new herbicides, the rate difference between effective weed control and crop tolerance is small. In order to successfully use herbicides, their application must be accurate and uniform.

Nozzles, spray tips, multiple nozzle booms, pressure regulation and sprayer calibration are the essential components of the spray-application technology.

2. Nozzles

Nozzles are comprised of a spray tip, a strainer, and a nozzle body and a cap (Figure 1).

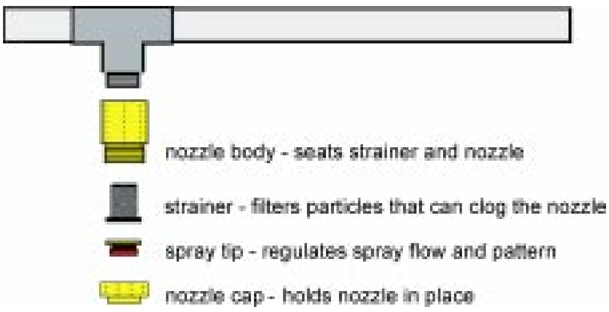


Figure 1. Nozzle assembly.

Spray tip is the most important nozzle component. It determines the flow and distribution of the spray. Tips are made in a variety of kinds each designed for a certain type of spray application.

Flat fan spray tips are designed specifically for multiple nozzle booms (Section 3). The spray pattern is tapered from the center (full flow) to the edges (lighter flow) and is designed to overlap with adjacent nozzles, creating a uniform pattern across a spray boom (Figure 2).

Even fan spray tips are designed for single pass sprays over crop rows or between rows of vegetable or plantation crops. The spray pattern is uniform (full flow) from edge to edge. Even fan spray tips are not made for use on multiple nozzle booms (Figure 2).

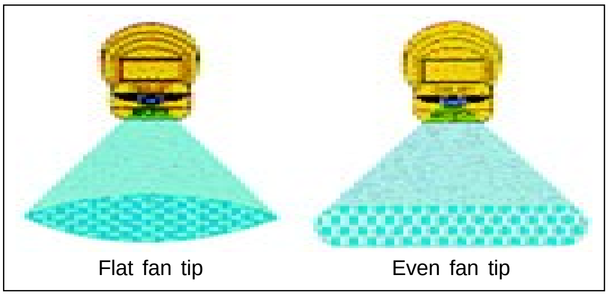


Figure 2. Spray patterns of flat fan and even fan spray tips.

Flood (cut) spray tips are designed to have a wide spray pattern at low pressure making them popular with knapsack sprayer operators. They are best suited for defoliants and total weed killers and in situations where multiple nozzle booms are not practical. The spray pattern is tapered from the center to the edge but it is not as uniformly tapered as that of the flat fan. The spray is heavy toward the very edges and coarse throughout the spray pattern. Using this nozzle in a “swinging” pattern across a field will normally result in poor application results. Overlapping by 50 per cent can help eliminate the inherent unevenness in the spray pattern (Figure 3).

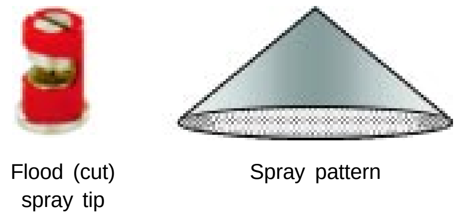


Figure 3. Flood (Cut) spray tip and spray pattern.

Variable cone spray tips have a cone-shaped spray pattern that is adjustable from a fine mist to a solid stream. The adjustable pattern makes variable cone spray tips versatile tools. Calibrating these nozzles is not easy due to the difficulty of adjusting the tip to the same pattern and flow time after time. While not ideal for most applications, they are useful for many insecticide, fungicide and total weed killer herbicide sprays (Figure 4).

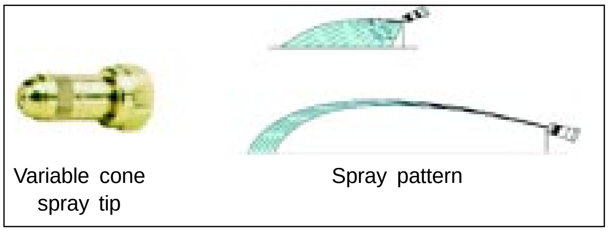


Figure 4. Variable cone spray tip and spray pattern.

Hollow cone spray tips produce a fine spray that is concentrated on the outside edge of the pattern. The spray approaches the target from different angles increasing coverage. They are designed for fungicide and insecticide applications where excellent coverage is needed. The fine spray pattern increases spray drift potential (Figure 5).

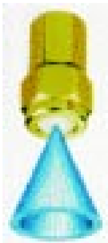


Figure 5. Hollow cone spray tip and spray pattern.

Strainers are fine mesh screens that are inserted into the nozzle body to filter out particles that can clog the spray tip. Strainers are needed for all spray solutions mixed up with any type of unfiltered water. Even with strainers in place, nozzle tips can become clogged. The best way to clean a clogged tip is to remove it from the nozzle body and rinse it in water. If necessary, a soft brush can be used to help remove particles. Never use a wire, or any hard tool, to clean a spray tip. This will damage the tip.

Worn out and damaged spray tips lose the ability to properly regulate the spray pattern and should not be used. Worn out tips have a greater output with the spray concentrated beneath the tip. Damaged spray tips have an erratic output, over-applying and under-applying (Figure 6). Inspect spray tips and spray patterns at regular intervals replacing worn out and damaged tips as needed.

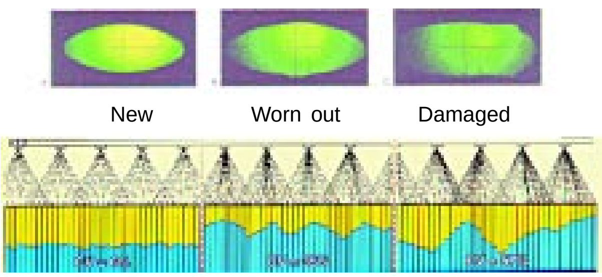


Figure 6. Output patterns of new, worn out and damaged spray tips.

3. Multiple nozzle booms

Multiple nozzles are used to increase application efficiency and accuracy (Figure 7). Hand booms can be purchased from a manufacturer or constructed from any type of plumbing material suitable in strength and weight. Aluminum, steel, brass, copper and plastic tubing with brass or plastic fittings have all been used to create boom sprayers.

Figure 7. Four nozzle boom attached to a knapsack sprayer.

Flat fan nozzles are spaced on the boom so that the spray pattern of adjacent spray tips will overlap by 30% (Figure 8). Spacing will depend on boom height and the angle rating of the spray tips. Larger angle tips have a wider spray pattern and are spaced further apart on the boom when the height remains constant.

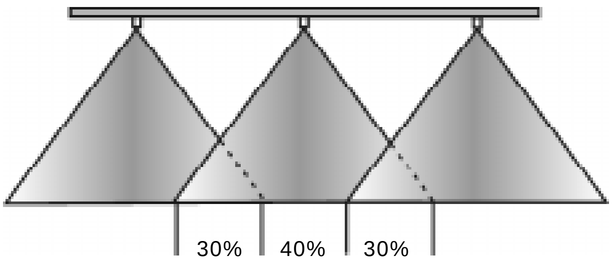


Figure 8. 30% overlap of adjacent spray patterns. Center 40% of each pattern does not overlap.

Spraying with a multiple nozzle boom

When a single flat fan nozzle is sprayed, only the middle third of the spray pattern of the nozzle can be considered to have a full rate application (Figure 9). When two or more are spaced to overlap by 30%, the tapered pattern of adjacent nozzles creates a uniform spray distribution. On the boom ends, where there is no adjacent nozzle, the outside edges of the spray will still have a light application.

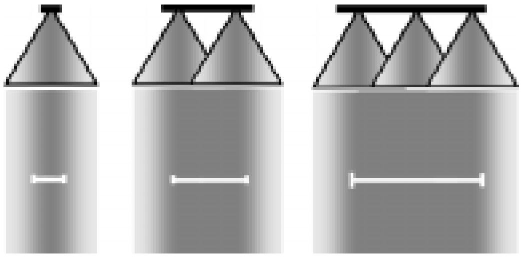


Figure 9. Effective spray swath of different booms.

The two most common spray tip angles are 80° and 110°. This refers to the size of the angle of the spray pattern from side to side (Figure 10).

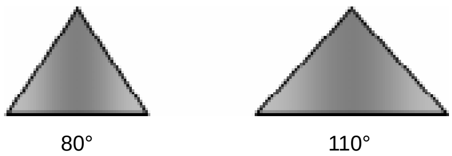


Figure 10. 80° and 110° spray angles.

In general, 80º nozzles will be spaced 50 cm apart on the boom and 110º nozzles will be spaced at 75 cm when the boom is used 50 cm above the target.

Adjacent passes of multiple nozzle booms must be overlapped by approximately 30%, similar to the way adjacent nozzles on the same boom should overlap. This will create a uniform application rate from one pass to the next (Figure 11).

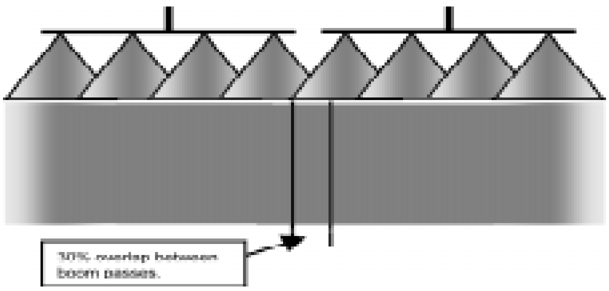


Figure 11. Uniform application between passes.

Figure 12. Strips from a boom being too low.

Height is important when using a boom sprayer. If the boom is too low to the ground, the nozzles will not overlap resulting in bands of concentrated spray with little or no spray in between (Figure 12). Boom height depends on nozzle spacing and nozzle angle ratings (Figure 13). Variable pressure, speed and mixing can cause the same application problems with a multiple nozzle boom as they will with a single nozzle lance.

Nozzle angle	50 cm spacing	75 cm spacing
65º	55-60 cm	83-89 cm
80º	43-48 cm	66-71 cm
110º	41-46 cm	50-55 cm

Figure 13. Minimum spray heights at two nozzle spacings

To determine the spray swath of multiple nozzle booms, multiply the nozzle spacing by the number of nozzles. When the boom is used at the appropriate height, this will give the spray swath width for that boom when multiple passes are made across a field. For example: 4 nozzles x 50 cm spacing = 200 cm swath width.

Spray applications

Herbicide applications need to be applied uniformly. Areas of over- or under-application will result in undesired application results. Potential problems include crop injury, lack of weed control and with residual herbicides, rotational crop injury.

Herbicide applications can be made using a single nozzle lance. However, spraying a straight swath with appropriate overlapping is extremely difficult and time consuming. If the single nozzle lance is swung from side to side while walking, the resulting application will have large areas of under- and over-application (Figure 14). Variable pressure, inconsistent speed and poor mixing in the tank can all contribute to non-uniform applications.

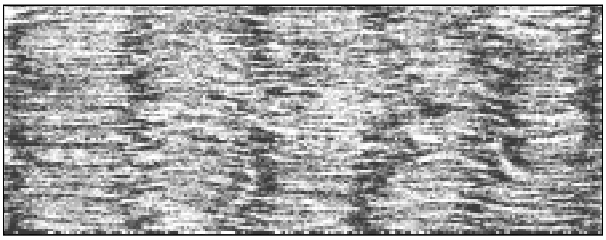


Figure 14. Typical spray distribution when an application is made by swinging a single nozzle lance. Dark areas show over-application and light areas show under-application.

Using a boom sprayer, compared to swinging a single flood jet nozzle, will increase the uniformity of spray applications. The width of a pass may be smaller using a three or four nozzle boom, but each pass will have very uniform herbicide distribution. Spray swaths of three meters or more can be obtained by fitting a knapsack with the appropriate nozzles and adjusting the spray pressure of the system to provide adequate output.

4. Calibration

Calibration is necessary in order to achieve accurate and uniform applications. Calibration is simply determining sprayer output for a known area. Speed, nozzle capacity and pressure influence sprayer calibration.

Speed is inversely proportional to spray application when boom output is kept constant. As you walk faster, less spray is applied to a given area (Figure 15).

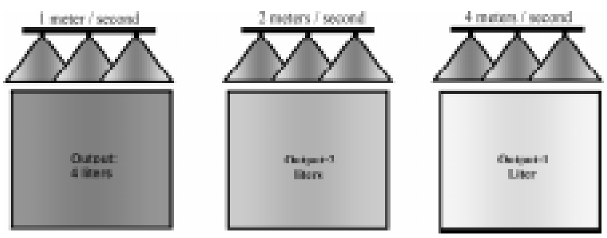


Figure 15. Effect of speed on spray application.

Nozzle capacity is a manufacturer's rating that tells what output a nozzle will have at a given pressure. At constant pressure and speed, nozzle capacity is directly proportional to sprayer output. Output becomes greater as nozzle capacity increases (Figure 16). When multiple nozzle booms are used on knapsack sprayers it may be necessary to keep the nozzle capacity ratings low to avoid exceeding the output capacity of the knapsack pump. Typical nozzle sizes are 700, 800 or 900 ml/minute. Smaller nozzle sizes are manufactured by some companies but may not be universally available. A 1000 ml/minute nozzle will have twice the output as a 500 ml/minute nozzle at the same pressure. The angle rating of a spray tip is not related to output.

Nozzle Size*	Pressure		Flow Rate	
(80º and 110º)	(PSI)	(BAR)	(gpm)	(ml/min)
01	30	2.0	0.09	340
	40	2.8	0.10	380
	50	3.5	0.11	415
02	30	2.0	0.17	640
	40	2.8	0.20	760
	50	3.5	0.22	830
03	30	2.0	0.26	985
	40	2.8	0.30	1135
	50	3.5	0.34	1290

Figure 16. Selected TeeJet® flat fan nozzle sizes (*measure in 10ths of gallons) and flow rates at various pressures.

Pressure. As pressure increases, sprayer output increases. However, this relationship is not direct. Pressure must increase four times in order to double nozzle output (Figure 17).

Pressure	Output per Minute
1 Bar (15 PSI)	1 liter
4 Bar (60 PSI)	2 liter

Figure 17. Pressure and output of a nozzle in one minute with an output rating of 1 liter per minute at 1 BAR.

Variable pressure will cause variable output. Pressure may also affect the spray angle of different nozzles. The nozzle angle rating is for a specific pressure. The spray angle of a nozzle will decrease when pressure drops below the recommended minimum pressure for that nozzle (Figure 18). Low pressure nozzles (nozzles that have spray angles maintained at low pressures) are manufactured. However, they may not be universally available.

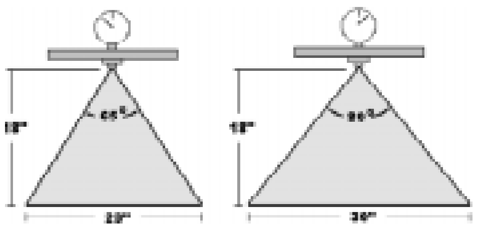


Figure 18. 80º spray tip at 1 BAR and 2 BAR pressure.

Calibrating a multiple nozzle boom

Calibration is done to determine sprayer output for a given area (i.e. liters per hectare or gallons per acre). The simplest way to calibrate is to measure the output against a known area (Figure 19).

In this example, a two nozzle boom with 80° nozzles spaced 50 cm apart will be used. An area of 100 square meters (1/100th of a hectare) will be sprayed using a tank filled with a known quantity of water (4 liters). When calibrating, operate the sprayer like it will be done in the field. Walk at a comfortable pace and pump the sprayer in a consistent manner.

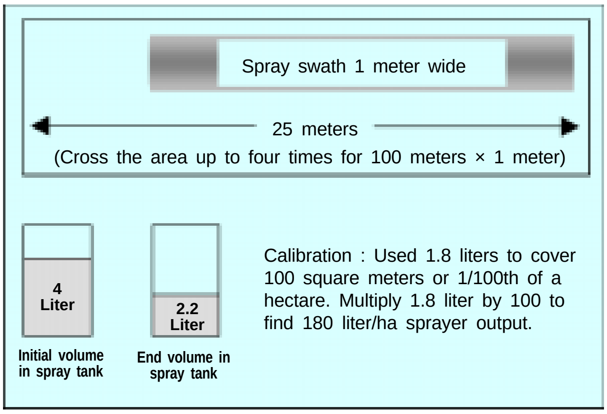


Figure 19. Calibration.

This sprayer has been found to have an output of 180 liters / hectare. This is only true for the speed and pressure that were used when it was calibrated.

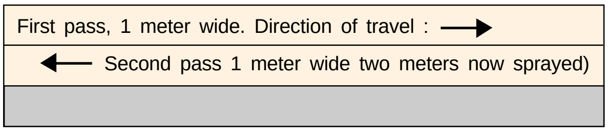
Determining the amount of herbicide to use

Once the sprayer output per area is known, the applicator can begin to prepare to spray a field.

With a sprayer output of 180 liters/hectare and a herbicide rate of 100 grams/hectare the calculations for spraying a one hectare field would be:

Wheat field size: **1 hectare**	180 liters / ha x 1 ha = **180 liters** 180 liters / 15 liter per tank = **12 tanks** **(Spray tank capacity of 15 liters)**

Put 100 grams of the herbicide into 12 liters of water and mix well. Pour one liter into each tank, fill with water, mix and spray at the same speed used for calibration. With this boom sprayer, straight passes will be made each meter across the field.



5. Pressure regulation

Maintaining a constant pressure can be very difficult with a knapsack sprayer. Without pressure regulation, pressure will tend to fluctuate between the down stroke of the pump and the upstroke - high on the down stroke and low on the upstroke. It will also tend to fluctuate as a person spraying becomes tired and finds it more difficult to maintain the initial pressure.

While it is possible to make adequate herbicide applications without a pressure regulator, a regulator will make sprays simpler and more accurate. Most knapsack sprayers do not come equipped with a pressure regulator. A traditional regulator may be far too expensive to justify purchase. Several companies are now manufacturing regulator valves that are intended specifically for knapsack sprayers (Figure 20). They are durable, accurate and relatively inexpensive.

Automatic pressure relief valves are attached to a lance or boom line, usually directly before the nozzle. They do not open until their rated pressure

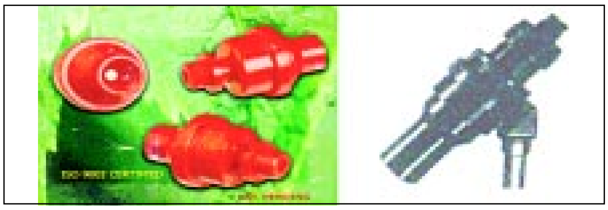
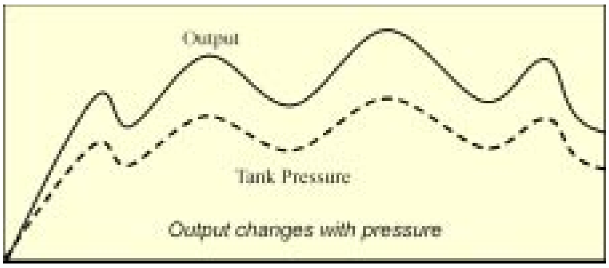


Figure 20. Pressure regulation valves.

is reached. Once the valve does open, excess pressure is managed down to the preset pressure. If pressure should drop below the preset pressure, the valve will shut off flow to the nozzle. Constant pressure regulator valves will help eliminate incorrect application caused by pressure being too high (over-spraying, crop injury) or too low (no weed control) (Figures 21 and 22). When these valves are correctly matched with nozzles, they will ensure proper nozzle performance. Pressure regulation, of some type, is critical in calibrating a sprayer.

Sprayer output without regulator valve



Sprayer output with regulator valve

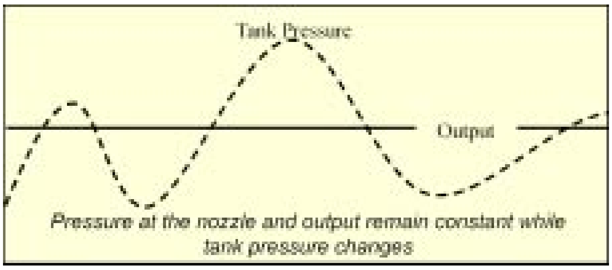


Figure 21. Sprayer output with and without regulator valves

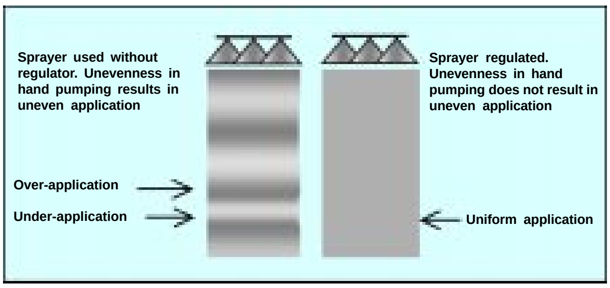


Figure 22. Unevenness in hand pumping will be regulated by pressure regulator valve.

6. Shielded spraying

Spraying with a shielded sprayer is done in row crops to keep pesticides away from crops that would otherwise be injured. A metal or plastic shield is placed over the end of a spray lance or boom. The shield is open on the bottom and enclosed on all other sides (Figure 23).

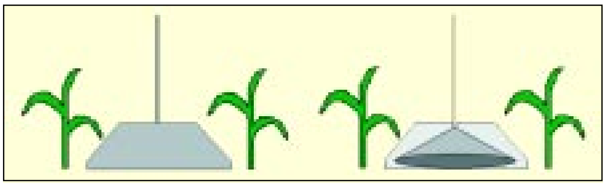


Figure 23. Shielded sprayer and spray pattern inside shield.

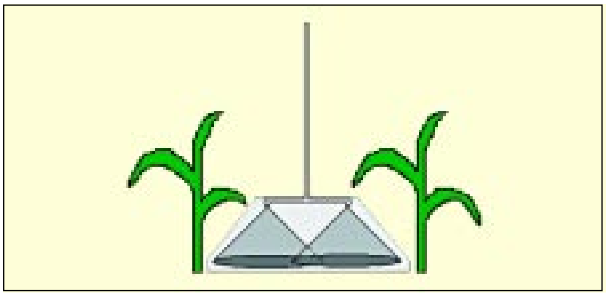


Figure 24. Shielded boom with two flat fan nozzles.

Typically, shielded spraying is used to apply complete weed killers or other herbicides that may damage a crop. The spray is placed between rows and is not applied to the crop. Herbicide application rates are calculated only for the actual area that will be sprayed. If a single nozzle is shielded, an even flat fan or hollow cone nozzle can be used. If more than one nozzle on a boom is shielded, flat fan nozzles should be used (Figure 24).

7. Mixing

It is important that the spray remains mixed. If an herbicide is not properly mixed in the spray solution, poor application will result. This will happen if the herbicide has settled to the bottom of the tank. When the application is made, the spray will initially be too concentrated, and subsequently too weak. Over- and under-application will result. Mix the solution when the chemical is first added. Stop at intervals while spraying to keep the solution mixed. Never allow a long time to pass between mixing and spraying. It is especially important when using dry formulations.

8. Cleaning

Always clean the sprayer after use or when changing to a new chemical. Rinse the tank with clean water, add fresh water to the tank and spray it through the lance or boom. This should be repeated twice. With most herbicides, extra precaution should be taken to ensure that no chemical is left in the sprayer. Some may contaminate a future spray mixture and cause unwanted crop injury.

9. Surfactants

Surfactants are materials that may be used with some herbicides to help them bind to, penetrate or spread uniformly over leaf surfaces. They improve the weed control of some herbicides, and are therefore, useful in certain situations (Figures 25 and 26). With some herbicides, however, crop injury can increase to unacceptable levels. Follow University developed guidelines when choosing to use a surfactant.

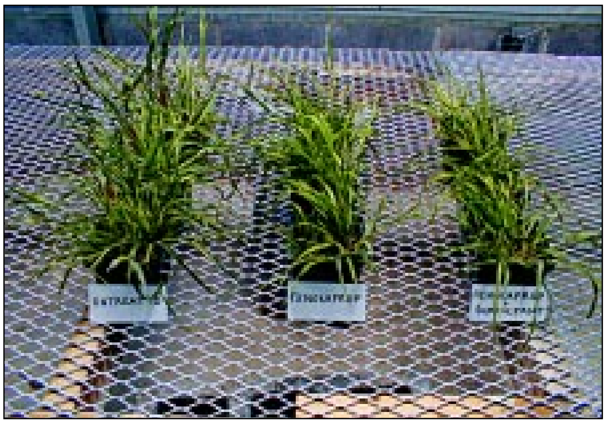


Figure 25. Untreated, fenoxaprop, and fenoxaprop plus surfactant treated *P. minor.* The surfactant had a minimal effect upon the efficacy of the herbicide.

Figure 26. Untreated, sulfosulfuron, and sulfosulfuron plus surfactant treated *P. minor.* The surfactant increased the efficacy of the herbicide.

10. Spray drift

Drift is the movement of spray droplets to unintended targets. Spray drift can injure or kill crops in adjacent fields and expose nearby people or animals to harmful pesticides. Causes of drift include droplet size, wind, nozzle height and temperature.

Droplet Size. Most nozzles spray a wide range of droplet sizes (Figure 27). Small spray droplets are much more likely to drift than large ones. They are more easily moved by wind and, if they are very small, can move with what might seem like no wind at all. Small nozzle sizes and high pressure will create more small droplets. To minimize the percentage of small droplets in a spray “cloud” use low pressure and large nozzle sizes. In some cases it is not desirable to have only large droplets. Small droplets can increase spray coverage and may be wanted with some fungicides, insecticides and certain contact herbicides. In this case it becomes very important to avoid other causes of spray drift.

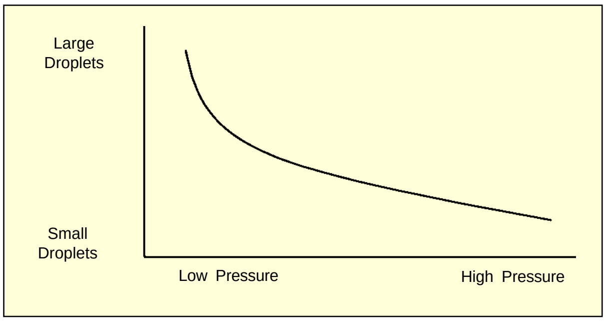


Figure 27. Average droplet size decreases with increased pressure.

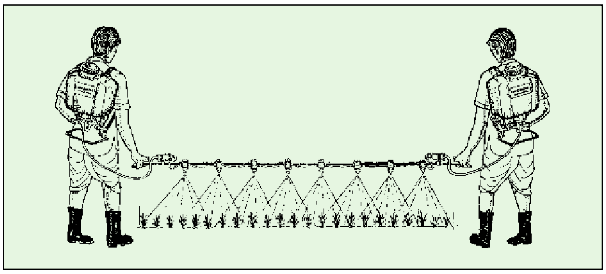
Wind. Drift potential increases with wind speed. Large nozzle sizes and low spray pressure should be considered when wind is likely to cause drift. As a general rule, the risk of wind-caused drift begins when tree leaves begin to move. While spray applications can be made in wind up to 6-8 kilometers per hour (moderate leaf movement), it is best to spray at calm times. In many cases, the early morning and late afternoons are good times to spray.

Spray Tip Height. Greater spray heights increase the chance that wind can cause drift.

Temperature. High temperature (25º C), with low humidity, makes droplets susceptible to drift due to evaporation. Avoid spraying under these conditions.

11. Pesticide safety

Pesticides are chemicals that can cause both short- and long-term health problems with people. While not all pesticides have the same level of health risk, they should all be handled carefully. Keep all pesticides out of the eyes and mouth. Avoid contact with the skin. If contact occurs with the skin, wash with soap and water immediately. Do not eat, drink or smoke while handling (mixing, spraying or storing) pesticides. Wear boots, long trousers and rubber gloves when spraying. Change and wash all clothing after spraying. Never store pesticides where children may accidentally become exposed. Do not re-use empty pesticide containers.



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Rice-Wheat Consortium for the Indo-Gangetic Plains

The Consortium is an Ecoregional Program of the Consultative Group on International Agricultural Research (CGIAR), managed by CIMMYT, involving the National Agricultural Research Systems, the International Agricultural Research Centers, and the Advanced Research Institutions. Its main objective is to promote research on issues that are fundamental to enhance the productivity and sustainability of rice-wheat cropping systems in South Asia.

These objectives are achieved through:

- Setting priorities for focused research on problems affecting many farmers.
- Promoting linkages among rice-wheat research specialists and other branches of research and extension.
- Encouraging interdisciplinary team approach to understand field problems and to find solutions.
- Fostering quality work and excellence among scientists.
- Enhancing the transfer of improved technologies to farmers through established institutional linkages.

Financial support for the Consortium's research agenda currently comes from many sources, including the Governments of Australia, Netherlands, Sweden, Switzerland, and the Department for International Development (DFID), the International Fund for Agricultural Development (IFAD), the United States Agency for International Development (USAID), and the World Bank.

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