Reducing Drift and Improving Deposition in Vineyards

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Summary

There are many inter-related factors influencing air and pesticide penetration and are primarily based on the crop target, the sprayer, the weather and the operator. This paper discusses research results on nozzle orientation, air volume and velocity and canopy density over the growing season and how they play an important role in reducing drift and improving deposition. Novel developments such as air restrictors and hydraulic motors have been designed to reduce airflow from the sprayer in an attempt to match air volume and speed with increasing crop canopy. The recycling sprayer provides a way of quantifying canopy development over the season, which may provide information for use when studying application volume. The correct orientation of the nozzles is crucial if pesticide is to be targeted correctly.

Introduction

There are many inter-related factors influencing air and pesticide penetration into grapevine canopies.

Sprayer	**Application**	**Target**	**Weather**	**Operator**
Design	Application rate	Variety	Wind speed	Skill
Droplet size	Nozzle orientation	Canopy structure	Wind direction	Attitude
Fan size	Forward speed	Area	Temperature	
Air volume		Every row	Humidity	
Air velocity and direction		Alternate row		

Table 1. Inter-related factors affecting pesticide drift and deposition

Current spray practice is to use the same settings on an airblast sprayer in the vineyard from the first application through to the last, irrespective of changes in canopy volume or density. A few growers may change application volume/hectare but certainly no changes are made to air flow (speed, volume or direction) nor forward speed. As the season progresses, as the canopy fills, growers frequently drive too fast and often pay too little attention to deposition on the leaves and clusters of grapes where disease or insects may occur.

Research by Bates and Dunst (2000) shows that *Vitus labrusca* Concord grapevine canopies develop rapidly during the 30 days following bloom. 100 node vines increase in leaf/vine area from 84,458 cm^2 to 18,7455 cm^2during the 30 day post-bloom period. Minimal pruned canopies grow from 24,7234 cm^2 to 38,6531 cm^2 during the same time period.

Traditional airblast sprayers direct the air from a single, axial flow fan, mounted directly behind the sprayer in an upward and outward direction. Axial fans are designed to move large volumes of air at low pressures, Landers (2002a) observed that in order to accommodate varying crop canopies, e.g as the season progresses, a number of modern sprayers are fitted with adjustable pitch propellers to provide variable airflows. An adjustable deflector plate can be fitted at the top and base of the air outlet to direct the air towards, and confine it to the target canopy. Deposition efficiencies are often erratic, Balsari (2003), stated that when the volume of air produced by the fan of the sprayer is increased there is no corresponding improvement in the quality of pesticide application.

Where the air goes, the droplets will surely follow. Early – mid season sprays are frequently applied at full fan speed, resulting in a mighty plume of pesticide going up into the air above the vineyard or towards a small leaf target on a small vine. Is it necessary to have the fan switched on or rotating at slow speed? Earlier research by Landers (2002b) showed that directing airflow with Cornell deflectors improves deposition by 20-30%. Deflecting the air into the canopy, in relation to forward travel, may prevent shingling (layering) of the vine leaves, improving penetration and therefore deposition. Farooq and Landers (2004) found that changing the orientation of the nozzles to counteract the blast of air in the vicinity of the sprayer air outlet showed improvements not only in better targeting of sprays to the canopy but also in reducing drift over and above the target.

Air-assistance aimed at directing the spray to the canopy and improving penetration into canopies has shown to be effective but over and under supply of air energy can result in inadequate deposition and poor control of the target pest or disease, as well as potential for off-target deposition. Balsari *et al*. (2001) have emphasized adjusting airflow to facilitate spray penetration into the developing vine canopy. Using air-blast sprayers, they found that increasing air volume reduced deposition on the spray side of fully developed canopy while it didn't affect deposition on the opposite side of the canopy. Using an axial-flow air-blast sprayer on grapevines, Pergher and Gubiani (1995) found that increasing airflow led to lower deposition and higher ground losses but differences were significant only on fully developed canopies in July.

Materials and Methods

Canopy development

Two LIPCO recycling tunnel sprayers (LIPCO, Sasbach, Germany) were fitted with Raven electonic flowmeters (Raven Industries Inc. Sioux Falls, SD) in the return (recycling) hose from the tunnel collecting troughs to the main tank. The flowmeters monitor the excess (recycled) spray not required by the canopy and provide an indication of canopy density. Two cooperating growers kindly used the sprayers for their pesticide application throughout the 2003 and 2004 growing seasons, following their own spray programme. One vineyard comprised the *Vitis labrusca* variety Concord, one block being pruned to 100 nodes, the other being minimum or machine pruned. The second vineyard grew *Vitis vinifera* varieties Carbernet Franc and Riesling.

Air volume and velocity

As part of the on-going project on optimizing spray penetration and deposition with air-blast sprayers, attachments were developed to change the airflow and velocity of the sprayers that do not have an option to change fan speed. A set of wooden "doughnuts" was developed to alter the airflow of a Berthoud S600EX sprayer (Berthoud, Cedex, France). The sprayer has a 61 cm diameter axial-flow fan operated through the tractor power-take-off. The fan intake is behind the sprayer and it discharges radially between the tank and fan. The "doughnuts" reduce the air intake to 2/3, 1/2, and 1/3 at the center of the fan. Air volume was determined by measuring air velocity 15 cm away from the fan outlet and at 8 locations along the periphery. The velocity was measured using an ultrasonic anemometer (model R3-50, Gill Industries Ltd, Hampshire, UK). The air volume from these measurements was determined to be 19383, 19671, 18769, and 17174 m^3/h for no, 2/3, 1/2, and 1/3 doughnuts, respectively. Velocity of the air at two sides of the sprayer for four fan intake openings was also measured at 77-point grid spread 3.5 m to horizontal from fan center and 3.5 m above ground.

The effect of air velocity on deposition in a vineyard was studied at New York State Agricultural Experiment Station Research Farm in Geneva during 2003. The vineyard had a row spacing of 2.7 m and plant spacing of 2.1 m. The vines were sprayed from two sides with four air volume rates using the right-hand side of the sprayer on three different days through the growing season. It was equipped with 5 Berthoud #10 discs and was operated at 4.8 km h^{-1} to obtain an application rate of 468 L/ha. Water sensitive cards on upper and lower side of five leaves from 3 vines in each plot were used for coverage assessment on each side of the vines. Coverage on the cards was determined using HP 6200C scanner and WRK Droplet scan image program (WRK, Cabot, AR).

Spray drift

Deposition inside grapevine canopies and drift up to 4 rows from the sprayer was studied at New York State Agricultural Station Research Farm in Geneva during 2003. The vineyard (Niagara variety on a vertical shoot position (VSP) trellis system) had a row spacing of 2.7 m and plant spacing of 2.1 m. The vines were sprayed from two sides using the up-stroke side of the sprayer on three different days throughout the canopy development season. The sprayer was equipped with Berthoud #10 discs and water was sprayed at 4.8 km/h to obtain an application rate of 468 L/ha. Water sensitive cards on the upper and lower surfaces of five leaves from three vines in each plot were used for coverage assessment of the vines. The same block was used to estimate spray drift deposition at different heights above ground up to 4 rows from sprayer. The up-stroke side of the sprayer with same application parameters as for inside canopy deposition was used for this trial and water was sprayed from one side of the row. Water sensitive cards on 4 vertical wooden poles were used to capture drifting droplets. One pole for each of 4 rows was placed next to canopy on the non-sprayed side of the vines. Cards on the poles were stapled at every 0.3 m interval starting from 1.8 m above ground. Coverage on the cards was determined using HP 6200C scanner and WRK Droplet Scan image program (WRK, Cabot AR.)

Nozzle orientation

The orientation of the nozzles will affect the spray pattern being emitted from the air blast sprayer. The nozzle orientation must take into account the upward and downward air movement created by the counter clockwise direction of the fan. A vertical patternator (Mibo, Milano, Italy) was used to measure spray liquid emitting from a Berthoud S600EX sprayer (Berthoud, Cedex, France) fitted with 5 Berthoud #10 discs on the left and right hand side. Nozzle orientation was altered to find the optimum spray pattern for the grape target zone.

Results and Discussion

Canopy development

The electronic flowmeters provided information regarding the volume of spray being returned to the tank. Table 2 shows the percentage of the application rate (935 litres ha^{-1}) being recycled to the tank in early season spraying in the 3rd week of May and mid-season one month later. An application rate of 1870 litres ha^{-1} was applied to the full Concord canopy in the 3rd week of July. The results indicate a reduction in volume being recycled as the canopy grows as the season progresses and could form the basis of a canopy volume measurement system.

Variety	Early season	Mid season	Full canopy
Cabernet Franc	53	17	
Riesling	37	3.5	
Concord 100 node pruned	87	18.8	28.1*
Concord minimum pruned	75	12.5	28.0*

*application rate 1870 litres ha^{-1}

Table 2. Percentage of application rate returned to the tank (LIPCO tunnel sprayer)

Air volume and velocity

The resulting velocity patterns are presented as Figure 1. From these patterns, it is clear that on the left side, the peak of the air stream center moves down with increasing distance away from sprayer center. The rate of descent increases with decreasing air intake, resulting in relatively low velocities in the spray target zone on the left of the sprayer compared to the right side. On the right side, the general trend showed a slightly rising stream due to the counter-clockwise direction of the fan. The air velocity on both sides was highest without a doughnut, velocity decreasing when decreasing the air intake. With the help of air velocity patterns it was found that at 1.0 m from sprayer center (≅ edge of vine canopy) and between heights of 1.25 to 2.25 m (≅ target canopy in grapes), the left side of the sprayer delivered air at < 4.0 m/s with all air intakes. For right hand side, this velocity ranged from 4-12, 4-8, 4-8, and 4-6 m/s with full, 2/3,1/2, and 1/3 of the intake, respectively.

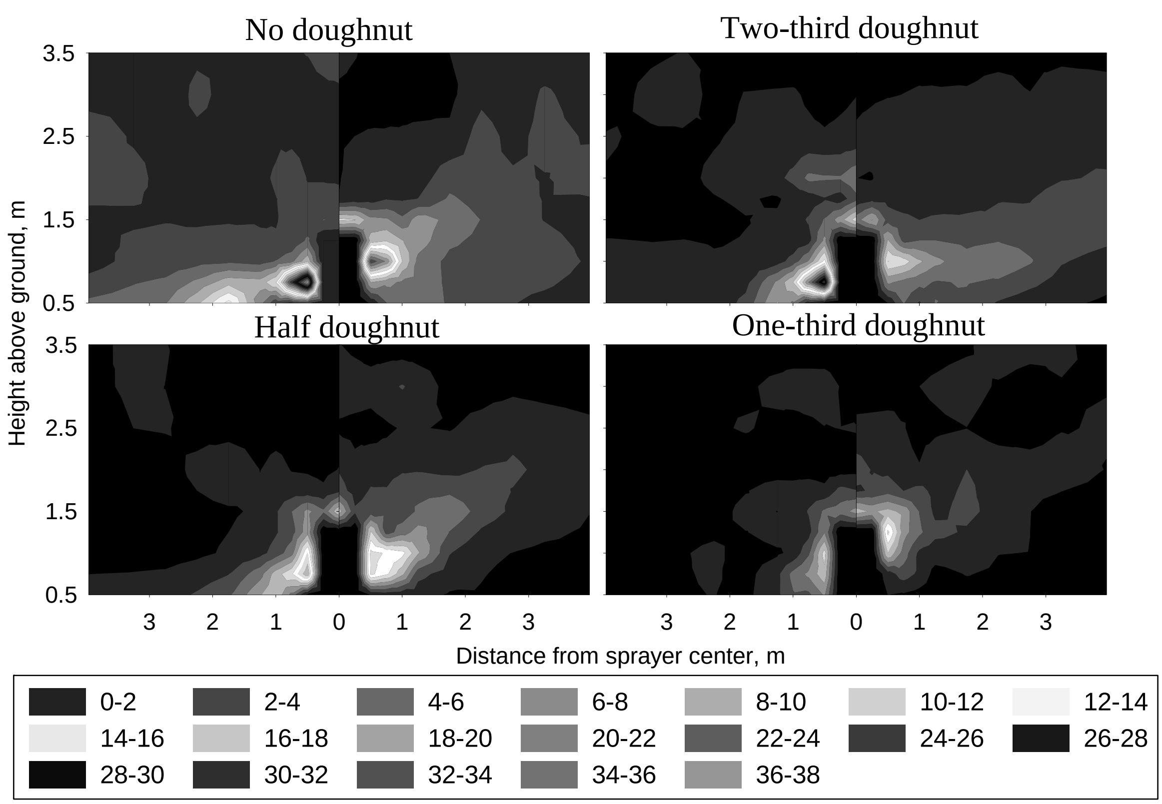

Figure 1: Air-velocity patterns for Berthoud air-blast sprayer with different sizes of air intake

Spray drift

Results of deposition measurements inside the canopy show that the spray coverage decreased with canopy growth (different application dates). As canopy develops, leaf area, contact area, and resistance to airflow increases. The total spray captured by the leaves might increase, but the results show that percent coverage is reduced. This reduction might be attributed to the less air-spray mixture passing through the canopy. The consistency of decrease in coverage on two sides of the canopy minimizes the possibilities of wind affecting this difference. The same trend is depicted by the decrease in coverage of water sensitive cards at each row with increasing canopy density. As is clear from Figure 2, coverage of water sensitive cards decreased with distance away from the sprayer. The coverage was recorded up to 4th row on June 18, the earliest stage of canopy growth studied. The coverage was recorded up to 2nd row on June 26 while it was only recorded on the first row on two dates in July.

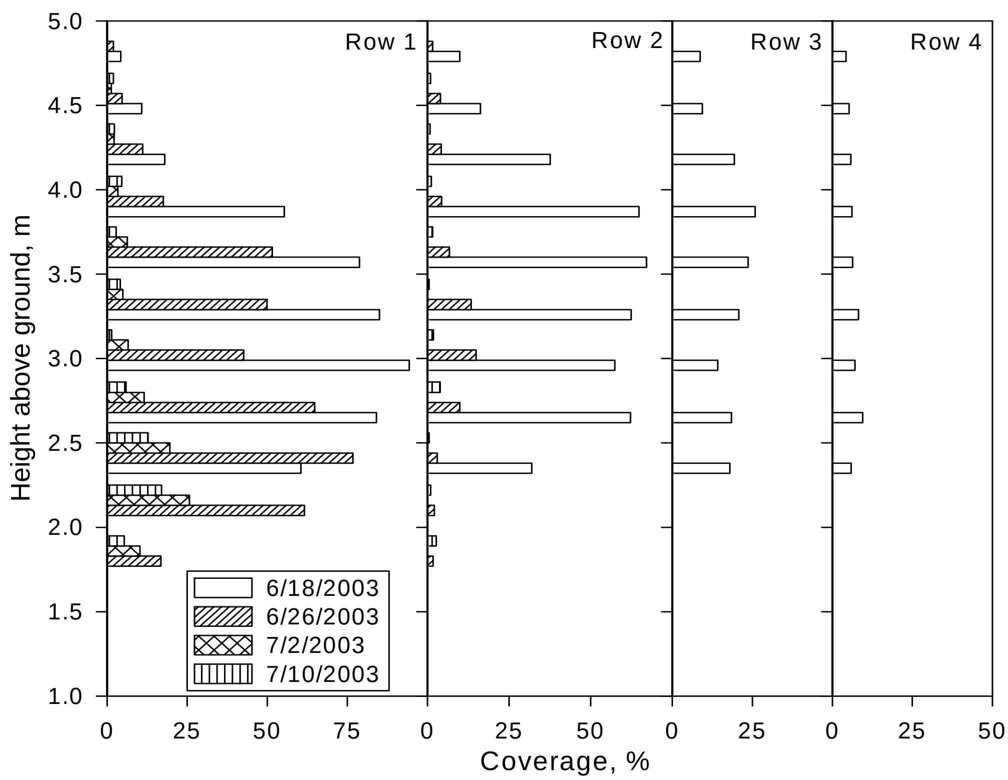

Figure 2. Drift deposits at different heights above ground and distances away from sprayer

On the up-stroke side, when the nozzle discharged along the air direction, considerable amount of spray was transported to areas above the canopy. As the air discharges in the radial direction on this side, the nozzles oriented downward give droplets an opportunity to penetrate through the upward moving air-stream. By the time, the spray droplets are influenced by the air, the air velocity reduces and its capacity to transport the spray droplets also reduces. The air discharged by the sprayer at upper sections of the outlet is bared of spray that reduces the risk of spray drifting to greater distances. Similar results were obtained in the 2004 growing season when a hydraulic motor was used to adjust air speed and volume on the same Berthoud airblast sprayer.

Nozzle orientation
Results from the patternator shows great variability in spray pattern produced according to nozzle orientation and which side of the sprayer they are fitted. Nozzles set in the "typical growers" pattern, i.e. pointing radially outwards resulted in a large quantity of liquid being blown above the target row. The best spray pattern for the grape zone occurred when the right hand side nozzles were pointing horizontally and the top two nozzles were 20^o below horizontal on the right side, to counteract the upward movement of the air from the fan. Best results occurred with the left side nozzles pointing 45^o upwards to counteract the downward direction of the air from the fan. The results show the importance of correct nozzle orientation if pesticides are to be applied effectively onto the target.

The results of the original growers setting may be seen in figure 3 with large amounts of spray drifting over and above the canopy height of 2.1m. Adjusting the nozzle orientation may be seen in figure 4, note the spray matches the canopy.

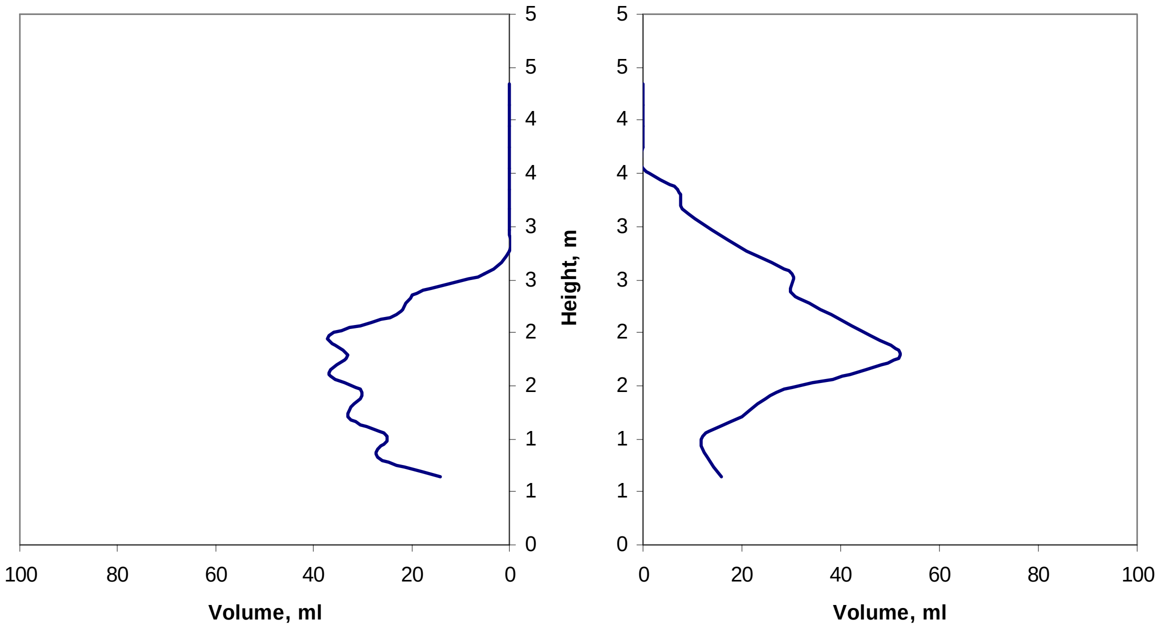

Figure 3. Vertical patternator results: growers original nozzle setting

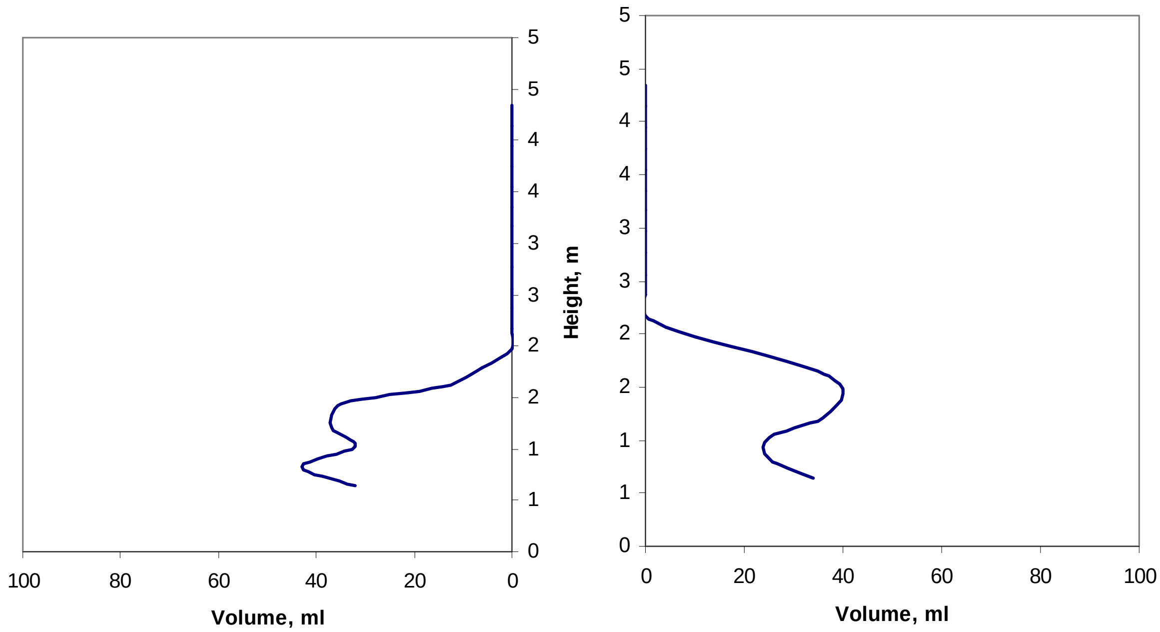

Figure 4. Vertical patternator results: "improved nozzle setting"

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