Reducing Drift and Improving Deposition in Orchards

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This paper describes trials conducted at Cornell University to study how changes in fan speed affects air direction, speed and volume and how these combine to affect drift and deposition in an apple orchard. Indoor trials were conducted using a Gill sonic anemometer to determine airflow. Field trials were then conducted in an orchard, using an AgTec P300 sprayer fitted with airshear nozzles operating at two fan speeds, 2076 rpm (540 rpm PTO) and 1557 rpm (405 rpm PTO). Drift was detected using Water sensitive cards and analyzed using DropletScan image analysis software.

At a fan speed of 2076 rpm, drift was detected up to 24.4m from the target row where 10% card coverage occurred. Reducing fan speed by 25%, resulted in considerably less drift, with card coverage at 6.1m and 12.2m from the target row being 16% and 0.20% respectively.

Reducing fan speed increased droplet size from 351 microns VMD at 2076 rpm to 460 microns VMD at 1557 rpm. Reducing fan speed provides a simple, inexpensive way of reducing drift.

Introduction

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 varieties but they still use their older sprayers; in modern plantings, this results in a vast plume of spray drifting above the target row. Many growers use sprayers with air-shear nozzles which rely on wind speed to create fine droplets.

Current application practice is to use the same airflow and liquid application rates at all times during canopy growth resulting in pollution, a waste of power and money and a high public profile of the spraying activity. The objective is to find the optimum combination of application parameters for different stages of canopy development to reduce drift while improving deposition.

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	**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

Sprayer Design and Drift

There are many inter-related factors affecting drift and deposition, Table 1. Droplet size, air volume, speed and direction are the main factors arising 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 whilst 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 (<150µm) can be carried some distance from the target row and up to 45% of spray particles emitted from hollow cone nozzles may be in the 30-100µm 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% for the air-blast and 65-90% 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 20m/s – 30m/s. 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, vapor drift from the airborne movement of highly volatile materials created by evaporation and secondly and more prominent, droplet drift, due to the movement of spray droplets in liquid form from the target area.

Materials and Methods

An apple grower in upstate New York was concerned with spray drifting from his property onto a neighbours garden. He was using an AgTec 300 LP (AgTec, Minnesota, USA) sprayer fitted with air shear nozzles to apply pesticides to a block of Crispin apple trees. The trees were on 6.0m row spacing, 3.6m tall and 3m wide and 2.7m spacing within the row.

The AgTec sprayer uses a low pressure pump (2 bar) to deliver liquid to air-shear nozzles where liquid is sheared into fine droplets by an air stream passing over shear plates. Droplet size is 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 is 80.5m/s (Donnell 2003).

Air velocity

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 centre, on the left-hand side to mimic distances found in the orchard. One location was taken at one-half of the row spacing (row centre) and one each at 1.2m on either side of the row center. At each horizontal location, measurements were made at 10 different heights above the ground from 0.5m to 3.6m. The deflector on top of the air outlet was adjusted to reach 2.7m 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.

Drift

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, North Carolina, USA).

For measuring comparative drift, 2.5 x 5.0cm water sensitive cards were attached to 2.5cm wide vertical poles. Eight cards were attached at an interval of 0.3m starting from 2.4m above the ground to a height of 4.3m. Four such poles were placed at intervals of 6m feet from the centre of the target row, covering 24.4m distance. For in-canopy deposition, 18 cards were randomly attached to leaves in the canopy. Coverage on the cards was determined using HP 6200C scanner and WRK Droplet scan image program (WRK, Cabot, AR).

Results and Discussion

Air velocity

The velocity vectors, Figure 1, 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 2.4m or more, the air velocities would cross over the tree and might not interact with the canopy.

For 6m row spacing the air escaping at the tree height ranged from 0.13m/s to 11m/s. The velocities at 2.4m height were 11.0m/s and 2.5m/s 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 0.13m/s to 0.76m/s At top center of the tree, the velocities ranged from 4m/s to 4.7m/s at 540 rpm, 2.23m/s to 2.55m/s at 410 rpm, 0.27m/s to 1.4m/s at 270 rpm. This air is also an added source of drift in this orchard application.

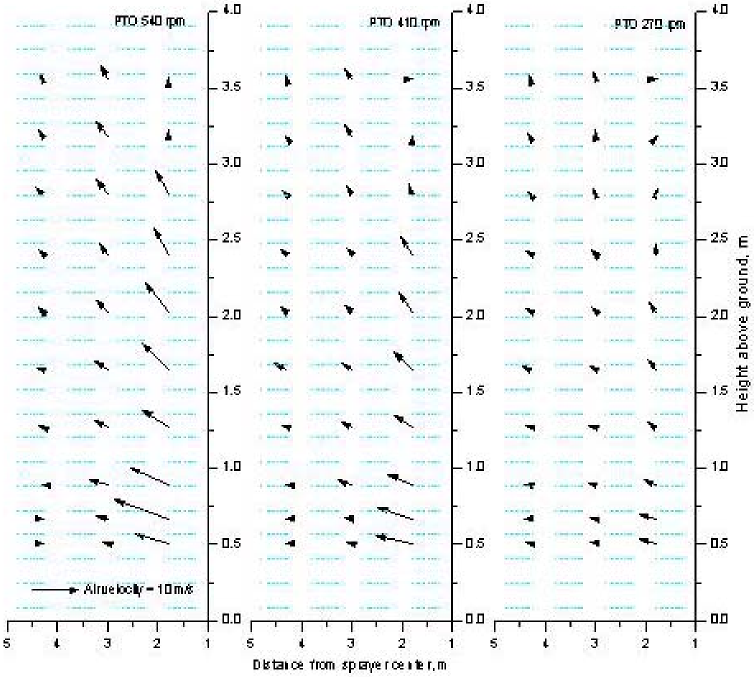

Figure 1. Air velocity patterns from left of sprayer for 3.4m trees at 6.1m row spacing

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 wider row spacing orchards, 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.

Drift

Tables 2 and 3 shows the effect of reducing tractor PTO speed and its effect on fan speed by 25%. At a standard fan speed of 2076 rpm, drift was detected up to 24.4m from the target row where 10% card coverage was recorded at the furthest drift pole. Reducing the fan speed by 25 % resulted in considerably less drift with card coverage at 6.1m and 12.2m from the target row being 16.0 % and 0.2 %, respectively.

Reducing fan speed increased droplet size from 360μm VMD at 2076 rpm to 460 μm 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.

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 2.5m/s coming from NW with gusts of 4.7m/s
[3] Mean wind was 3.4m/s coming from NW with gusts of 5.6m/s

Table 2. The effect of fan speed on spray drift from the AgTec sprayer

Tractor PTO Speed, rpm	Sprayer Fan Speed, rpm	Ground Speed, mph	Spray Coverage, %	VMD	VD(0.1)	VD(0.9)
540	2076	6.0 km/h	36.1	351	144	786
405	1557	5.5km/h	27.5	460	180	737

Table 3. The effect of fan speed on canopy coverage and droplet size

Conclusions

Reducing fan speed by 25% 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. Care must be taken when reducing engine speed to ensure that the engine has significant torque reserve to pull a sprayer full of spray uphill. Reducing air speed over the AgTec air shear nozzles by 25 % only increases droplet VMD by 31% and still provides acceptable coverage for disease and insect control.

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