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Strategies to Maximize Pesticide Deposit and Coverage for Effective Spraying in Orchards and Vineyards

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Although each crop requires a slightly different approach to the application of pesticides, some general principles apply to almost all spraying situations. Spraying for fruit trees and grapevines is no different. But there are a number of factors that need to be accounted for to achieve maximum crop protection from a pesticide application:

- Selecting the proper equipment, particularly the correct type and size of nozzle

- Applying the pesticide at the right time and under the right conditions
- Checking the accuracy of equipment periodically to ensure that the correct amount of the pesticide recommended on the pesticide label is applied and distributed uniformly onto the target

When applying pesticides in orchards and vineyards, certain tasks are required to achieve maximum biological efficacy from the pesticides applied:

1. Mix pesticides uniformly (especially dry products) in the sprayer tank. This can be accomplished only if the agitation system in the tank has sufficient capacity for its size and is operating properly.
2. Choose a pump with sufficient capacity to deliver the required gallonage (gal/acre) to the nozzles.

3. Ensure that hoses and fittings between the pump and nozzles are properly sized to minimize pressure losses.
4. Ensure that there is a minimum loss of pesticides delivered from the nozzles to the target (i.e., minimize spray drift).
5. Achieve maximum deposition and retention of droplets on the target (minimum rebound).
6. Provide thorough and uniform coverage of the target with droplets carrying active ingredients.

This publication focuses on what is necessary to accomplish the goals listed in tasks 5 and 6—achieving maximum deposition of pesticide sprayed on the target; and achieving adequate coverage of the target’s surface with the pesticides applied.



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Figure 1. Spray drift is a major reason for not achieving maximum spray deposits on the target.

Strategies to Achieve Maximum Spray Deposit on the Target

Minimize Spray Drift

If spray drift (movement of pesticides by wind from the application site to an off-target site, as shown in Figure 1) cannot be minimized, the goal of achieving maximum spray deposition on the target can’t be realized. Strategies to minimize spray drift are discussed in detail in another Ohio State University Extension publication (FABE-535) “Strategies to Minimize Spray Drift for Effective Spraying in Orchards and Vineyards” (ohioline.osu.edu/factsheet/fabe-535). This fact sheet highlights a number of key strategies reviewed in that publication.

There are three main reasons why the risk of spray drift is considerably higher for spraying orchards and vineyards than it is for spraying field crops:

1. **The nature of the target being sprayed:** In field crop spraying, the target is relatively uniform, is a short distance from the nozzles, and the droplets are directed downward. The target in orchards and vineyards is not uniform in size or shape (there may be gaps in the canopy), there is a much longer distance from the nozzles, and the droplets are directed in an upward trajectory.
2. **The type of sprayer being used:** Field crop sprayers release droplets downward over the target. Orchard and vineyard sprayers use a powerful fan that blows droplets in a horizontal and upward trajectory, making the droplets much more susceptible to drift.
3. **The type of nozzles and the size of the droplets sprayed:** Field crop sprayers generally use flat-fan nozzles that discharge relatively large droplets. Orchard and vineyard sprayers are more often equipped with hollow-cone nozzles that produce very fine to fine category droplets which are more drift-prone.

Taking the above reasons into consideration, anyone spraying pesticides in orchards and vineyards must be extremely conscious about—and try to minimize—the factors that influence the occurrence of spray drift.

Key Strategies To Minimize Spray Drift:

- Select a type and size of nozzle that doesn’t discharge a high volume of droplets in the Extremely Fine or Very Fine categories.
- Consider that spray pressure affects the size of droplets released from a nozzle. Higher pressure produces smaller droplets. Therefore, avoid operating the sprayer at high pressures.
- If possible, don’t spray in high winds, high temperatures, and low relative humidity conditions.
- 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.
- Carefully direct the air from the fan towards the canopy to ensure that the sprayed droplets are intercepted by the canopy.

- 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 will reduce drift risk.

Know Your Target

The reason the word “target” is used in this document is because it is important to apply the pesticide to the part of the plant canopy being targeted. The proper nozzle must be selected and the application equipment needs to be set up based on what pest is being controlled in order to effectively and efficiently apply pesticides to the targeted part of the plant canopy.

For example, when applying a fungicide to manage Gray Mold of grapes (*Botrytis cinerea*) as shown in Figure 2, the target is the bunch of grapes, not the leaves. Therefore, grapes should be the primary target and should be treated with the appropriate fungicide to maximize the deposition and coverage of the fungicide on the grapes.

For better deposition, and to save fungicide, sprayer adjustments should be made, such as only turning on nozzles that will provide coverage on the zone of the grapevine where the grape bunches are located as shown in Figure 3.

When the target of a pesticide application is the grape bunches, and the canopy is too heavy, pruning the canopy as shown in Figure 4 may be necessary to expose the grape bunches to the pesticide droplets carrying active ingredients.

Get the Best Sprayer and Operate It at Peak Efficiency

Although the air-assisted sprayer type shown in Figure 5 is the type used by most tree fruit and grape growers in the U.S., many other, more efficient types of air-assisted sprayers are used in other parts of the world are discussed in Ohio State University Extension publication (FABE-533) “Sprayers for Effective Pesticide Application in Orchards and Vineyards” (ohioline.osu.edu/factsheet/fabe-533).

Even if spray drift is taken into consideration when spraying pesticides, how much pesticide actually deposits on the target is heavily influenced by how the sprayer is operated. Since most orchard and



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Figure 2. The target of the spraying should be the area that has a problem. Even the best deposition of fungicides on leaves will not prevent diseases such as the Gray Mold shown here if the deposition on the grapes is not adequate.



Ernesto Velazquez, Unsplash

Figure 3: When the target to be treated is grape bunches, sprayers should be adjusted so that only the target zone (grape bunches) are treated with pesticides.



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Figure 4. If pesticide is being applied to protect grapes—not grape leaves—from disease, make sure the grape leaves are pruned to expose the grape bunches.



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Figure 5 (above). A typical airblast sprayer used in orchards and vineyards.

Figure 6 (right). This type of airblast sprayer is most commonly used in orchards and vineyards. Note that the sprayer lacks deflector plates, and the top three nozzles should have been turned off.



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vineyard sprayers rely on air flow to transport small droplets of pesticide to the target, special attention should be given to the direction, volume, and flow rate of the air coming out of the sprayer.

The airblast sprayer shown in Figure 5 is equipped with deflector plates on the top and bottom of the fan. These deflector plates direct air mixed with droplets toward the target. However, the same type of sprayer shown in Figure 6 has two design and/or adjustment issues that significantly reduce the spray deposited on the target:

1. The top two to three nozzles on each side of the sprayer aren't directing spray toward the targets and should be turned off.
2. There are no deflector plates to direct the air plume towards the target.

The angle of the deflector plates on the sprayer should be adjusted to match the height of the canopy each time spraying is done at an orchard or vineyard. This adjustment is necessary because the canopy height may vary from one orchard or vineyard to another, or even within the same orchard or vineyard throughout the growing season.



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Figure 7. Ribbons tied around the fan show the direction that air is exiting the sprayer.

A practical way to determine the correct trajectory of the air discharged from the fan is to tie ribbons around the area where air is exiting the fan. Then turn on the fan, watch the direction the air blows the ribbons, and adjust the angle of the deflectors accordingly, as shown in Figure 7.

A sprayer can only be effective, efficient, and safe if it's spraying the amount of pesticide recommended on the pesticide label. This means the sprayer should be properly checked and calibrated before it's taken to the field in addition to being periodically checked and calibrated during the spraying season to make sure the actual application rate is aligned with the intended, or recommended application rate. If there is a difference between the actual and the intended application rates that is greater than 5%, adjustments must be made to reduce the error margin below 5%. The procedure used to properly calibrate an orchard/vineyard sprayer, and a more detailed discussion on adjusting the sprayer to maximize pesticide deposits on the target are in Ohio State University Extension publication (FABE-537) "Calibration of Orchard and Vineyard Sprayers" (ohioline.osu.edu/factsheet/fabe-537).

Strategies to Achieve the Optimum Coverage On the Target

Adequate amounts of pesticide being sprayed on the target is only one aspect of efficient pesticide application. An equally important aspect is how efficiently and uniformly the target is covered with the pesticide. The term used to describe this is “spray coverage.” The goal in spraying fungicides and insecticides is to land as many droplets on the target as possible (maximum coverage). This is one reason why operators of air-assisted orchard and vineyard sprayers use nozzles that produce droplets that are smaller than those produced by the nozzles on field crop sprayers.

As shown in Table 1, when the nozzle’s droplet size increases, the spray coverage decreases even though all the nozzles have the same flow rate of 0.2 gal/min. Although extremely fine or fine droplets theoretically provide a much higher level of coverage, they should not be used because of the extremely high level of drift risk associated with them.

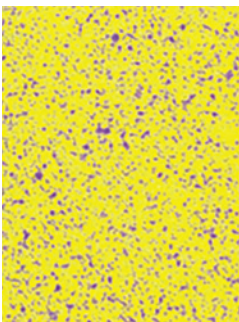
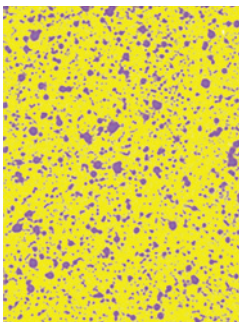
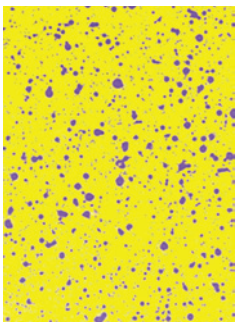
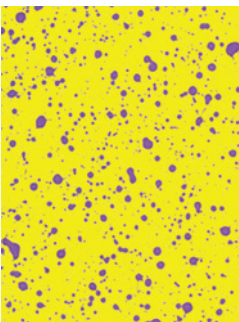




The most practical and easy way to determine the location and uniformity of pesticide application is to use water-sensitive papers attached to leaves in

different locations of the canopy (depth, height). These water-sensitive papers should also be affixed to the upperside and underside of leaves, as shown in Figure 8. Check the coverage on these cards after spraying pesticides.

Spray droplets intercepted by the water-sensitive cards leave a blue stain on normally yellow cards, representing the spray deposit and coverage. No deposit on the cards indicates that the pesticide is not reaching that area of the vine and orchard canopy. The coverage shown on the card in Figure 9 is ideal (approximately 30% of the card is covered with spray droplet stains) for most situations. The spray coverage shown in Figure 10 represents excessive coverage, resulting in a waste of pesticides.

You can also determine how much spray is intercepted by the canopy or passes through the canopy to the next row by placing water-sensitive papers on several rods and staking them in front of, in the middle of, and behind the row to be sprayed, as shown in Figure 11. The rods can also be placed at some distance away from the edge of the vineyard or orchard (Figure 12) to determine if drift is taking place in the form of droplets (note that extremely small droplets may not leave a mark on these water sensitive papers).

Table 1. Effect of nozzle design on droplet size and spray coverage
Note that all nozzles shown have the same flow rate of 0.2 gal/min

	Twinjet 11002	XR 8002	TurboTeejet 11002	Air Induction 110015
Spray Coverage				
Pressure	40 psi	40psi	40psi	70psi
Nozzle				
Droplet Size Class	Very Fine	Fine	Medium	Coarse



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Figure 8. Use water sensitive cards to determine the coverage level on the target sprayed.



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Figure 9. A water sensitive card after the spraying is done. This represents ideal coverage of the target sprayed.



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Figure 10. A water sensitive card after the spraying is done. This represents excessive spray coverage which is not needed.



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Figure 11 (left). Water sensitive cards placed at different heights on a rod is a practical way to determine how much spray passes through the canopy and goes to the next row. **Figure 12 (right).** Water sensitive cards placed on a rod some distance from the edge of the orchard or vineyard is a practical way to determine if drift is taking place.

Adjust Air-Flow Depending on the Canopy Characteristics

Too little and too much air results in ineffective and inefficient coverage of the target. The goal is to 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. This adjustment will result in very little spray droplets escaping the canopy.

Be aware that under fully-developed canopy conditions too much air flow can force leaves together, creating a surface that blocks the passage of air. When air cannot penetrate the canopy, it moves upward in a vertical trajectory, further exacerbating the off-target movement of droplets. In general, most, if not all of today's air-assisted or airblast sprayers, generate more air assistance than what is needed. This is especially true for vineyard spraying.

So, it is very important to take the time to adjust the air stream characteristics (direction, air speed, and air flow rate) suitable for the tree or vine canopy conditions at the time of the spray applications.

Summary and Recommendations

A successful spray operation in orchards and vineyards achieves maximum efficacy from the pesticide applied while also reducing the off-target losses in the air (drift) or on the ground. An adequate amount of pesticide reaching the target is only one aspect of efficient pesticide application. An equally important aspect is how efficiently and uniformly the target is covered with the pesticide as outlined in this fact sheet. In addition, there are several other important tasks that need to be completed to achieve the best results from spraying pesticides in orchards and vineyards:

- Carefully read and follow the recommendations on the pesticide label, in the nozzle manufacturers' catalogs, and in the sprayer operator's manuals.
- Choose the right sprayer with the best type and size of nozzles that deliver the required application rate with droplets of the desired size to the target. Minimize the loss of spray on the ground and in the air while maximizing pesticide deposit and coverage on the target. Use apps developed by the sprayer/nozzle manufacturers when selecting nozzles.
- Calibrate the sprayer to ensure that 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.
- 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 that mixing is done in the appropriate order.
- 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 applications that reduce pesticide consumption.
- 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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