Just Enough: Ground Speed and Spray Coverage for Efficient Orchard Spraying

Project No.: **14-WATER3-Niederholzer/Giles/Markle**

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Objectives:

1) Determine sprayer ground speed needed to move pesticide just above the tops of mature, tall almond trees at different times of the year (dormant vs full bloom vs May vs hull split) using conventional air blast sprayers. Document the differences in speeds and demonstrate grower-friendly means to determine optimum ground speed for a specific sprayer in a specific orchard.
2) Compare leaf coverage at different levels of the canopy using different sprayer ground speeds in spring.
3) Evaluate spray coverage in the tops of almond trees using different sprayer configurations (nozzles, nozzle location on the sprayer, etc.) and spray times (early morning vs mid-day vs evening)
4) Measure drift and ground deposition using a combination of string samplers and Kimbies (cellulose pads)
5) Extend results from this and previous work to growers and PCAs via meetings, publications and internet.

Interpretive Summary:

Spray deposit in almond trees – measured by water sensitive paper -- was reduced in the upper canopy, but not the lower canopy, when sprayer speed increased from 1.7 MPH to 3.3 MPH.

Spray deposit in almond trees – measured by micronutrient tracer -- was reduced by 30% when applied as temperatures reached 80^{o}F and relative humidity dropped below 40%.

Materials and Methods:

Two experiments (EXP) were conducted in a commercial orchard in the southern Sacramento Valley in June, 2014. Tree rows were oriented N-S. A PTO airblast sprayer (36" axial fan) – regularly used to deliver effective pest management in this orchard -- was used with a spray volume of 100 gallons per acre (GPA) and an operating pressure of 150 psi. No changes in nozzle number (6 per side) or set up were made during the experiments. Where speed changes required higher spray flow rates to maintain GPA, larger nozzles were used in the same locations following the same pattern of volume delivery (two thirds of spray flow from the upper half (3) of the nozzles on each side of the sprayer).

EXP 1: The purpose of this study was to assess differences in percent spray coverage within the canopy at different ground speeds using water sensitive paper (WSP) cards. Also tested was whether the direction of sprayer travel down the row could influence coverage. Water (only) was sprayed down the same side of the tree row at 100 GPA at 1.7 or 3.3 MPH while the sprayer was driving south to north and at 1.7 MPH north to south. Differences in spray coverage were measured using WSP held in a square card holder placed at 10' and 20' above the orchard floor. At each of the four sampling locations for each height in three separate trees, cards were arranged facing up, down, towards the sprayer row, and facing away from the sprayer row. Total card area per direction = 6 in^2.) Percent spray coverage (relative deposition) was determined by DropletScan™ image analysis.

EXP 2: This study was conducted to assess differences in spray deposition within the canopy at different combinations of temperature and relative humidity through the day. In addition, the indirect spray deposit from fall-out from the spray cloud was measured at the same time. Using the same sprayer as in EXP 1 and a similar set up (2 MPH, 100 GPA, 150 psi, six nozzles per side) one of four different micro-nutrients (170 ppm cobalt, copper, manganese or molybdenum) plus 8 oz of non-ionic surfactant per 100 gallons of spray solution was sprayed at a different time of the same day: 0630, 0830, 1030, or 1330 hours. Wet and dry bulb temperature (^{o}C) was measured before and after each application. Spray was applied to three tractor aisles on either side of the tree row where the samplers were located. Care was taken so that the direction of sprayer travel was opposite for each side of each tree row. The sprayer traveled down tractor aisles 1, 3, and 5 in one direction and 2, 4, and 6 in the opposite direction. Samples were taken from lower (10') and upper (20') canopies of five trees in a single row between tractor aisles 3 and 4. Spray deposition was captured on small squares of absorbent fiber held in the card holders similar to those used in EXP 1. Indirect spray fall out was measured on fiber squares placed at the bottom of a square plastic pan with ?" tall sides, so placed at a 20' height in the tree row that the source of all captured spray was from above without interference of foliage. Fallout samplers were placed in different trees than the four-sided samplers. Micro-nutrient tracers were extracted from the fiber samplers and the amount present determined at the UC Davis Analytical Lab. The spray volume reaching each sampler was calculated from pre-spray tank tracer concentrations and the amount of tracer recovered from each sampler.

Results and Discussion:

EXP 1: Total coverage in the upper canopy (20') was significantly less at 3.3 MPH than 1.7 MPH (**Table 1**). These data are consistent with those measured by Dr. Joel Siegel, USDA, and other Almond Board of California funded researchers over the past five years, documenting decreasing spray coverage and/or pest control with increasing sprayer ground speed. Total average spray card coverage for lower (10') canopy did not change with sprayer ground speed or direction of travel (**Table 1**). Sprayer travel direction did not influence total average coverage in the upper canopy.

In the upper canopy (20'), average spray coverage on cards facing the sprayer, facing away from the sprayer, or facing downwards was not significantly different between tractor speeds and direction, despite large numerical differences (**Table 2**). These apparent numerical differences without statistically significance indicate high variability in the coverage between sampling sites in the three trees used. Average coverage in the upward facing cards was significantly less at 3.3 MPH compared to 1.7 MPH when the sprayer was traveling in the opposite direction, but not when the sprayer was traveling in the same direction at 1.7 MPH.

Significantly more coverage was measured on the cards facing the sprayer (front and bottom) than those facing away (top and back) at 10' height in the canopy when coverage from all the treatments were considered together (**Table 3**). These data support previous research results showing non-uniform coverage from every-other-row spraying. When the same comparisons were made for cards in the upper canopy (20'), coverage was generally much less and coverage on the cards facing away from the sprayer was not significantly different from that facing the sprayer on facing down. Coverage on the cards facing up was significantly more than that on the cards facing away from the sprayer (back).

Table 1. Percent spray coverage on water sensitive paper in mature almond trees as influenced by 1) tractor speed and/or direction and 2) height above the orchard floor using a 36" axial fan PTO-powered airblast sprayer. Data are from a single sprayer pass down one side of the tree row. Data in the same column followed by the same letter are not significantly different ($p \leq 5\%$). June 2, 2014

Sprayer set up	10' from orchard floor	20' from orchard floor
1.7 MPH North	47.66 a	2.76 a
1.7 MPH South	39.06 a	2.19 a
3.3 MPH North	42.29 a	0.21 b

Table 2. Percent spray coverage on water sensitive paper positioned at 20' in mature almond tree canopy as influenced by 1) tractor speed and/or direction and 2) aspect of sampling location in the canopy relative to the direction of sprayer (36" axial fan PTO-powered airblast sprayer) travel. Data are from a single sprayer pass down one side of the tree row. Data in the same column followed by the same letter are not significantly different ($p \leq 5\%$).June 2, 2014

Sprayer set up	Front @ 20'*	Back @ 20'	Bottom @ 20'	Top @ 20'
1.7 MPH North	1.88 a	0.30 a	2.38 a	4.19 ab
1.7 MPH South	3.01 a	0.62 a	2.31 a	5.06 a
3.3 MPH North	0.14 a	0.04 a	0.04 a	0.63 b

*stats after SQRT trans

Table 3. Percent spray coverage on water sensitive paper in mature almond trees as influenced by 1) height above the orchard floor and 2) aspect of sampling location in the canopy relative to the sprayer (36" axial fan PTO-powered airblast sprayer). Data are from a single sprayer pass down one side of the tree row. Data in the same column followed by the same letter are not significantly different ($p \leq 5\%$).June 2, 2014.

Location from sprayer	10' from orchard floor	20' from orchard floor
Back	3.83 a	0.32 a
Top	10.02 a	3.29 b
Bottom	69.53 b	1.58 ab
Front	88.64 b	1.69 ab

EXP 2:

Average spray deposit decreased by a third in the lower canopy as application temperature 80^{o}F and relative humidity (RH) dropped below 40% (**Table 4**). Further increase in temperature and decrease in RH did not result in additional decrease in deposition. A similar, but statistically insignificant drop in upper canopy spray deposition was measured across the same temperatures and RHs (**Table 4**).

Average spray deposit was 2-6x greater in the lower canopy than the upper canopy (**Table 4**). These differences were significant at each application timing, but much less dramatic than measured with water sensitive paper in EXP 1 using the same sprayer, set up, and orchard locations only 3 weeks previous. Metal tracers are a more accurate measure of total spray deposited, while water sensitive paper and analysis practices do not measure very small drops (< 50 microns) and so provides only a qualitative measure of spray deposit. In addition, data in EXP 1 are from a single sprayer pass, while in EXP 2 there were 6 passes made. Some fall out and drift from other rows may have slightly increased the deposition on the samplers in the middle of the six passes.

Spray deposit was nonuniform between the four sampling aspects at each canopy height (**Table 5, 6**). These differences are noteworthy in that they further document the non-uniform spray coverage resulting from spraying moderately dense, tall tree canopies from equipment on the orchard floor.

Finally, a significant amount of spray deposition falling from above the canopy was measured (**Table 7**), although temperature and RH changes did not significantly influence the amount of deposition.

Table 4. Average spray solution (ml) deposited on fiber targets (38.7 cm^2) in mature almond trees as influenced by height above the orchard floor and weather conditions at the time of application. Spray was delivered by a 36" axial fan PTO-powered airblast sprayer. Data in the same row (a/b) or column (y/z) followed by the same letter are not significantly different (p≤ 5%). June 19, 2014

Weather conditions at the time of the start of spraying: Temperature (^{o}F), % Relative Humidity and Delta T (difference between dry bulb and wet bulb temperatures ^{o}C)	3 m (10')	6 m (20')
61^{o}F; 80%; 0.5	0.08 a y	0.02 b z
72^{o}F; 43%; 6.0	0.09 a y	0.03 b z
79 ^{o}F; 34%; 8.0	0.05 a z	0.02 b z
89 ^{o}F; 24%;10.0	0.06 a z	0.01 b z

Table 5. Average spray solution (ml) deposited on fiber targets (38.7 cm^2) at 3 m (10') above the orchard floor in mature almond trees as influenced by weather conditions at the time of application and sampler aspect. Three three rows, oriented N-S, on either side of the sampled trees were sprayed with tracer. Means in the same row in bold font followed by the same letter are not significantly different (p≤ 5%; Tukey's HST). Remaining row of data are medians and not significantly different (p=0.066). June 19, 2014

Temperature (^{o}F), % Relative Humidity and Delta T (difference between dry bulb and wet bulb temperatures ^{o}C)	East	West	Bottom	Top
61^{o}F; 80%; 0.5	**0.07 ab**	**0.11 a**	**0.10 bc**	**0.05 c**
72^{o}F; 43%; 6.0	0.09 a	0.12 b	0.10 b	0.05 a
79 ^{o}F; 34%; 8.0	**0.05 a**	**0.07 a**	**0.06 a**	**0.03 b**
89 ^{o}F; 24%;10.0	**0.07 a**	**0.06 ab**	**0.07 a**	**0.04 b**

Table 6. Average spray solution (ml) deposited on fiber targets (38.7 cm^2) at 6 m (20') above the orchard floor in mature almond trees as influenced by weather conditions at the time of application and sampler aspect. Spray was delivered by a 36" axial fan PTO-powered airblast sprayer. Three three rows, oriented N-S, on either side of the sampled trees were sprayed with tracer. Data in the same row followed by the same letter are not significantly different (p≤ 5%, Tukey HSD). Data in bold font were sqrt transformed prior to statistical analysis. Actual data presented. June 19, 2014

Temperature (°F), % Relative Humidity and Delta T (difference in dry bulb and wet bulb temperatures °C)	East	West	Bottom	Top
61°F; 80%; 0.5	**0.01 a**	**0.01 a**	**0.02 a**	**0.03 a**
72°F; 43%; 6.0	0.02 a	0.02 a	0.03 a	0.04 a
79 °F; 34%; 8.0	0.02 ab	0.01 a	0.02 ab	0.03 b
89 °F; 24%;10.0	0.01 a	0.00 a	0.01 ab	0.01 b

Table 7. Average spray solution (ml) deposited on fiber targets (38.7 cm^2) falling from above at 6 m (20') above the orchard floor in mature almond trees as influenced by weather conditions at the time of application. Spray was delivered by a 36" axial fan PTO-powered airblast sprayer. Three three rows, oriented N-S, on either side of the sampled trees were sprayed with tracer. Data followed by the same letter are not significantly different (p≤ 5%, Tukey HSD). June 19, 2014

Temperature (°F), % Relative Humidity and Delta T (difference in dry bulb and wet bulb temperatures °C)	Fall out
61°F; 80%; 0.5	0.05 a
72°F; 43%; 6.0	0.05 a
79 °F; 34%; 8.0	0.07 a
89 °F; 24%;10.0	0.04 a