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Spray Drift of Pesticides

This NebGuide discusses conditions that cause particle drift, and methods private and commercial applicators may employ to reduce drift potential from pesticide spray applications.

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Spray drift of pesticides away from the target is an important and costly problem facing both commercial and private applicators. Drift causes many problems including:

1. damage to susceptible off target sites,
2. a lower rate than intended which can reduce the effectiveness of the pesticide, wasting pesticide and money, and
3. environmental contamination, such as water pollution and illegal pesticide residues.

Drift occurs by two methods; vapor drift and particle drift. This NebGuide focuses mainly on conditions that cause particle drift, and methods to reduce the drift potential of spraying pesticides.

Drift Dynamics

A solution sprayed through a nozzle divides into droplets that are spherical or nearly spherical in shape. A recognized measure for indicating the size of these droplets is microns.

Droplets smaller than 100 microns are considered highly driftable and are so small they cannot be readily seen unless in high concentrations, such as fog. By comparison, a dime is about 1,270 microns thick. As a result of the small size, drift is more dependent on the irregular movement of turbulent air than on gravity.

Particle drift is the actual movement of spray particles away from the target area. Many factors affect this type of drift, but the most important is the initial size of the droplet. Small droplets fall through the air slowly, and are carried farther by air movement.

Table I shows the effect of droplet size on the rate of fall. The longer the droplet is airborne, the greater the potential for drift.

Diameter, microns	Time to fall 10 feet in still air
1 (Fog)	28 hours
10 (Fog)	17 minutes
100 (Mist)	11 seconds
200 (Fine Spray)	4 seconds
400 (Coarse Spray)	2 seconds
1,000 (Coarse Spray)	1 second

When leaving the nozzle, the solution may have a velocity of 60 feet per second (41 mph) or more. Unless the spray particles are electrostatically charged, there are two forces acting upon the emerging droplets. These forces--gravity and air resistance--greatly influence the speed and movement of spray droplets.

Droplet speed is reduced by air resistance, which breaks up the droplets. After their initial speed slows, the droplets continue to fall under the gravitational pull.

With lower boom heights, the initial speed may be great enough that the droplet reaches the target before drift occurs. Large droplets maintain a downward velocity longer than smaller ones. Small droplets also evaporate quickly, leaving minute quantities of the pesticide in the air (Figure 1). Larger droplets are more likely to be deposited on the intended target.

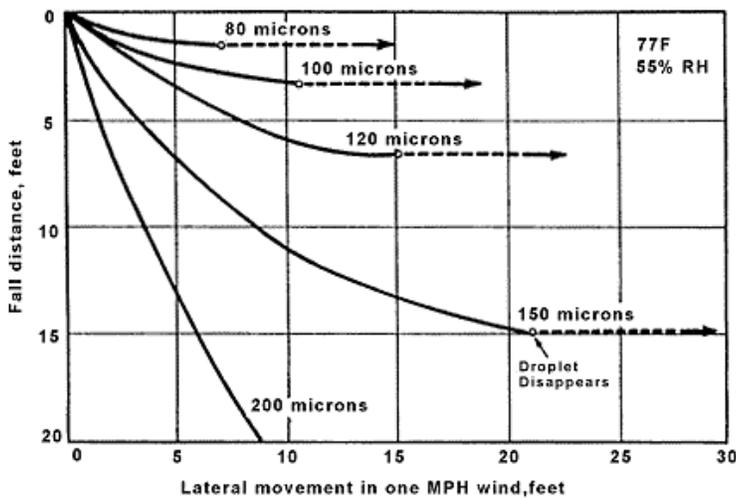


Figure 1. Lateral movement of water droplets. (Hofman, et al., 1986)

Ideally, most of the volume should be contained in larger droplets. When pressure is increased, a higher percentage of droplets are small droplets. With a greater proportion of the total spray volume in smaller droplets, the potential drift onto off-target sites increases.

Altering Droplet Size

Many components of a sprayer can be adjusted to alter droplet size. Of these, nozzle type selection is one of the most critical.

Nozzle Type: Spray droplets are produced from nozzles in different ways. A *fan nozzle* forces the liquid

under pressure through an elliptical orifice and the liquid spreads out into a thin sheet that breaks up into different-sized droplets.

A *flood nozzle* deflects a liquid stream off a plate that causes droplets to form. A *whirl chamber nozzle* swirls the liquid out an orifice with a circular motion and aids the droplet formation with a spinning force.

Droplet sizes are influenced by various nozzle types and different spray pressures. The full cone produces the largest droplets which result in lower drift potential. For many herbicide applications a large droplet gives good results, but for good plant coverage (i.e. postemergence application), large droplets may not give good pest control.

Nozzle Type	Volume Median Diameter, microns
Hollow Cone	360
Extended Range Flat Fan	460
Standard Flat Fan	470
Full Cone	680

Volume median diameter (VMD) is a term used to describe the droplet size produced from a nozzle tip. VMD is the droplet size at which one-half the spray volume consists of large droplets and one-half consists of smaller droplets. Since it takes many more small droplets to make up one-half the spray volume, there always will be more small droplets present in a typical spray pattern.

Remember, nozzles produce a wide range of droplet sizes. A nozzle that can produce only one size droplet is not presently available. Therefore, the goal in the proper application of pesticides is to achieve a uniform spray distribution while retaining the spray droplets within the intended target area.

Spray Pressure: Spray pressure influences the formation of the droplets. The spray solution emerges from the nozzle in a thin sheet, and droplets form at the edge of the sheet. Higher pressures cause the sheet to be thinner, and the sheet breaks up into smaller droplets.

Large orifice nozzles with higher carrier volumes produce larger drops. Small droplets are carried farther downwind than larger drops formed at lower pressures (*Figure 1*).

The relationship between flow rate (GPM) and pressure (PSI) is not linear. For example, to double the flow rate would require the pressure to be increased by four times. This action would greatly contribute to the drift potential and is not an acceptable method to increase carrier volumes. If the carrier volume needs to be changed, select a different nozzle tip that meets the spraying requirements. Consult NebGuide G89-955, *Nozzles--Selection and Sizing*, for proper selection.

Table III shows the mean droplet size for nozzles when spraying at three pressures. Higher pressures decrease the droplet size.

	Nozzle Pressure		
Nozzle Spray Angle	15 PSI	40 PSI	60 PSI
Degrees	Volume Median Diameter, microns		
40	900	810	780
65	600	550	530
80	540	470	450
110	410	380	360

Nozzle Spray Angle: Nozzles that have wider spray angles produce a thinner sheet of spray solution and smaller droplets at the same pressure (*Table III*). However, wide angle nozzles can be placed closer to the target, and the benefits of lower nozzle placement outweigh the disadvantage of slightly smaller droplets. Lower pressures can be used to reduce the amount of fine droplets. For lower pressures with flat fan nozzles, low pressure or extended range nozzles must be used.

Spray Volume: The size or capacity of the nozzle also influences droplet size. The larger orifice increases the droplet size at a common pressure. It increases the number of refills, but the added carrier improves coverage and in some cases increases pesticide effectiveness. *Table IV* shows the influence of an increasing flow rate on droplet size at a constant pressure. With some pesticides, such as Roundup and Landmaster, the carrier must be kept low.

	Flow Rate		
Nozzle Type	0.2 GPM	0.5 GPM	0.8 GPM
	Volume Median Diameter, microns		
Std. Flat Fan	390	470	560
Extended Range Flat Fan	360	460	560
Flood Jet	370	450	540
Full Cone	-	680	770

Other Drift Factors

Boom Height: Operating the boom as close to the sprayed surface as possible (stay within manufacturer's recommendation) is a good way to reduce drift. A wider spray angle allows the boom to be placed closer to the target (*Table V*). Booms that bounce cause uneven coverage and drift. Wheel-carried booms stabilize boom height, which reduces the drift hazard, provides more uniform coverage, and permits lower boom height. Shielded booms reduce the drift from excessive air movement from travel speed and wind.

Table V. Suggested minimum spray heights. (NebGuide G89-955)				
	Nozzle Spacing			
	20 inches		30 inches	
	Percent Overlap			
Spray Angle Degrees	30%	100%	30%	100%
	Spray Height, inches			
65	22-24	-NR-	-NR-	-NR-
73	20-22	-NR-	29-31	-NR-
80	17-19	26-28	26-28	-NR-
110	10-12	15-17	14-18	25-27
-NR- Not recommended if height is above 30 inches.				

Nozzle Spacing: Nozzle spacing for a given spray volume requires an increase in orifice size as the spacing increases. This typically means the boom height will have to be increased to get the proper overlap. However, enlarging the droplet size is more important than the increase in boom height.

As a general guideline, do not exceed a 30 inch nozzle spacing because the spray pattern uniformity begins to degrade. A configuration of nozzle spacing, height and direction which gives 100 percent overlap is preferred.

Wind Speed: The amount of pesticide lost from the target area and the distance it moves both increase as wind velocity increases (*Table VI*). However, severe drift injury can occur with low wind velocities, especially under temperature inversion situations. Most recommendations are to stop spraying if the wind speeds exceed 10 mph. Wind influences can be minimized by using shielded booms and lower boom height.

Table VI. Effect of wind speed on drift in a 10 foot fall (Ross and Lembi, 1985)		
	Wind Speed	
Droplet Diameter, microns	1 MPH	5 MPH
	Drift, feet	
100 (Mist)	15.4	77
400 (Coarse Spray)	3.0	15

Wind Direction: Pesticides should not be applied when the wind is blowing toward a nearby susceptible crop or a crop in a vulnerable stage of growth. Select a time when there is little wind or the wind blows gently away from susceptible crops. If these conditions do not exist, consider another method of control or time of application.

Air Stability: Air movement largely determines the distribution of spray droplets. Wind generally is recognized as an important factor, but vertical air movement often is overlooked.

Temperature inversion is a condition where cool air near the soil surface is trapped under a layer of warmer air. A strong inversion potential occurs when ground air is 2° to 5°F cooler than the air above.

Under inversion conditions, little vertical mixing of air occurs, even with a breeze. Spray drift can be severe. Small spray droplets may fall slowly or be suspended and move several miles to susceptible areas, carried by a gentle breeze.

Avoid applying pesticides near susceptible crops during temperature inversion conditions. Inversions can be identified by observing smoke from a smoke bomb or a fire. Smoke moving horizontally close to the ground would indicate a temperature inversion.

Relative Humidity and Temperature: Low relative humidity and/or high temperature conditions cause faster evaporation of spray droplets and a higher potential for drift. During evaporation the droplets become smaller.

The quantity of spray that evaporates is related to the quantity of the spray deposit. Evaporation is greater from the same deposit in small droplets than in larger drops because the small droplets have greater surface area relative to their volume. Less pesticide gets to the target (*Figure 1*).

Evaporation increases the drift potential, so spray during lower temperature and higher humidity conditions. Pesticides differ in their evaporation rate. Use formulations and adjuvants that reduce evaporation.

As a rule of thumb, if the relative humidity is above 70 percent, the conditions are ideal for spraying. A relative humidity below 50 percent is critical enough to warrant special attention.

Spray Thickeners: Some spray adjuvants act as spray thickeners when added to a spray tank. These materials increase the number of larger droplets and decrease the number of fine droplets. They tend to give water-based sprays a "stringy" quality and reduce drift potential. Consult NebGuide G88-872, *Surfactants and Herbicides*, for additional guidelines.

Droplets formed from an oil carrier tend to drift farther than those formed from a water carrier. Oil droplets are usually smaller, lighter and remain airborne for longer periods, but don't evaporate quickly.

Best Management Practices Concerning Pesticide Drift

All nozzles produce a range of droplet sizes. The small, drift-prone particles cannot be eliminated but can be reduced and kept within reasonable limits. Here are some tips:

1. Select low or nonvolatile pesticides.
2. Read and follow the pesticide label. Instructions on the pesticide label are given to ensure the safe and effective use of pesticides with minimal risk to the environment. Each pesticide is registered for use on specific sites or locations. Surveys indicate approximately 65 percent of drift complaints involved application procedures in violation of the label. Apply a pesticide only if economic thresholds warrant an application.
3. Use spray additives within label guidelines. This will increase the droplet sizes and pesticide effectiveness.
4. Use larger orifice sizes. This will give larger droplets and will increase the number of tank refills, but will improve coverage and effectiveness.

5. Avoid high pressure. High pressure creates finer droplets; 45 PSI should be considered maximum for conventional broadcast spraying.
6. Use drift-reduction nozzles. They will produce larger droplets when operated at low pressures.
7. Use wide angle nozzles, low boom heights, and keep the boom stable.
8. Drift is minimal when wind velocity is under 10 mph. Do not spray when wind is greater or blowing towards sensitive crops, gardens, dwellings, livestock or water sources.
9. Use shielded booms. When banding, use shroud covers.

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Weight and Measure Conversions

Weight	16 ounces = 1 pound = 453.6 grams 1 gallon water = 8.34 pounds = 3.78 liters
Liquid measure	1 fluid ounce = 2 tablespoons = 29.57 milliliters 1 tablespoon = 3 teaspoons 16 fluid ounces = 1 pint = 2 cups 8 pints = 4 quarts = 1 gallon
Length	3 feet = 1 yard = 91.44 centimeters 16.5 feet = 1 rod 5,280 feet = 1 mile = 1.61 kilometers 320 rods = 1 mile
Area	9 square feet = 1 square yard 43,560 square feet = 1 acre = 160 square rods 1 acre = 0.405 hectare 640 acres = 1 square mile = 1 section
Speed	88 feet per minute = 1 mph 1 mph = 1.61 km/hour

Volume

27 cubic feet = 1 cubic yard
1 cubic foot = 1,728 cubic inches = 7.48 gallons
1 gallon = 231 cubic inches
1 cubic foot = 0.028 cubic meters

Common abbreviations and terms:

GPM = gallons per minute
GPA = gallons per acre
PSI = pounds per square inch
MPH = miles per hour
RPM = revolutions per minute
GPH = gallons per hour
FPM = feet per minute

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