Strategies to Minimize Spray Drift for Effective Spraying in Orchards and Vineyards

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For many reasons, including production costs, safety, and the environment, it is important to maximize pesticide deposits on the target when spraying pesticides. Spray drift is a major challenge to pesticide applicators trying to achieve this goal. Spray drift is defined as wind moving a pesticide from the application site to an off-target site (see Figures 1 and 2).

Drift can occur during spraying and even after spraying as a result of the evaporation of pesticides. Both situations move pesticides away from the application site. Vapor drift from evaporation, however, poses a relatively low risk of injury to nearby sensitive crops compared to the physical movement of spray droplets outside the intended application site.

The creation or reduction of spray drift is impacted by various factors:

- Spray characteristics, such as volatility and viscosity of pesticide formulation
- Equipment and application techniques used for spraying pesticides
- Weather conditions at the time of application, including wind speed and direction, temperature, relative humidity, and the stability of the air around the application site
- Operator care, attitude, and skill

Although complete elimination of spray drift is impossible, it can be significantly reduced by awareness of its major causative factors, and by taking precautions to minimize their influence

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Figure 1. Spray drift becomes an even more serious concern when an application is done under windy conditions.

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Figure 2. Even in calm days spray drift can happen mostly because too much air assistance is provided by conventional airblast sprayers.

on the off-target movement of droplets. Extensive information related to factors influencing spray drift is in the Ohio State University Extension publication

(FABE-525) "Effect of Major Variables on Drift Distances of Spray Droplets" (**ohioline.osu.edu/factsheet/fabe-525**).

The risk of drift is considerably higher when spraying in orchards and vineyards compared to spraying in field crops for three main reasons:

1. The target being sprayed in field crops is relatively uniform, it's a short distance from the nozzles, and the droplets are directed downward. The target in orchards and vineyards is not uniform in size and shape (there may be gaps in canopy), there is a much longer distance from the nozzles, and the droplets are directed in an upward trajectory.
2. The type of sprayer used in field crops releases the droplets downward just over the target. The sprayer used in orchards and vineyards uses a powerful fan that blows droplets in a horizontal and upward trajectory, making the droplets much more susceptible to drift.
3. The type of nozzle and droplet size used in field crop spraying is most often a flat-fan nozzle that discharges relatively large droplets. Orchard and vineyard sprayers are generally equipped with hollow-cone nozzles that produce very fine to fine category droplets.

ASABE Spray Quality Classes:

Extremely Fine (EF)
Very Fine (VF)
Fine (F)
Medium (M)
Coarse (C)
Very Coarse (VC)
Extremely Coarse (EC)
Ultra-Coarse (UC)

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Figure 3. A typical airblast sprayer used in orchards and vineyards in U.S.

For the reasons outlined above, more precautions should be taken to reduce the drift risk when spraying in orchards and vineyards.

Although the air-assisted (airblast) sprayer type shown in Figure 3 is used by most fruit and grape growers in the U.S., many other more efficient types of air-assisted sprayers used in other parts of the world are discussed in OSU Extension publication (FABE-533) "Sprayers for Effective Pesticide Application in Orchards and Vineyards" (**ohioline.osu.edu/factsheet/fabe-533**).

Nozzles play a significant role in generating or reducing spray drift. The American Society of Agricultural and Biological Engineers (ASABE) developed nozzle manufacturing standards for classifying nozzles based on the droplet size (spray quality) produced from nozzles at different spray pressures.

Typically, for field sprayers or sprayers without air-assistance, nozzles producing very fine or fine droplets have a high-risk of producing drift and are not recommended. However, these spray classes can result in higher levels of spray coverage on the target surface, which usually leads to higher levels of crop protection in orchards and vineyards—if they aren't impacted by wind drift. Another factor to consider is that very small droplets don't have the momentum needed to penetrate the canopy. Even a light wind can carry very small droplets miles away from the application site if they don't quickly evaporate after being discharged from the nozzle. Fortunately, air-assisted sprayers allow us to take advantage of Very Fine and Fine droplets. Air-assisted sprayers transfer these drift-prone droplets to the target with minimum loss if the operator is aware of and takes care to manage factors that create drift.

However, it is prudent to minimize the use of nozzles and not operate in conditions that result in the generation of Extremely Fine and Fine droplets.

Minimize Spray Drift in Orchards and Vineyards with These Cost-Effective and Practical Spraying Practices

1. Spray pressure affects the size of droplets released from a nozzle. Higher pressure produces smaller droplets. Therefore, avoid operating the sprayer at high pressures. Although 200 to 300 psi is the norm for many U.S. growers when operating airblast sprayers, a pressure of 100 to 150 psi is more than adequate to generate the fine to medium size droplets that improve penetration and coverage on the target.

2. Consider switching to low-drift nozzles. In the U.S., the typical sprayer used in orchards and vineyards is an airblast sprayer equipped with hollow-cone (most often) or conventional flat-fan nozzles (less common). Both nozzle types produce extremely fine, very fine, and fine droplets that are highly susceptible to drift. Hollow-cone nozzles operated at high pressure are especially susceptible. In recent years, nozzle manufacturers have introduced new nozzles that significantly reduce the number of extremely small, drift-prone droplets. In other parts of the world—especially Europe— some growers are gradually switching to these low-drift air-induction nozzles to spray fruit trees. This switch was made based on field experiments that evaluated the biological efficacy of conventional nozzles versus low-drift nozzles in orchards. These experiments showed that low-drift nozzles are as effective in controlling insects and diseases as conventional nozzles while also significantly reducing spray drift. Moreover, in some European countries (Germany, Belgium, and Sweden), using air-induction nozzles that are recognized as "low drift" is mandatory when spraying pesticides in orchards and vineyards. However, much fewer efficacy trials have been conducted to document the effectiveness of low-drift nozzles in vineyards, and the results so far have been mixed and not very promising when applying contact-type pesticides

3. Spraying in high winds, high temperatures, and low relative humidity increases the risk of spray drift. If the sprayer is non-air-assisted with nozzles that produce very small droplets, the droplets are likely to be subject to drift in windy conditions. Even "drift-resistant" droplets quickly lose mass because of evaporation and become drift-prone in low humidity, high-temperature conditions during spraying. If weather conditions are not favorable, and there is a concern about spraying that might result in drift, wait for more favorable conditions. Review the forecast and schedule spraying accordingly. Use apps that provide current, local weather conditions and use that information to make sound decisions on when to spray. Be aware that wind speeds shown in apps display data taken from nearby weather stations that may not reflect the wind speeds in your specific spraying location. Therefore, it is best to carry a small hand-held, battery-powered wind meter (anemometer) to check the wind speed several times before and during spraying. The price of a wind meter is usually one-third the hourly fee a lawyer can charge a client sued for drift-related damages.

4. Pay attention to atmospheric surface-inversion conditions. Typically, under normal meteorological conditions, the air temperature decreases with elevation. Cool air tends to sink, displacing lower warm air and causing vertical upward air movement that carries small droplets, or vaporized pesticide active ingredients, higher into the air. Under these conditions, the opportunity for crop injury at any off-target site is very small because the pesticide is dispersed in a somewhat vertical direction, and is diluted into the atmosphere. However, under stable air conditions, and usually very early in the morning, a warm air layer at some distance overhead may act like a blanket, holding down cooler air underneath. This phenomenon is referred to as atmospheric inversion. Particles suspended in the cool layer, including the active ingredients of vaporized pesticide, cannot move anywhere except laterally, possibly for several miles. Eventually, the suspended cloud may encounter a downdraft, forcing it back towards the ground and depositing it off-target, possibly over a sensitive crop. This form of drift is outside the control of the applicator. The best strategy is to avoid spraying when the air is calm, and the chances of an inversion are high. Usually, clear nights, combined with no wind, increase the chance of inversion, especially early in the morning.

5. Adjust the sprayer fan air-flow rate and volume so that the air being directed into the canopy replaces the air already in the canopy, but dies down significantly as it reaches the other side of the canopy. A proper air adjustment results in very little spray droplets escaping the canopy. As shown in Figures 1 and 2, it is very likely that too much air is being discharged from the sprayers in those photos because droplets are passing through more than one row of crops. Adjust the air-flow rate carefully with the understanding that under fully-developed canopy conditions too much air can force leaves together, creating a surface that blocks the passage of air. Air that cannot penetrate the canopy moves upward in a vertical trajectory, further exacerbating the drift situation. In general, most if not all of today's air-assisted or airblast sprayers are designed primarily with orchard spraying in mind, and therefore generate excessive air flow. So, it is very important to take the time to adjust the air stream characteristics (direction, air speed, and air flow rate) until they are suitable for the vine canopy conditions at the time of the spray applications. As a side benefit, reduced air assistance results in lower fuel consumption. Some new sprayers are equipped with a mechanism that allows the operator to adjust the opening in the fan's air intake section to best match canopy conditions. For sprayers that don't have this feature, the fan speed may be able to be adjusted if the fan is powered by a hydraulic motor. If the fan is not powered by a hydraulic motor, try reducing the percentage of engine (PTO) speed by:

   - Running the engine at lower speeds (this may not be practical in hilly orchards and vineyards).
   - Adjusting the angle of the fan blades.
   - Partially covering the fan's air intake section to reduce the volume of air going into the fan.

6. The travel speed of the sprayer also influences spray drift. Even when adjustments are made to restrict air intake into the fan, too much air may reach the canopy if the travel speed is extremely low. Slow travel speeds allow the canopy to be exposed to the air flow for a much longer time period, thus contributing to drift. This situation is further exacerbated when the air speed from the fan is high, and the sprayer travel speed is low. However, traveling too fast is also not recommended because the air doesn't have time to displace the air inside the canopy and reach to the other side. Traveling too fast results in inadequate spray deposition on the outer edge of the row, which reduces protection against insects and diseases. Some studies indicate the best results are achieved when the travel speed is between 2.5 to 4 mph.

7. When spraying the outer side of the last row, turn off the nozzles on the side of the sprayer that are pointed away from the canopy. In addition, if you are using a conventional airblast sprayer with radial air discharge, cover the air exit port on the side of the sprayer facing away from the canopy. Both of these actions further reduce the risk of spray drift.

8. Carefully direct the air from the fan towards the canopy to ensure that the sprayed droplets are intercepted by the canopy. With conventional airblast sprayers, deflector plates (see Figure 4) must be installed on both the top and the bottom of the fan, and on both side of the sprayer, to guide the spray plume toward the canopy and at a level equal to the canopy's height, as shown in Figure 5. The size of the deflectors should be big enough to effectively direct the air at the canopy. The angle of the deflector plates may vary from one orchard or vineyard to another orchard or vineyard depending on the target canopy's characteristics (height and location of target to be treated), or even within the same orchard or vineyard if the canopy is exhibiting different growth stages. A practical way to find out the correct trajectory of the air discharged from the fan is to tie ribbons around the area where air is exiting the fan (Figure 6). Then turn on the fan, watch the direction that the air blows the ribbons, and adjust the angle of the deflectors accordingly. Obviously, the deflectors on the sprayer shown in Figure 6 are too small and not adjusted to match the canopy height. In addition, when using a sprayer under the canopy conditions shown in Figure 6, the nozzles above and below the dashed lines should be turned off to

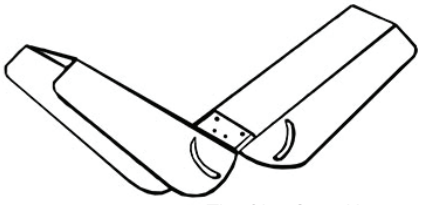

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Figure 4. Deflector plates mounted on top of the sprayer direct air-assisted spray towards the canopy.

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Figure 5. Adjust the angle of the deflectors according to canopy height.

Deveau and Ledebuhr, sprayers101.com/airblast101

Figure 6. Ribbons tied around the fan show where air is exiting the sprayer.

avoid excessive drift and to save pesticides.

Summary and Recommendations

A successful spray operation in orchards and vineyards achieves maximum efficacy from the pesticide applied while minimizing the off-target (drift) movement of pesticides. Spray drift poses health risk to nearby people and animals, increases the risk of polluting natural resources like air and water, and wastes pesticides that could have been used to treat pests in orchards and vineyards.

While reducing drift is one of the major tasks for anyone involved in pesticide application, there are several other important tasks that need to be efficiently completed in order to achieve the best results from spraying pesticides in orchards and vineyards:

- Carefully read and follow the recommendations provided on pesticide labels, in nozzle manufacturers' catalogs and in sprayer operators' manuals.
- Choose the right equipment. Choose a sprayer that delivers the required application rate with droplets of the desired size to the target with minimum loss of spray on the ground and in the air.
- Select the right type and size of nozzle to achieve maximum pesticide deposit and coverage on the target.
- Calibrate the sprayer to ensure the recommended amount of pesticide (based on the product's label) is applied.
- Understand how to calculate the correct amount of chemical product to mix in the tank as explained in Ohio State University Extension

Publication FABE 530, "How Much Chemical Product Do I Need to Add to My Sprayer Tank?" **ohioline.osu.edu/factsheet/fabe-530**

- Check the sprayer setup to ensure that the pesticide is distributed evenly on all parts of the canopy.
- If more than one type of chemical is added to the sprayer tank, check the products' labels to ensure mixing is done in the appropriate order.
- Operate the nozzles at a pressure that allows them to produce the spray quality (droplet size) recommended on the product label.
- Slow down when spraying. Spray coverage at the inner parts of the canopy is usually improved at slower speeds. However, travel speeds too low are likely to result in excessive use of pesticides and increased spray drift.
- Take advantage of technological advancements in spray technology, such as variable-rate and site-specific application that reduces pesticide consumption. as explained in Ohio State University Extension Publication FABE 538, "Advancement in Technology for Reduction of Pesticides Used in Orchards and Vineyards" **ohioline.osu.edu/factsheet/fabe-538**
- Utilize apps developed by sprayer/nozzle manufacturers to select the best nozzle type and size for a specific application situation.
- Conduct tasks such as sprayer calibration and mixing/loading of chemicals in areas that are free of ground and surface water pollution.
- Be safe. Wear protective clothing, goggles, rubber gloves, and respirators as recommended on the product's label when calibrating the sprayer, doing the actual spraying, and cleaning the equipment.

The following websites are excellent sources of additional information on spraying orchards and vineyards:

- **platform.innoseta.eu**
- **sprayers101.com/airblast101**

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