Is Your Air blast Sprayer Doing What You Want?

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Air assisted application technologies for apple and citrus orchards are normally adapted to nursery tree crops. However, compared with orchard crops, nursery trees are usually narrow and sharp and are difficult to apply pesticide with conventional delivery systems. Little information is available on current nursery spray application practices whereby applications of required amounts of pesticides achieve effective pest and disease control with minimum chemical loss. Questions also remain whether some new application methods such as drift retardants and air induction nozzles have potential advantages over conventional nozzles in nurseries, and whether performances similar to air induction nozzles can be achieved by using conventional nozzles with larger orifices and/or operating the sprayer at lower pressure.

During the past decade, several types of hydraulic air induction nozzles (also called "low-drift nozzles") were introduced into the market for improving pesticide delivery methods and reducing drift. Most air induction nozzles were configured with two small holes on the nozzle chamber upstream from nozzle orifices. These nozzles have been reported to produce higher volume deposits in lower parts of canopies (Zhu et al., 2004) because they can produce a greater proportion of large droplets than conventional hydraulic nozzles. Some reports indicated these "low-drift" nozzles did not significantly reduce drift in orchards.

Drift retardants were reported to reduce spray drift in many laboratory studies. Laboratory tests indicated that drift retardants could increase the volume median diameter of spray droplets initially, but most polymer based drift retardants lost effectiveness when recirculated through pumps (Reichard et al., 1996; Zhu et al. 1997). Although there are some disadvantages associated with adding drift retardants to spray mixtures, some nursery growers have expressed interest in using these chemicals if they can reduce potential drift damages to adjacent crops, or contamination of nearby residential areas.

Applications of pesticides and other production strategies have ensured adequate and high quality food, fiber, floral and nursery crops to meet the wide variety of canopy structure characteristics, growing circumstances, and marketing requirements. Transport of spray to target plant surfaces with high quality atomization is essential to ensure effective spray application in crop protection.

Field investigation tests

An air blast sprayer was investigated in a commercial nursery field to compare spray deposits at various elevations within crabapple trees and on the ground among three different application techniques: conventional hollow cone nozzles (HC), air induction nozzles (AI), and conventional hollow cone nozzles with a drift retardant (HCDR). The sprayer produced 130 ft/s average air velocity near the nozzles when operated at the high gear setting. The sprayer was operated with five identical nozzles equally spaced on one side of the 36-inch diameter air deflector. Nozzles used for HC and HCDR were five conventional hollow cone nozzles and nozzles used for AI were five flat fan air induction nozzle. The flow rate from the sprayer was maintained at 6.2 gallon/min for all three application methods. The sprayer travel speed was 4 miles/hr at which the application rate was 70 gallon/acre.

Spray deposits within tree canopies, under the sprayed trees, and on the ground at different distances from the sprayer (Figure 1) were collected with nylon screens, plastic plates and plastic tapes, respectively.

Figure 1. Plan view of spray site showing location of spray collectors downstream from the air blast sprayer for trials in the field test.

The spray mixture was 3 grams of fluorescent tracer per liter of water for HC, HCDR and AI. For HCDR, the spray mixture was additionally mixed with a drift retardant containing 1% polyvinyl polymer as the active ingredient. Concentration of the drift retardant used in the HCDR tank mixture was 0.49% (v/v).

Field target samples were collected 15 minutes after each spray, and placed in clean glass bottles in non transparent boxes. Spray deposits on all sampling targets were washed with distilled water immediately after they were brought to the laboratory, and then were determined with a luminescence spectrometer.

Droplet sizes from nozzles for AI at 120 psi, and HC and HCDR at 240 psi without air assist were measured with a particle/droplet laser image analysis system (Figure 2).

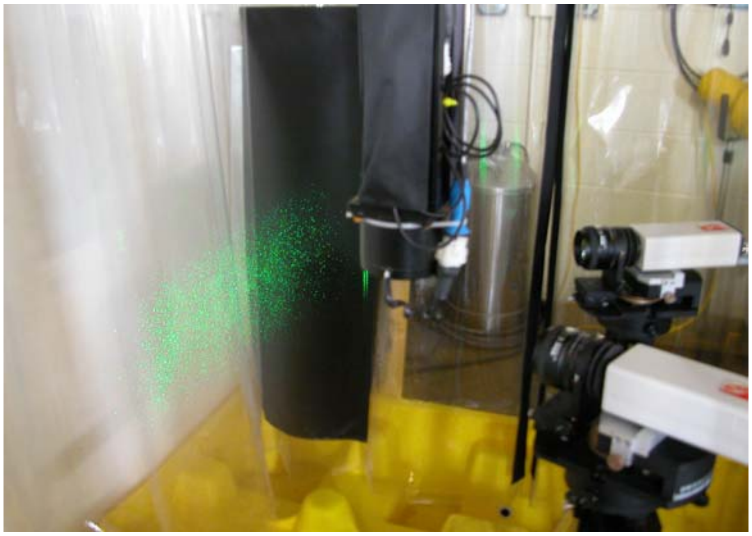

Figure 2. Droplet size measurement with a particle/droplet laser image analysis system

1. **Which spray technique is the best with an air blast sprayer?**

There were no significant differences in spray deposits on screens at different elevations within crabapple tree canopies among the three spray techniques (AI, HC and HCDR) (Figure 3). Therefore, statistically AI, HC and HCDR treatments produced nearly the same quantity of spray deposits within tree canopies. Also, there were no significant differences among deposits at four elevations within tree canopies for the three treatments.

To produce uniform spray deposits across the tree canopy, air blast sprayers for nursery applications are usually recommended to operate with the same nozzle settings as orchard applications. Specifically, recommendations are to use a larger nozzle at the top of each side, with the capacity of the top nozzle at least three times greater than other individual nozzles. However, results in this study with three different spray techniques showed that spray deposit was

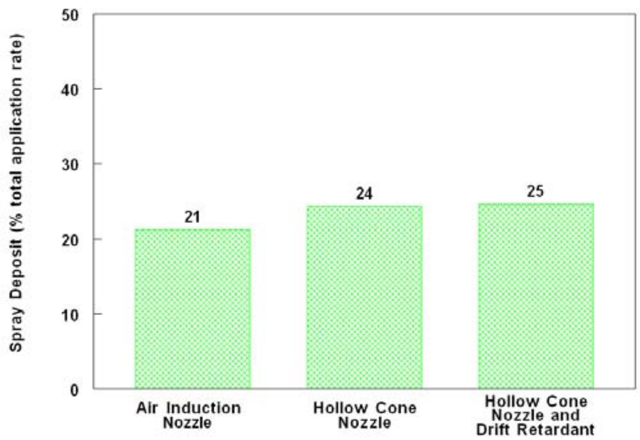

Figure 3. Percentage of total spray application rate deposited in the middle of tree canopies from the air blast sprayer with conventional hollow cone nozzles (HC), air induction nozzles (AI), and conventional hollow cone nozzles with a drift retardant (HCDR), respectively.

uniform across the tree canopy from top to bottom with the equal capacity nozzles on the air blast sprayer**.** Nursery trees are usually much thinner and sharper with less canopy volume per area than orchard trees. **It was reasonable to assume from this study that the sprayer with the equal capacity nozzles had the capability to deliver uniform spray deposits throughout the trees.**

Figure 3 also shows average spray deposits in percentage of total spray application rate on nylon screen collectors (simulating leaves) varied from 18 to 30% with the three treatments in the tests. Total spray deposits on screen collectors within a tree canopy were not significantly different among sprays for the AI, HC and HCDR treatments.

The volume median diameter of water droplets in the main spray sheet from a conventional hollow cone nozzle at 120 psi was 202 µm (Table 1). The volume of average spray deposit on leaves is equivalent to 2000 droplets of 202 µm sustained on a 1-square inch area. The recommended droplet density in the target area was from 130 to 190 droplets per square inch for spraying insecticides and 320 to 450 droplets per square inch for spraying fungicides. The number of 202-µm droplets on tree leaves was 4 to 15 times the number of droplets actually required for the target area. Therefore, tree canopies received excessive spray deposits discharged from AI, HC and HCDR treatments at the 70 gallon/acre application rate (Figure 4). A typical application rate in commercial nurseries is 100 gallons/acre with the capacity of the nozzles at the top of the sprayer three times the capacity of other individual nozzles. This is similar to the recommendation for orchard applications.

Table 1. Droplet sizes at 20 inch below the nozzle for Air induction nozzles (AI) at 120 psi, and Hollow cone nozzles (HC) and Hollow cone nozzles with drift retardant (HCDR) at 240 psi without air assist.

Nozzle	Average Droplet Size (µm)		
	$D_{V.1}$[a]	$D_{V.5}$	$D_{V.9}$
AI	158	407	824
HC	150	202	290
HCDR	157	222	332

[a] $D_{V0.1}$, $D_{V0.5}$, and $D_{V0.9}$ = Droplet diameters such that 10%, 50%, and 90% of total liquid volume that is in droplets smaller than $D_{V0.1}$, $D_{V0.5}$, and $D_{V0.9}$, respectively.

(a) (b)

Figure 4. After 70 gallon/acre rate was applied: (a) leaves were saturated with spray deposits; (b) water sensitive paper was fully covered by water droplets.

2. How much spray volume deposited on the ground?

Figure 5 shows the average ground spray deposits under the sprayed trees and at different distances from the sprayer. Statistical analysis indicated that there was no significant difference for ground deposits on targets under the sprayed trees among the AI, HC and HCDR treatments. Therefore, compared to the total amount of spray deposits on the ground near the sprayed trees, the amount of spray runoff from tree leaves to the ground was not significantly different among the three treatments. The average spray deposit on the ground beneath the sprayed trees was about 24% of the average foliar deposit within tree canopies with AI, HC and HCDR treatments.

The average ground deposits collected by the plastic tapes at 15 ft from the sprayer for the two trials with AI, HC and HCDR were 20.6, 17.6, and 22.5% of the total spray volume, respectively. Also, a considerable portion of the spray volume was deposited on the ground beyond 15 ft from the sprayer (Figure 5). In the three treatments, about 10% of the total spray volume was lost on the ground at 25 ft downstream from the sprayer, about 4% of the total spray volume was lost on the ground at 35 ft from the sprayer, and about 0.5% of the total spray volume was lost on the ground at 50 ft from the sprayer. Therefore, a significant amount of spray volume was lost on the ground with all three treatments at the 70 gallons/acre rate.

Zhu et al. (1997) reported some polymer drift retardants could lose their effectiveness and perform similar to water after 2 to 3 recirculations through a centrifugal pump. Likewise, the air induction nozzles did not provide significant drift reduction, compared to using the conventional hollow cone nozzles. Any droplets larger than 350 µm in diameter from AI, HCDR and HC would be further broken up by the aerodynamic pressure produced by the parallel air flow from the air blast sprayer. Data in Table 1 illustrate that droplets with more than 50% of spray volume from AI at 120 psi was larger than 407 µm, and more than 90% of spray volume from HC at 240 psi was smaller than 290 µm, and more than 90% of spray volume from HCDR at 240 psi was smaller than 332 µm, respectively. Obviously, a great portion of droplets from AI in the air blast sprayer might have encountered some breakup due to air shearing effect. Laboratory measurements illustrated that all AI, HC and HCDR treatments produced nearly 10% spray volume with sizes of droplets smaller than 160 µm (Table 1). Our previous research indicates that droplets smaller than 200 µm are prone to drift. Therefore, AI and HCDR might not achieve their advantages of producing large droplets as normally claimed to reduce drift potential from the air blast sprayer in the nursery field tests.

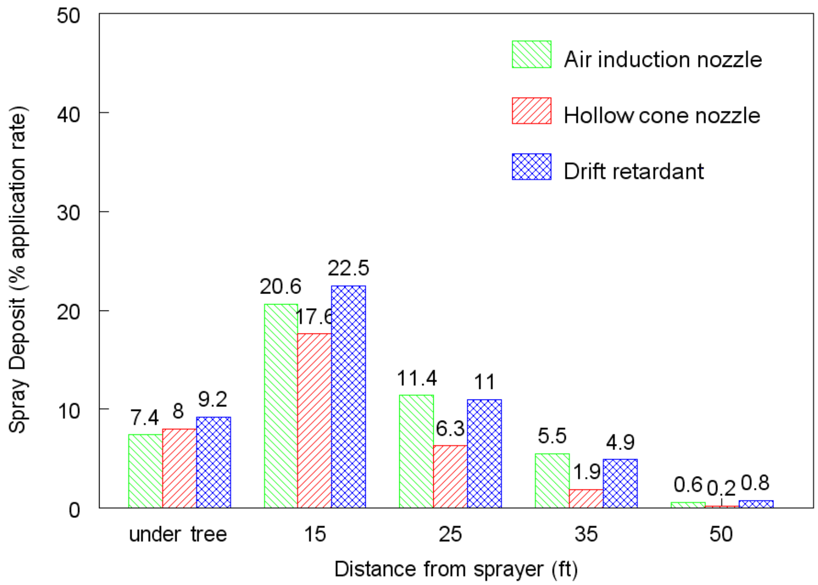

Figure 5. Percentage of total spray application rate deposited on the ground at different distances from the sprayer with conventional hollow cone nozzles (HC), air induction nozzles (AI), and conventional hollow cone nozzles with a drift retardant (HCDR), respectively.

3. How can growers get the best performance for their air blast sprayers?

Growers have several choices to ensure their spray practice can provide adequate chemicals on the intended targets with minimum off-target loss. First and foremost **growers should make their sprayers properly calibrated** to obtain constant output from all nozzles. Although it takes time for calibration, it will greatly save growers money and pesticides.

Since this study has shown that tree leaves received excessive spray deposition and a large portion of spray volume lost on the ground, **growers should practice to apply less spray volume than that is recommended for orchard applications**. If the application rate is from 70 to 100 gallons per acre (GPA) and trees are shorter than 10 ft high, growers should conduct a test in a small area of their nurseries, where both water and chemical rates are reduced by half for a specific pest or disease control and prevention. Reducing the application rate of a pesticide can be accomplished by mixing a standard spray solution, and using smaller nozzles to reduce the spray output while not changing travel speed. That is, the reduced rate of 35 to 50 GPA uses the same chemical concentration as the rate of 70 to 100 GPA. Then levels of control between the small area with the reduced spray rate and other areas with the 70 to 100 GPA application rate should be compared. If there is no difference in the level of control between the two areas, the reduced-rate test can be expanded to larger areas. This should be done on a trial basis to be sure that growers achieve the proper control of the target pests.

While the application rate is important, the spray coverage on leaves and trees is another critical factor. Many systemic chemical products only move through the leaf surfaces where they are deposited. If the leaf surface is totally missed, it will be susceptible to damage from the pests. **Growers can check the coverage by placing water sensitive papers inside tree canopies**. The water sensitive paper is a yellow card. When water droplets deposit on the card, the contact area will become blue, so it can give growers a good review of the coverage with the total number of droplets and sizes of droplets.

Growers should adjust the nozzle angles to ensure the spray reaches the desired parts of trees. Selectively turning nozzles on and off can help prevent drift and excess ground deposits of sprays. In the nursery application, it was not necessary to place a larger output nozzle at the top of the nozzle manifold on the air blast sprayer as normally recommended for orchard spray applications. Using larger output nozzles at the top of the nozzle manifold may be less efficient and increase spray losses to the ground. Finally, **growers should be sure to clean sprayers including the boom and pumps after each use**.

Acknowledgements

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