Chapter 20

Drift of Pesticides

In This Chapter

After learning the information in this chapter, you will be able to:
1. Define drift.
2. Describe how nozzles and spray droplets affect drift.
3. List ways to manage drift, considering equipment, environmental conditions and the pesticide.

Keywords

spray drift, vapour drift, droplet size, boom sprayer, air blast sprayer, nozzle, humidity, surface inversion, sensitive area, buffer zone

Your goal is to get the pesticide from the application equipment to the intended target while avoiding non-target zones such as nearby crops, environmentally sensitive areas, and areas of human activity. The equipment you use could be a back pack sprayer, a seed drill, an air blast sprayer or a boom sprayer. The target could be a weed, a part of the crop plant, fruit on a tree, a seed or the seedbed.

What is Drift?

Pesticides may move from the target site because of spray (particle) drift or vapour drift. Drift may reduce the effectiveness of the pesticide in the targeted area and may have a harmful effect on nearby plant or animal life. Drift can occur while you apply pesticides or many hours later.

Spray Drift (Particle Drift) is the movement of spray droplets away from the target area. This usually occurs when the wind is strong enough to pick up and carry the spray droplets. Small spray droplets drift further than large droplets. Granular and powder formulations will also drift.

Vapour Drift is the invisible movement of pesticide vapours. Some pesticides are volatile and change to the vapour state after a period of time in the soil, air or on the plant. This vapour will be carried to other areas and may cause serious problems if susceptible plants are nearby. Vapour drift is a condition of the pesticide and the environmental conditions, not the application method used.
Before you can understand how to reduce spray drift, you need to understand the behaviour of spray droplets.

The most important factor that affects drift is the initial size of the droplet. **Large droplets are not as likely to drift as smaller droplets.** The old saying “the bigger they are, the harder they fall” applies here. Actually, the larger they are, the closer they fall. Equipment manufacturers focus on droplet size when designing nozzles to reduce drift and some pesticide labels have droplet size restrictions.

**How Droplet Size is Measured**

Droplet size is measured in microns or micrometres (µm). One µm equals 0.001 mm. To imagine the size of a micron, consider that one dime is about 1.270 µm thick.

**Volume Median Diameter** (VMD or \(D_{v0.5}\)) is the manufacturer’s term to describe the ‘average’ droplet size produced by a nozzle. Even at constant pressure, nozzles produce a range of droplet sizes. The VMD is the droplet size where half of the spray volume is made up of the smaller droplets and half of the spray volume is made up of the larger droplets. The following graph shows the range of droplet sizes produced by a nozzle. The best nozzles have a very small range of droplet sizes shown by the lower line in the graph. This means most of the spray volume is droplets that are about the same size as the VMD. This allows you to make comparisons between nozzle types.

![Graph showing range of droplet sizes](image)

The following table shows the effect of droplet size on drift. The smaller droplets take longer to fall to the target, giving them more opportunity to be carried away in the air currents. Droplets smaller than 150 µm are the droplets that are the most likely to drift.
Effect of Droplet Size on Drift Potential

<table>
<thead>
<tr>
<th>Diameter (µm)</th>
<th>Description of Spray</th>
<th>Time to Fall 10 Feet in Still Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fog</td>
<td>28 Hours</td>
</tr>
<tr>
<td>10</td>
<td>Fog</td>
<td>17 Minutes</td>
</tr>
<tr>
<td>100</td>
<td>Fog</td>
<td>11 Seconds</td>
</tr>
<tr>
<td>200</td>
<td>Fine Spray</td>
<td>4 Seconds</td>
</tr>
<tr>
<td>400</td>
<td>Coarse Spray</td>
<td>2 Seconds</td>
</tr>
<tr>
<td>1000</td>
<td>Coarse Spray</td>
<td>1 Second</td>
</tr>
</tbody>
</table>


Spray Nozzle Classification

The American Society of Agricultural and Biological Engineers (ASABE, formerly ASAE) and the British Crop Protection Council (BCPC) classify flat fan spray nozzles by droplet size. The manufacturers of nozzles use this classification when describing the distribution of droplets from different types of nozzles.

Spray Nozzle Classification

<table>
<thead>
<tr>
<th>Classification</th>
<th>Colour Code</th>
<th>Symbol</th>
<th>VMD (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely Fine</td>
<td>Purple</td>
<td>XF</td>
<td>~50</td>
</tr>
<tr>
<td>Very Fine</td>
<td>Red</td>
<td>VF</td>
<td>&lt; 150</td>
</tr>
<tr>
<td>Fine</td>
<td>Orange</td>
<td>F</td>
<td>151-250</td>
</tr>
<tr>
<td>Medium</td>
<td>Yellow</td>
<td>M</td>
<td>251-350</td>
</tr>
<tr>
<td>Coarse</td>
<td>Blue</td>
<td>C</td>
<td>351-450</td>
</tr>
<tr>
<td>Very Coarse</td>
<td>Green</td>
<td>VC</td>
<td>451-550</td>
</tr>
<tr>
<td>Extremely Coarse</td>
<td>White</td>
<td>XC</td>
<td>&gt; 551</td>
</tr>
<tr>
<td>Ultra Coarse</td>
<td>Black</td>
<td>UC</td>
<td>&gt;662</td>
</tr>
</tbody>
</table>

Remember – one nozzle can produce different classifications of droplets (different sizes) at different pressures. A nozzle might produce a medium spray at low pressure, but produce a fine spray at a higher pressure. The nozzle manufacturers can provide you with information on droplet size for each of the nozzles that they sell.
Boom Sprayer Nozzles

The most common nozzle used in boom spraying is the flat fan style. This nozzle uses hydraulic pressure to atomize the spray mix into a wide range of droplet sizes. The smaller droplets typically provide better coverage on the plants, but are more likely to evaporate and drift. Smaller droplets slow down quickly once they leave the nozzle orifice (opening) and take a much longer time getting from the nozzle to the target. Larger droplets, on the other hand, evaporate slowly and move in the direction they were sprayed (because they have more momentum). However, they are also more likely to bounce off the plant and provide less coverage.

Air Blast Sprayer Nozzles

Spray nozzle classification (very fine to extremely coarse) was originally developed for flat fan nozzles spraying into still air under specific conditions. While nozzle manufacturers sometimes provide spray nozzle classifications for cone-pattern directed-spray nozzles such as disc-core, these ratings do not account for the effects of shear from air-assistance or spraying over larger distances. When you select nozzles remember that droplet size decreases when you
- increase pressure
- increase the nozzle angle into an air stream, and
- increase the distance from nozzle to target (due to evaporation).

Choosing the Right Nozzles

Before you apply pesticides, consider which spray nozzles will provide the best range of droplet sizes for the application. Very fine to fine droplets will cover more leaf surface than coarse droplets but are more likely to drift. Coarse droplets will cover less leaf surface than fine droplets but are less likely to drift. Spray nozzles that produce medium sized droplets are a good compromise.

Venturi (or air induction) nozzles, produce coarser droplets that contain air bubbles. These droplets shatter on impact and improve coverage while minimizing drift. They are mostly used in boom spraying, but are used in air blast spraying as well.
How to Manage Drift

The best way to manage drift is to spray under the correct conditions with a properly adjusted sprayer. You need to consider the:

- equipment
- environmental conditions, and
- pesticide formulation.

Consider the Equipment

Consider how the following may affect spray drift:

- type of nozzle
- spray pressure
- travel speed
- nozzle to target distance, and
- specialty equipment.

Type of Nozzle

The type of nozzle you select is the most important factor affecting droplet size. You must decide what type of nozzles you need to use to produce the right quality of spray for your application. The nozzle size you choose will determine the nozzle rate (flow rate).

Nozzle Description

Most manufacturers use similar nomenclature to describe their nozzles. The example below shows how “TeeJet®” brand nozzles are described using a combination letter and number system.

For TeeJet® nozzles, a combination letter and number system describes each type of nozzle.

For example, “XR8002 VS” is a nozzle sold by TeeJet®

<table>
<thead>
<tr>
<th>Letter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>XR</td>
<td>This describes the manufacturer’s series; XR is extended range.</td>
</tr>
<tr>
<td>80</td>
<td>This is the fan angle (80°) when spraying water at 40 psi; Other angles are 110° and 65°.</td>
</tr>
<tr>
<td>02</td>
<td>This is the nozzle rate in US gallons of water per minute; in this case, 0.2 US gallons per minute at 40 psi.</td>
</tr>
<tr>
<td>VS</td>
<td>VS describes the nozzle material; in this example, “V” means the VisiFlo colour code and “S” means stainless steel.</td>
</tr>
</tbody>
</table>
The following chart shows the prefixes (leading letters) that TeeJet® uses for the flat fan nozzles that they sell.

### Prefixes of TeeJet® Flat Fan Nozzles

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Description</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>XR</td>
<td>Extended Range</td>
<td>Maintains good spray pattern between 15 and 60 psi.</td>
</tr>
<tr>
<td>DG</td>
<td>Drift Guard</td>
<td>Uses a pre-orifice design to give a coarse spray at standard pressures and nozzle output – pressure range 30 to 60 psi.</td>
</tr>
<tr>
<td>AI</td>
<td>Air Induction</td>
<td>Uses a venturi to draw in air mixing with spray liquid to form coarse droplets.</td>
</tr>
<tr>
<td>TT</td>
<td>Turbo TeeJet</td>
<td>Uses a swirl chamber and a turbo flood jet design to create a wide angle coarse spray – pressure range 15 to 90 psi.</td>
</tr>
<tr>
<td>TJ</td>
<td>TwinJet</td>
<td>Contains two orifices, one oriented slightly back, and the other slightly forward, to produce a finer spray at a given nozzle rate.</td>
</tr>
</tbody>
</table>

### Colours

Newer nozzles follow a standard colour coding system which identifies the nozzle rate. Be careful with older nozzles – they are also coloured, but the colour does not match the new coding system.

<table>
<thead>
<tr>
<th>Nozzle Tip Colour</th>
<th>US Gallons per Minute at 40 psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange</td>
<td>0.1</td>
</tr>
<tr>
<td>Green</td>
<td>0.15</td>
</tr>
<tr>
<td>Yellow</td>
<td>0.2</td>
</tr>
<tr>
<td>Lilac</td>
<td>0.25</td>
</tr>
<tr>
<td>Blue</td>
<td>0.3</td>
</tr>
<tr>
<td>Red</td>
<td>0.4</td>
</tr>
<tr>
<td>Brown</td>
<td>0.5</td>
</tr>
<tr>
<td>Gray</td>
<td>0.6</td>
</tr>
<tr>
<td>White</td>
<td>0.8</td>
</tr>
</tbody>
</table>

When selecting nozzles from a catalogue, don’t confuse the colour code for flow rate with the colour code for droplet size.
Nozzle Rate

Nozzles that give higher output will produce larger droplet sizes because they have a larger opening (orifice). The following table shows how droplet size changes with different nozzle types when pressure remains the same.

<table>
<thead>
<tr>
<th>Nozzle Type at 40 psi</th>
<th>Nozzle Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.2 GPM</td>
</tr>
<tr>
<td>STD TeeJet® 80°</td>
<td>Fine</td>
</tr>
<tr>
<td>XR TeeJet® 80°</td>
<td>Fine</td>
</tr>
<tr>
<td>TT TeeJet® 110°</td>
<td>Medium</td>
</tr>
<tr>
<td>DG TeeJet® 80°</td>
<td>Medium</td>
</tr>
</tbody>
</table>

Spray Nozzle Classification

Source: TeeJet® Catalog 51

The table shows that, if you choose nozzles with higher rates, the spray will be coarser and less likely to drift. You will have to refill your tank more often, but the increased amount of water or other carrier improves coverage and can increase pesticide effectiveness. Note: for air blast spraying, once runoff starts, no more pesticide will be deposited on the target so increasing water volumes will result in increased runoff onto the soil.

Spray Angle

When boom spraying, wider spray angle nozzles can help to reduce drift. Nozzles that have wider spray angles (for example, 110°) create smaller droplets than nozzles with narrower spray angles (for example, 80°). Although smaller droplets generally increase the chance of drift and reduce penetration in dense canopies, the wider angle nozzles allow you to place the boom closer to the target. This placement greatly reduces drift. Using a lower pressure will help to prevent the formation of the smaller droplets but may reduce the spray angle.
Spray Pressure

Spray pressure is one way to change the droplet size. The pressure affects the formation of the droplets as they leave the nozzle. Lower pressures create larger droplets. Higher pressures create smaller droplets. **Do not use pressure to make large rate adjustments.** It takes a four-fold change in pressure to achieve a one-half change in rate and this often destroys the spray pattern. You might think that if you increase the pressure and speed up the droplets you get better spray penetration – it does not. Studies show that, although the droplets initially move faster, this does not last long.

**Do not operate nozzles at pressures below their working limits.** Follow the pressure recommended by the manufacturers. Operate nozzles at pressures in the middle of the recommended range to allow for minor changes in pressure (as maintained by a rate controller). A pressure lower than recommended will prevent the spray plumes from reaching the designed spray angle. The spray pattern will be less uniform. Air induction nozzles require higher pressures than conventional flat fan nozzles.

Travel Speed

A faster travel speed could increase drift. A faster travel speed could cause the spray pattern to distort (shearing effect), particularly when traveling into the wind. Smaller droplets could be created, leading to increased chance of drift. Even if you use a larger nozzle to produce a coarser spray, the shearing effect that comes with a higher travel speed may offset the benefits of the larger nozzle. Always decide what nozzle size and travel speed are appropriate under your spray conditions at the time.

Nozzle to Target Distance

**Lowering the boom of the sprayer can help to decrease drift.** A lower boom reduces the distance that the spray droplets must travel and minimizes the effects of air currents. Each type of nozzle tip has a specific nozzle-to-target distance so check with the manufacturer for more information. Maintain a stable boom height to ensure uniform coverage. Booms that bounce cause uneven coverage and drift. When lowering the boom or using wide angle nozzles, check nozzle spacing to maintain sufficient overlap for even coverage.
Air Blast Spraying

Reducing the distance from the nozzle to the target helps reduce drift. The nozzles on a conventional air blast sprayer should be positioned to match the profile of the target and counteract any “spin” created by the fan on some sprayers. Even in the correct position, the top nozzles have to spray further to reach the top of a tree than the other nozzles. One option is to use venturi nozzles in the top few positions. Alternately, sprayers can be fitted with ducted exhaust ports in the form of towers or a series of flexible pneumatic tubes to direct the spray.

Maintain a minimal effective distance between each nozzle and the target to improve uniformity and reduce drift. Adjust the air speed and redirect air and spray for different crops, different zones within a crop (such as the fruit zone in grape) or different stages of growth.

Specialty Equipment

Hoods, Screens, Air Assist Sprayers and Deflectors

You can protect the spray from air currents by using hoods (shrouds), perforated screens, air assist sprayers or deflectors.

Individual nozzle hoods protect the top portion of the spray from each nozzle. Other hoods cover the whole boom. There are some disadvantages to using hoods. For example, you must keep a near perfect seal at the front and back of the shields to prevent air movement underneath. Some boom hoods make it impossible to see the nozzles and require a flow monitoring system.

Perforated screens reduce the air speed passing over the spray. Small droplets hit and stick to the screen, combine with others, and fall to the target. One disadvantage of these screens is that they may affect how the boom folds.

Air Assist or air curtain sprayers use an air stream to carry small droplets down to the target. The air gives the droplet momentum and prevents it from hanging in the air. Its exposure to air currents is reduced. When using an air assist sprayer, you must adjust the speed and direction of the air stream to match the crop canopy and the environmental conditions of the application.
Deflectors should be fitted to the top and bottom of most air blast sprayers to direct the spray into the canopy. Deflectors are commercially available, but are often too short to effectively redirect air. Alternatively, towers can be fitted to air blast sprayers to redirect air into the target canopy. A low-cost deflector that was designed for Kinkelder vineyard sprayers reduced drift and increased spray deposit by 25%.

All hoods, screens and deflectors must be carefully cleaned to prevent contamination of other crops and sensitive plants.

Wiper or Wick Weeders

You can apply a herbicide with a wiper or wick weeder to eliminate drift. Since no droplets are formed, no particle drift is possible. For wick weeders to work, the weeds must be higher than the crop so that the weeds are the only plants touched by the herbicide. Two passes in the opposite direction may be needed to adequately apply the herbicide.

Consider the Environment

Consider how the following may affect spray drift and how you can manage it:
- wind speed
- wind direction
- temperature and relative humidity, and
- environmentally sensitive areas.
Spray when winds are light to moderate. If you notice that the wind speed has increased, stop spraying until the wind speed decreases. Read the label for statements about wind speeds for specific pesticides. Drift can occur in periods of dead calm, changeable (gusting) wind, and high-speed wind.

You can estimate wind speed by looking at the effects the wind has on the environment. The following table describes some wind effects and the approximate wind speed at boom height.

<table>
<thead>
<tr>
<th>Wind Condition</th>
<th>Description</th>
<th>Wind Speed</th>
<th>Visible Signs</th>
<th>Spray Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Still</td>
<td>Surface inversions may lead to vapour drift long after spraying is completed.</td>
<td>0 - 2 km/h</td>
<td>Smoke rises vertically.</td>
<td>Don’t spray.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0 - 1.25 mph)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gusty</td>
<td>These conditions make wind direction unpredictable and may indicate an inversion.</td>
<td>Not applicable</td>
<td>Direction keeps changing.</td>
<td>Don’t spray.</td>
</tr>
<tr>
<td>Light Air</td>
<td>Suitable conditions</td>
<td>2.0 - 3.2 km/h</td>
<td>Smoke moves in the direction of the wind.</td>
<td>Avoid spraying fine droplets on sunny days.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.25 - 2 mph)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light to Gentle Breeze</td>
<td>Ideal conditions</td>
<td>3.2 - 9.6 km/h</td>
<td>Leaves rustle, wind is felt on face, twigs in motion.</td>
<td>Ideal spraying</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2 - 6 mph)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Wind</td>
<td>Higher wind speeds pose the most risk of drift through, around or over target.</td>
<td>9.6 - 16 km/h</td>
<td>Small branches move, dust raises.</td>
<td>Spray with caution or don’t spray.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6 - 10 mph)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Wind Direction
Do not apply pesticides if the wind is blowing towards susceptible crops, areas of human activity or environmentally sensitive areas. Try to spray when the wind direction is stable, and blowing away from these areas.

Temperature and Relative Humidity
Some pesticides require a certain temperature to work effectively. Air temperature and relative humidity affect droplets. As soon as a droplet leaves the nozzle, it begins to evaporate. When temperatures are cooler and humidity is high, a droplet lasts longer. **On a hot, dry day, spray droplets evaporate more quickly and are more likely to drift.** Large droplets may become very small during the time it takes them to travel the distance between the nozzle and the target. **Spraying on dry days when the relative humidity is below 50 percent will increase drift.** In extreme cases of high temperatures and low humidity, pesticides can crystalize and settle on a target. These crystals may later be activated by moisture and lead to unwanted residues.

Surface Inversions
A **surface inversion** occurs when cool air near the soil surface is trapped under a layer of warmer air. This happens at night when the earth cools. Inversions create problems for spray operators because they can cause pesticide spray to:

- stay concentrated for long periods over the target,
- move sideways with the cool air in light wind for many kilometres,
- drain down slopes and concentrate in low-lying regions,
- drift unpredictably as the inversion dissipates during the morning.
Field air temperatures are often very different from local or regional forecasts, so the most reliable method of detecting inversion conditions is to measure temperatures at, and several metres above, the ground. Spray operators can recognize a surface inversion when:

- there is a big difference between the daytime and night time temperatures,
- evening and night time wind speeds are calm,
- humidity is low
- daytime cumulus clouds tend to collapse toward evening,
- overnight cloud cover is 25% or less,
- sounds seem to carry further,
- odours seem more intense and travel long distances,
- mist, fog, dew and frost occur,
- smoke or dust hangs in the air and/or moves laterally in a sheet.

Inversions can be more intense over colder soil conditions that include dry, cultivated, mulched, or coarse soils and also over closed crop canopies.

**If you suspect there’s an inversion, don’t spray.** To avoid problems caused by a surface inversion, wait until the temperature rises 2° to 3° Celsius after sunrise before you spray.
Examples of environmentally sensitive areas include woodlots, ponds, and stream banks. Don’t spray right next to these areas.

**Buffer zones** are areas that are left untreated to protect sensitive areas. Plant a hedgerow (or shelter break), or leave an untreated area of natural vegetation to protect sensitive areas. Some pesticide labels tell you to leave a buffer zone when you spray. A buffer zone is always a good idea, whether or not the label says so. Take precautions when you spray next to greenhouses where cooling fans could draw in spray mist. Let greenhouse growers know when you plan to spray so that they may take precautions.

**Spray Drift Awareness Zones**

You can reduce the drift of pesticides by planning ahead. Where do you use pesticides on your farm(s)? On a map of your farm, identify these areas and surround them with a 1 kilometre spray drift awareness zone. Survey the zone and identify any sensitive areas that could be affected by spray drift such as neighbouring sensitive crops, native flora and fauna, waterways and wetlands, bees, homes, farm buildings, and areas of human activity. Plan to leave buffer zones between these areas and any environmentally sensitive areas. Decide how you will reduce drift into these sensitive areas. Note that droplets could move well beyond the 1 kilometre zone, depending on the conditions, even long after the application.

**Note:** Don’t confuse Spray Drift Awareness Zone with Buffer Zone.
Consider how the pesticide may affect spray drift. When you choose a pesticide, consider the:

- formulation and volatility
- adjuvants, and
- label statements about the environmental hazards.

**Formulation and Volatility**

Some pesticides change more quickly into vapour than others. They have a high volatility. Choose pesticides that are low volatility formulations and avoid spraying when temperatures are high.

**Adjuvants**

Adjuvants will affect droplet size by changing the physical properties of the spray mix (for example, viscosity and surface tension). How droplet size is affected depends on the specific adjuvant and can also depend on the formulation of the pesticide. Some adjuvants increase droplet size, others decrease it, while others have no effect at all. Many pesticides include adjuvants in their formulation. Use an adjuvant only when the label tells you to.

**Label Statements about Environmental Hazards**

Always read and follow the label directions. Instructions on the label include information about ways to reduce drift and procedures to follow when you apply near and around environmentally sensitive areas. Look for specific directions about:

- buffer zones
- sprayer application rates (water volumes)
- nozzle and pressure suggestions
- acceptable conditions for spraying,
- wind speeds, and
- weather conditions to avoid.

Remember, only use a pesticide when necessary and use it according to label directions.
Practice Your Understanding

1. What is spray drift (particle drift)?

2. Large droplets are not as likely to drift as smaller droplets.

   TRUE          FALSE

3. What is Volume Median Diameter (VMD)?

4. If leaves are rustling, and wind can be felt on your face, should you be spraying pesticides?

5. Which of the following is the most important factor affecting spray droplet size?
   
   a) Spray pressure
   b) Type of nozzle
   c) Relative humidity