Reducing Spray Drift From Orchards – A Successful Case Study

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Reducing spray drift and improving deposition are increasing concerns for fruit growers. Drift results in damage to susceptible off target crops, environmental contamination to watercourses and an unintentionally reduced rate of application to the target crop, thus reducing pesticide effectiveness. Pesticide drift also affects neighboring properties, often leading to public outcry and conflict. For many dwarf-tree apple orchards we have found that reducing fan speed by 25 percent provides a simple, inexpensive method of reducing drift.

The application of pesticides has been of concern for many years, particularly in relation to methods of reducing drift and improving deposition. Many growers still use older airblast sprayers with hollow cone or air-shear nozzles which provide a large amount of air to penetrate traditional large fruit tree canopies. During recent years many growers have removed traditional tree plantings and replaced them with dwarf and semi-dwarf trees, but still use the older sprayers; the result is over-spraying of the target row and drift.

Spray drift from air-blast sprayers is an important and costly problem facing fruit growers (Landers, 2002). Drift results in damage to susceptible off target crops, environmental contamination to watercourses and an unintentionally reduced rate of application to the target crop, thus reducing pesticide effectiveness, (Landers 1999). Pesticide drift also affects neighboring properties, often leading to public outcry and conflict.

Sprayer Design and Drift

There are many interrelated factors affecting drift and deposition (see Table 1). Droplet size, air volume, speed and direction are the main factors from the sprayer. Landers and Schupp (2001), and Osborne et al. (2002) investigated increasing droplet size by using air induction nozzles and found that drift is considerably reduced while maintaining acceptable deposition levels for plant growth regulators.

Air speed and direction are critical if droplets are to be placed in the target canopy and not drift past the trees. The authors are currently researching methods of matching air volume, speed and direction to the growing canopy in order to find the optimum operating parameters.

Smaller droplets (<150 µm) can be carried some distance from the target row and up to 45 percent of spray particles emitted from hollow cone nozzles may be in the 30-100 µm size. The Spray Drift Task Force (1998) measured the droplet size spectrum from air-blast and mist blower (Ag Tec) classes of sprayer. The Volume Median Diameter (VMD) ranged from 138-210 µm from the air-blast and 73-110 µm from the mist-blower. The percentage of droplets <141 µm ranged from 26-52 percent for the air-blast and 65-90 percent for the mist blower. Both the VMD and the percent volume <141 µm confirm that the mist blower produced finer droplets and a higher volume of drift prone droplets. Thus, most currently used sprayer types produce considerable quantities of drift-prone droplets. The size of a droplet strongly influences its trajectory after being emitted from a hydraulic nozzle at a speed of 45-67 mph. The droplet rapidly decelerates due to friction until it attains a velocity that is solely a function of its diameter. Air movement in which the droplet descends also influences its trajectory.

Two types of drift can occur. The first is vapor drift from the airborne movement of highly volatile materials created by evaporation and the second, and more prominent, is droplet drift due to the movement of spray droplets in liquid form from the target area.

TABLE 1

Interrelated factors affecting pesticide drift and deposition

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		

The Case Study

An apple grower in upstate New York was concerned with spray drifting from his property onto a neighbor's garden. He was using an AgTec 300 LP sprayer fitted with air shear nozzles to

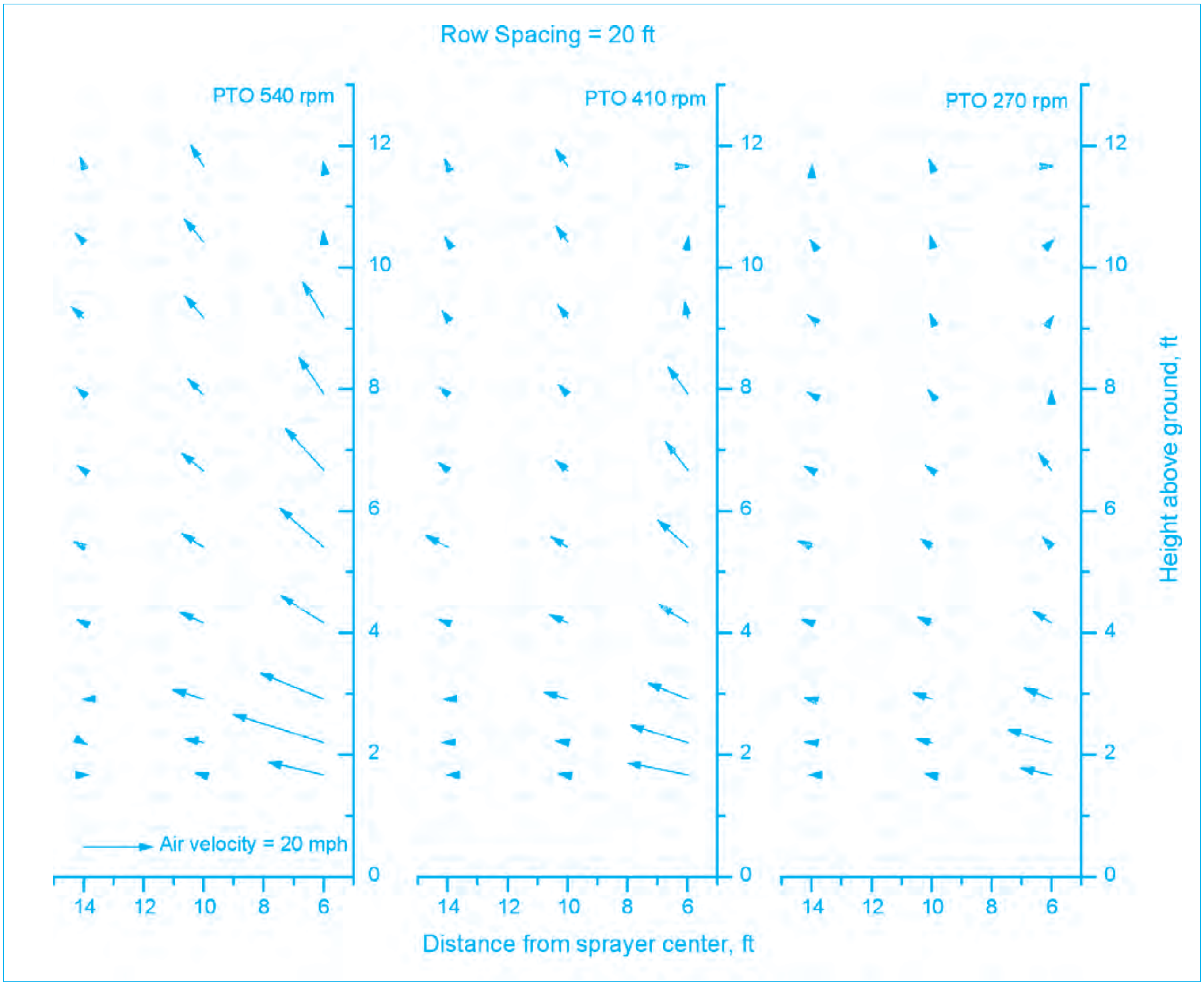


Figure 1. Air velocity patterns from left of AgTec sprayer for 12 ft. tall apple trees at 20 ft. row spacing for three tractor PTO speeds.

apply pesticides to a block of Crispin apple trees. The trees were spaced 20 feet between rows and 9 feet between trees in the row. They were 12 feet tall and 10 feet wide.

The AgTec sprayer used a low pressure pump (30 psi approximately) to deliver liquid to air-shear nozzles where liquid was sheared into fine droplets by an air stream passing over shear plates. Droplet size was determined by a balance between liquid/air at the shear plate. For the same liquid flow, the higher air velocity creates smaller droplets and vice-versa. Air shear nozzles tend to provide finer atomisation than hydraulic nozzles. Air speed at the shear plate was 180 mph (Donnell 2003).

During the winter of 2003, tests were conducted in a very large barn to measure air volume, speed and direction using an ultrasonic anemometer (model R3-50, Gill Industries Ltd, Hampshire, UK). Air velocity was measured at tractor PTO speeds of 540, 410, and 270 rpm. Velocity measurements were made at three distances from the sprayer center, on the left-hand side to mimic distances found in the orchard. One location was taken at one-half of the row spacing (row center) and one each at four ft on either side of the row center. At each horizontal location, measurements were made at 10 different heights above the ground from 1.6 to 11.8 ft. The deflector on top of the air outlet was adjusted to reach 12 ft tall apple trees. Fan speed for each tractor PTO speed was recorded using a tachometer. Air velocity measurements in a horizontal direction normal to sprayer travel and in the vertical were used to determine the velocity vectors away from the sprayer. The velocity vectors can be seen in Figure 1.

The velocity vectors at the measurement locations indicate that reducing the PTO rpm not only reduces the magnitude, but also the direction of air velocities especially at the upper heights. Using the sprayer and tree geometry, it was found that closest to the sprayer for each row spacing and at heights of 8 ft or more, the air velocities would cross over the tree and might not interact with the canopy.

For 20 ft row spacing, the air escaping at the tree height ranged from 0.3 to 24.4 mph. The velocities at eight ft height were 24.4 and 5.6 mph at 540 and 410 rpm. These velocities might carry considerable amounts of spray material with it. At other heights above and at 270 rpm, the range was 0.3 to 1.7 mph. At top center of the tree, the velocities ranged from 8.8 to 10.6 mph at 540 rpm, 5.0 to 5.7 at 410 rpm, 0.6 to 3.2 mph at 270 rpm. This air is also an added source of drift in this orchard

AgTec sprayer.

Field trials with AgTec sprayer.

Drift poles.

TABLE 2

The effect of fan speed on spray drift from an Ag Tec sprayer

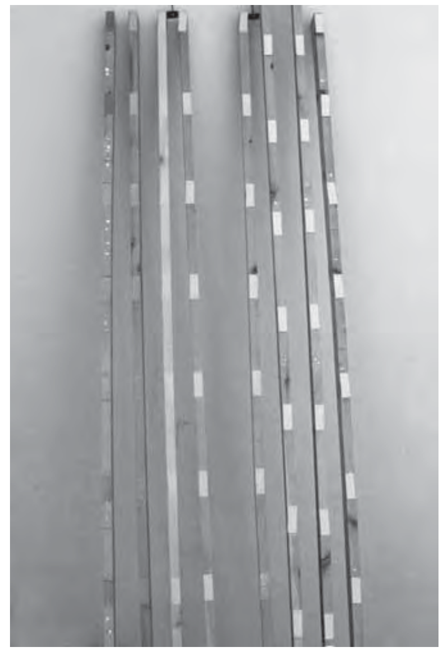
Tractor[1] PTO Speed, rpm	Sprayer Fan Speed, rpm	Row 1	Row 2	Row 3	Row 4
		Spray Coverage, %			
540[2]	2076	75.90	69.00	16.60	10.10
405[3]	1557	16.70	0.20	0.10	0.04
		Cards Covered over 50 % (Total cards = 8)			
540	2076	6	8	0	0
405	1557	0	0	0	0

[1]John Deere 5520 tractor
[2]Mean wind was 5.5 mph coming from NW with gusts of 10.5 mph
[3]Mean wind was 7.7 mph coming from NW with gusts of 12.5 mph

TABLE 3

The effect of fan speed on canopy coverage and droplet size

Tractor PTO Speed, rpm	Sprayer Fan Speed, rpm	Ground Speed, mph	Spray Coverage, %	VMD	VD(0.1)	VD(0.9)
540	2076	3.70	36.1	351	144	786
405	1557	3.43	27.5	460	180	737



Water sensitive cards attached to drift poles.

application.

It should be noted that air velocity measurements were taken inside a barn in the absence of apple canopies. With measurements in the presence of apple trees, the difference between row spacing will be more prominent. For orchards with wider row spacing, the distance between sprayer and the canopy also plays a role by helping air diversion, in addition to droplet fall off due to gravity and increased evaporation. The air tries to divert around the trees coming in its way. As the distance between sprayer and tree decreases, the air will have more opportunity of diverting around the tree. The air released at a considerable upward angle to reach the treetop will have an initial boost for upward diversion and might cross over the tree.

During June 2004, when the trees were in full canopy, tests were conducted in the orchard. The effect of tractor PTO speed on in-canopy deposition, droplet size and off-target drift was studied using water sensitive cards (Syngenta).

For drift evaluation, cards were attached to one-inch-wide vertical poles. Eight cards were attached at 12-inch intervals starting from 8 feet above the ground to a height of 14 feet. Four such poles were placed at intervals of 20 feet from the center of the target row, covering 80 feet distance. For in-canopy deposition, 18 cards were randomly attached to leaves in the canopy. Coverage on the cards was determined using an HP 6200C scanner and WRK Droplet scan image program (WRK, Cabot, AR).

We measured the effect of reducing tractor PTO speed and fan speed by 25 percent. At a standard fan speed of 2076 rpm, drift was detected up to 80 feet from the target row where 10 percent card coverage was recorded at the furthest drift pole (Table 2 and 3). Reducing the fan speed by 25 percent resulted in considerably less drift. Card coverage at 20 feet and 40 feet from the target row was 16.0 percent and 0.2 percent, respectively.

Reducing fan speed increased droplet size from 360 mm VMD at 2076 rpm to 460 mm VMD at 1557 rpm. Changes in droplet VMD was of interest due to airflow and speed being critical to provide droplet creation with an air-shear nozzle.

Conclusions

Reducing fan speed by 25 percent provides a simple, inexpensive method of reducing drift from an AgTec sprayer. Other methods of fan speed reduction include reducing engine speed, fitting a hydraulic motor to provide infinitely variable speed control, or applying an air restrictor to the air intake. Reducing air speed over the AgTec air shear nozzles by 25 percent only increased droplet VMD by 31 percent and still provided acceptable coverage.

References

Donnell J. 2003. Personal communication. Ag Tec Crop sprayers. Minnetonka, MN

Landers, A.J. 1999. Spray drift management – ways to improve deposition, drift reduction and sprayer output. *American Fruit Grower,* Feb. 1999, 199 (2):36-38.

Landers, A.J. and Schupp, J.R. 2001. Improving deposition and reducing drift in orchards. *New York Fruit Quarterly 9* (1): 3-6.

Landers, A. J., (2002), "The answer is blowing in the wind," *Aspects of Applied Biology*, 66, *International Advances in pesticide application*, pp. 177-184.

Osborne, J.L., Landers, A.J. and Schupp, J. (2002). Efficacy of Apogee on McIntosh apples comparing two pesticide application technologies, a disc-core type cone nozzle and air induction nozzle. *Proc. 23rd Symposium on Pesticide Formulations and Application Systems: Surviving the change in the Agrochemical Industry*. October 15-16, Norfolk, Va. Pp. 213-220. West Conshohocken, PA: ASTM International.

Spray Drift Task Force (1998), "A summary of airblast sprayer application studies," Stewart Agricultural Research Services, Inc. Macon, MO, pp. 10.

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