

Reducing Spray Drift



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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 publication will mainly focus on conditions that cause particle drift and methods to reduce the drift potential from spraying pesticides.

Drift Dynamics

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

Droplets smaller than 100 microns are considered highly "driftable" and are so small that they cannot be readily seen unless in high concentrations such as fog. By comparison, a human hair is about 100 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.

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 are gravity and air resistance. These forces greatly influence the speed and movement of spray droplets.

The 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.

Table 1. Effect of droplet size on drift potential (Ross and Lembi, 1985).

Diameter (microns)	Spray Type	Time to Fall 10 in Still Air (Seconds)
1	Fog	100,800
10	Fog	1020
100	Mist	11
200	Fine	4
400	Coarse	2
1,000	Coarse	1

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

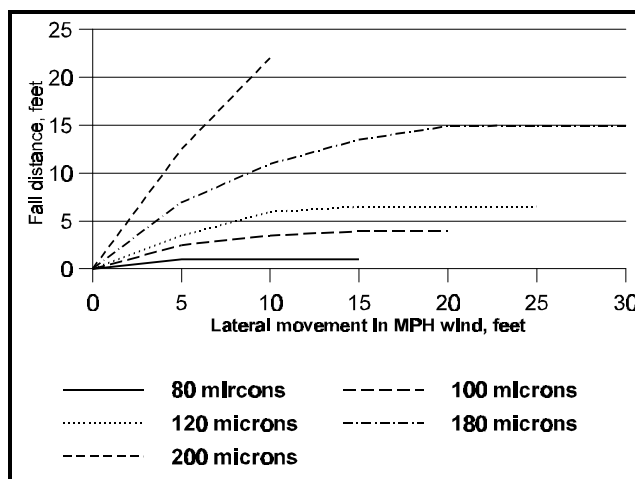


Figure 1. Lateral movement of water droplets. (Hoffman, et al., 1986) at 77°F, 55% RH

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.

Table 2. Effect of nozzle type on droplet size. Volume Median Diameter ($D_{V0.5}$, Microns) (Womac et. al., 1997)

Nozzle Type, Pressure and Flow Rate	15 psi	20 psi	30 psi	40 psi	50 psi	60 psi	90 psi
Extended Range Fan XR-80° (Spraying Systems, 40 psi and 0.2 gpm)	239	214	177	159		141	
Flat Fan LD-80° (Lurmark, 40 psi and 0.2 psi)	367		264	223		189	157 ¹
Rain Drop Fan RF-80° (Delavan, 40 psi and 0.2 gpm)		339	290	248	215	200	
Drift Guard Fan DG-80° (Spraying Systems, 40 psi and 0.2 gpm)			350	292	260	234	
Extended Range Fan XR-110° (Spraying Systems, 40 psi and 0.2 gpm)	199	185	166	153		142	
Flat Fan LD-110° (Lurmark, 40 psi and 0.2 psi)	335		238	209		183	156 ¹
Drift Guard Fan DG-110° (Spraying Systems, 40 psi and 0.2 gpm)			296	241	219	206	
Turbo Flat-fan TT-110° (Spraying Systems, 40 psi and 0.2 gpm)	392		311	271		215	179
Flood CP (CP Products, 20 psi and 0.25 gpm)		418	341	300			
Flood TK (Spraying Systems, 10 psi and 0.2 gpm)	236	224	213	207			
Turbo Floodjet TFVS (Spraying Systems, 10 psi and 0.2 gpm)	598	552	492	427			
Rain Drop RA (Delavan, 40 psi and 0.2 gpm)		549	468	422	394		
Turbo Drop TD 110° (Greenleaf) (40 psi and 0.25 gpm)				610		511	374 ¹
Hollow Cone TXVS (Spraying Systems, 40 psi and 0.2 gpm)				178	173	169	

¹ Droplet sizes at 100 psi.

Droplet sizes are influenced by various nozzle types and different spray pressures. Table 2 presents several nozzles and droplet sizes generated at 40 psi. The full cone, turbo floodjet produces the largest droplets which results in lower drift potential. For many herbicide applications, a large droplet will give good results but for

good plant coverage (i.e. postemergence application), large droplets may not give good pest control.

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 of droplet is not available at the current time. 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. Table 3 shows the mean droplet-size for nozzles when spraying at three pressures. Higher pressures decrease the droplet size.

Table 3. Effect of spray angle and pressure on droplet size

	Pressure (psi)		
Spray Angle	15	40	60
Degrees	Volume Median Diameter, microns		
65	600	550	530
80	540	470	450
110	410	380	360

Nozzle Spray Angle: Nozzles that have wider spray angles will produce a thinner sheet of spray solution and smaller droplets at the same pressure (Table 3). 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 which 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 will increase the droplet size at a common pressure. It will also increase the numbers of refills, but the added carrier improves coverage and in some cases increased pesticide effectiveness. Table 4 shows the influence of an increasing flow rate on droplet size at a constant pressure. With some pesticides, such as Roundup, the carrier must be kept low.

Table 4. Effect of flow rate on droplet size at 40 psi. (Spraying Systems, Inc., 1996)

Nozzle Type	Flow Rate (gpm)		
	0.2	0.5	0.6
	Volume Median Diameter, microns		
Standard Flat-fan	390	470	560
Extend Range Flat-fan	360	460	560
Floodjet	360	450	540
Full Cone	-	680	770
Hollow Cone	220	360	-

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. Booms that bounce will cause uneven coverage and drift. Wheel-carried booms will stabilize boom height, which will reduce the drift hazard, provide more uniform coverage, and permit lower boom height. Shielded booms also reduce the drift from excessive air movement from travel speed and wind.

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

A configuration of nozzle spacing, height, and direction which gives 100% uniform spray coverage is preferred.

Wind Speed: The amount of pesticide lost from the target area and the distance it moves both increase as wind velocity increases (Figure 2). However, severe drift injury can also 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.

Droplet Drift vs Wind Speed

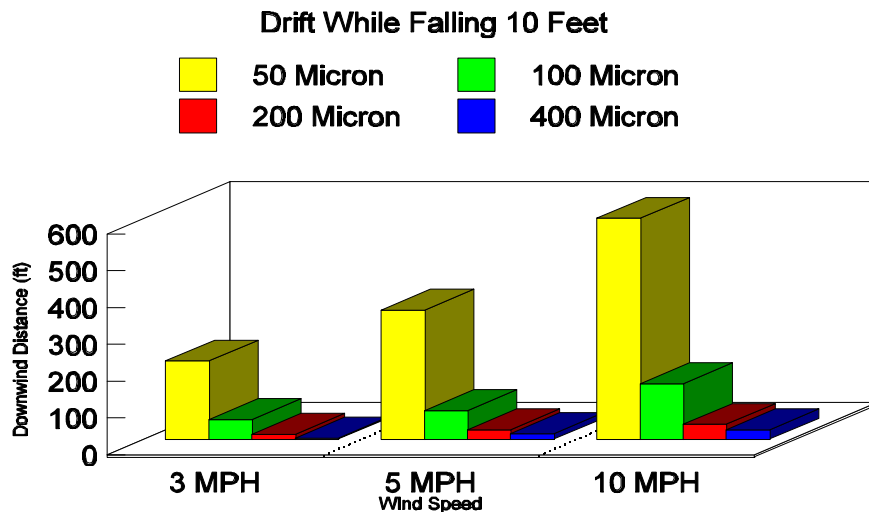


Figure 2. Effect of wind speed on drift in a 10 foot fall.

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 is generally recognized as an important factor, but vertical air movement is often 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 under inversion conditions. Small spray droplets may fall slowly or may be suspended and move several miles with a gentle breeze to susceptible areas.

Avoid applying pesticides near susceptible crops during temperature inversion conditions. Inversions can be identified by observing smoke from a smoke bomb or fire

(Figure 3). Smoke moving horizontally close to the ground would indicate a temperature inversion.

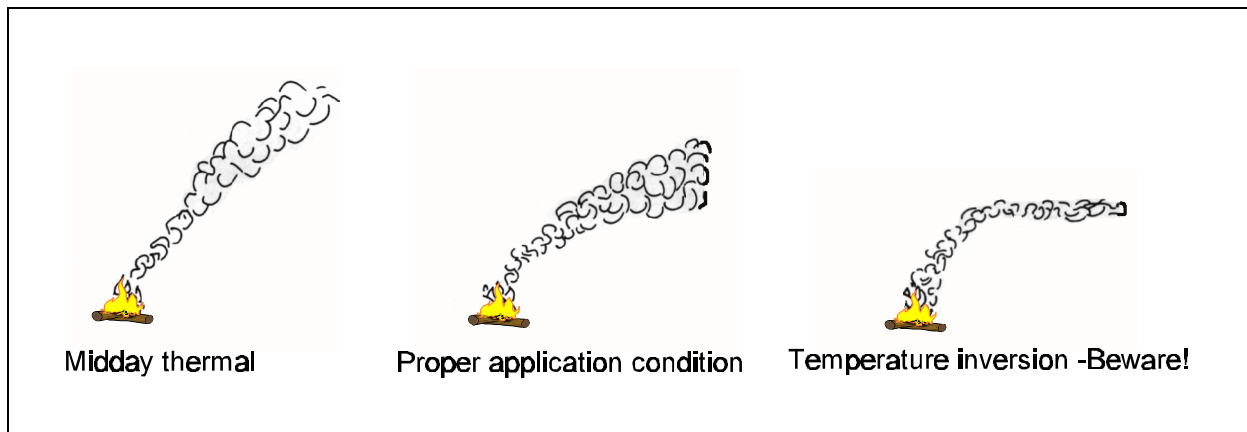


Figure 3. Smoke rising with wind velocity below 5 MPH.

Relative Humidity and Temperature: Low relative humidity and/or high temperature conditions cause faster evaporation of spray droplets and thus, 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. Thus, 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%, the conditions are ideal for spraying. However, a relative humidity below 50% 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.

Droplets formed from an oil carrier tend to drift further 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 they 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 that approximately 65% of the 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 create 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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