Improving Spray Deposition for Almond Orchards

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Introduction

Accurate and effective spray application for pest control in almond production is an opportunity for increased efficiency, reduced cost and environmental stewardship. Increasing deposition within the upper sections of the tree canopy during single pass operations can benefit the grower economically through reduced pesticide and energy use. Evaluating spray application practices that are beneficial to the growers, in terms of energy savings and commodity protection, and provide good environmental stewardship in terms of minimizing off-orchard drift is of interest to all stakeholders. Spray application studies rarely combine results in terms of in-canopy deposition and off-orchard drift sedimentation with commodity (nut) exposure to insects/pests for establishing pest control efficacy. Sprayer technology and physical canopy characteristics have changed over the last two decades and, due to the large acreage associated with almond production within the state, there is a need to evaluate spray application practices that are beneficial to the growers and provide good environmental stewardship. More than 15 years ago, Dibble (Chapter 34, Sprayers and spray application techniques, Almond Production Manual, 1996) indicated that poor spray coverage was often due to increased ground speed or spray applications that tended to drench trees with large droplets. The assumption from using larger droplet sizes was that the spray would penetrate dense canopies to the tops of trees where deposition is typically low and pest infestation high. These ideas are difficult to overcome and generally result in the need for a second spray application to ensure adequate pest control.

The goal of this project was to continue a collaborative effort between independent researchers concerned with: monitoring spray applications for Navel Orangeworm (NOW) pest control efficacy, measuring spray deposition within the orchard based on sprayer parameters and environmental concerns with off-orchard drift from different spray practices.

Objectives

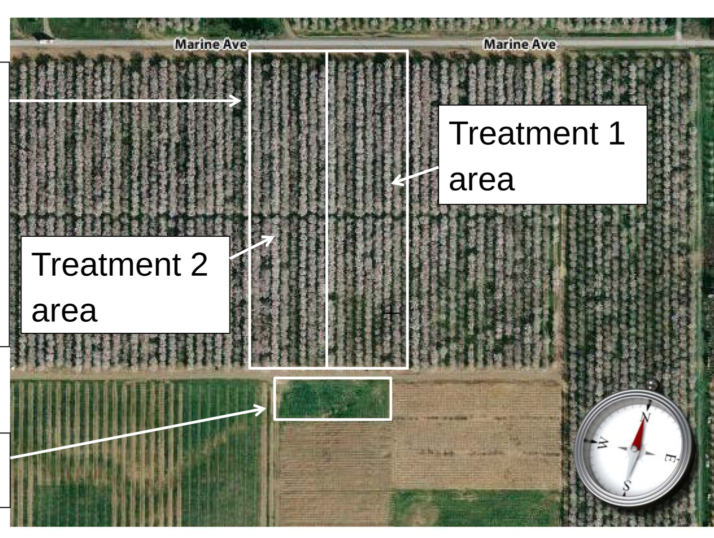
1. Determine spray deposition on Nonpareil trees and off-target areas for a typical grower spray application rate at two different ground speeds; and
2. Establish NOW control on almond nuts at hull-split for the different spray applications within the lower and upper portions of the canopy.

Test Block for Study:

Treatment 1 area: ~ 3.0 ac,
Treatment 2 area: ~ 3.0 ac.

Note: Treatment 2 was located in western half of test block.

Off-orchard drift area: ~ 1.0 ac.



Treatments 1 and 2 sprayed three Nonpareil tree rows within a seven tree row block. Each Nonpareil tree row was treated with one spray pass per side of tree. Tree spacing was16 ft; row spacing was 22 ft.

Figure 1. Study site was located at Nickels Soil Laboratory, Block M-1, planted February 1990.

Spray formulation and equipment

Spray applications for both treatments were made with a tractor towed Air-O-Fan sprayer (Model No. GB36R, Air-O-Fan Products Corp., Reedley, CA) at full airflow and 540 PTO rpm. Treatment 1 was sprayed at a ground speed of **1.8 mph**, treatment 2 ground speed was **2.4 mph**. The spray application rate for both treatments was 100 gal/ac. The sprayer was calibrated off-site prior to the tests. Each application used 9 nozzles on one manifold on one side of the sprayer; system pressure for each treatment was 150 psi. The sprayer for treatment 1 was set up to spray two-thirds of the volume from the upper half of the nozzles; treatment 2 was set up to spray two-thirds of the volume from the top three nozzles. All nozzles for both treatments were configured with slotted nylon strainers and DC-25 cores (Teejet Spraying Systems, Inc., Wheaton, IL). Figure 2 and 3 show the nozzle disc configurations along the sprayer manifold for each application; figure 4 shows the spray application during treatment 2. Formulations were similar for each spray treatment: DuPont™ Altacor™ (water dispersible granules) was added at 4 oz/ac, R-11® non-ionic surfactant was added at 8 oz/100 gal and micro-nutrient tracers, for deposition recovery measurements, were added at 1.5 pts/ac (Molybdenum) for treatment 1 and 2 pts/ac (Manganese) for treatment 2.

Treatment 1 total nozzle flow rate was 4.1 gpm. Target ratio of flow was 2/3rd of the total flow from the top half of nozzles along the manifold.

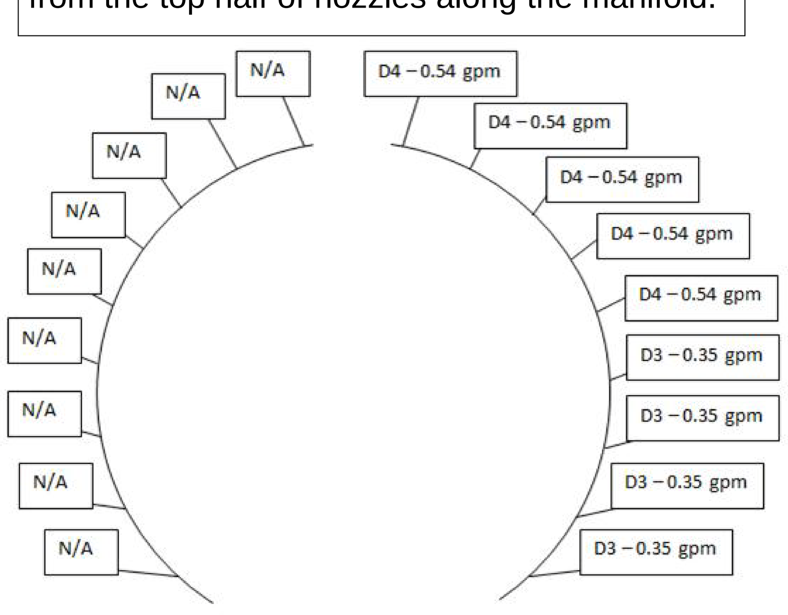


Figure 2. Nozzle configuration along manifold for treatment 1.

Treatment 2 total nozzle flow rate was 5.3 gpm. Target ratio of flow was 2/3rd of the total flow from the top third of nozzles along the manifold.

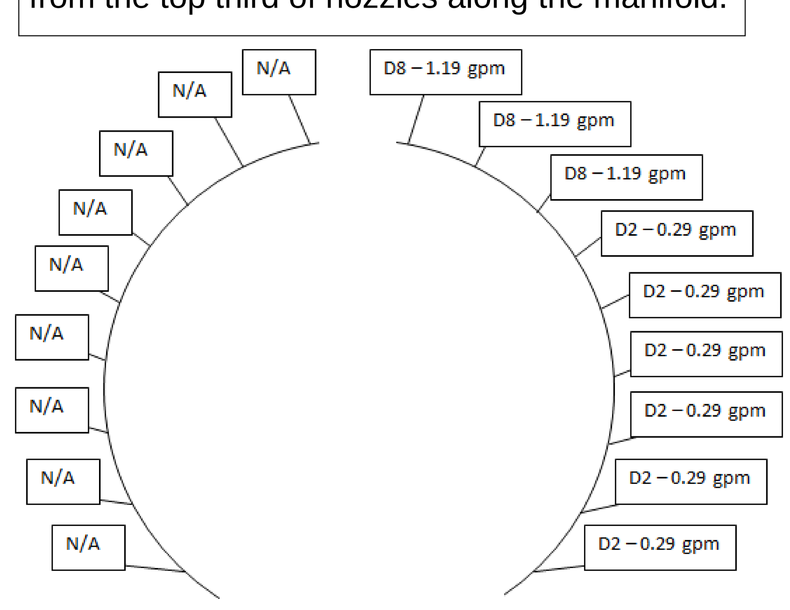


Figure 3. Nozzle configuration along manifold for treatment 2.

Figure 4. One-sided boom spraying for hull-split.

Figure 5. Deposition on water sensitive paper within the low canopy after hull-split treatment (note adjacent mesh cylinder).

Figure 6. Ground deposition on water sensitive paper along the tree line (note adjacent steel plate media).

Orchard configuration and deposition sampling

The orchard was configured with 43 trees per row aligned along a north-south direction. Tree rows alternated between Nonpareil, and two pareil varieties, within the test block (Figure 1). A fallow/grass field was located just south of the orchard footprint for off-orchard drift measurements. Both treatments were applied the same day approximately 1 hour apart. Prior to, and after, each treatment nuts (untreated "control" and treated) from the upper and lower portion of the canopy (75 nuts/replicate tree/canopy height) and whole leaves (100 leaves/replicate tree/canopy height) were sampled from four replicate trees within the middle Nonpareil row of the respective test block. All nut samples (control, 1 day after the spray treatment (DAT) and 14 DAT) were exposed to NOW eggs. Water sensitive paper (WSP) and artificial media (mesh cylinders and steel plates - Figures 5 and 6) were placed within the orchard for qualitative and quantitative analyses and comparisons with deposition measurements from biological media (leaf punches and whole leaf samples). Three drift sedimentation transects (four locations/transect) were aligned perpendicular to the test block: two transects were aligned along the respective north-south test block boundary and an additional transect was aligned perpendicular to the respective test block middle. Drift was measured along these transects at 50, 75, 100 and 200 ft south of the orchard foot print. Figures 7 and 8 show a typical transect layout and a sampling platform. Figures 9-11 show qualitative results (water sensitive paper).

Figure 7. Four locations along three transects were sampled for drift during each treatment.

Figure 8. Drift sedimentation platform with alpha-cellulose sheets (9 in. x 6 in.), water sensitive paper (1 in. x 3 in.) and steel plates (1 in. x 3 in.).

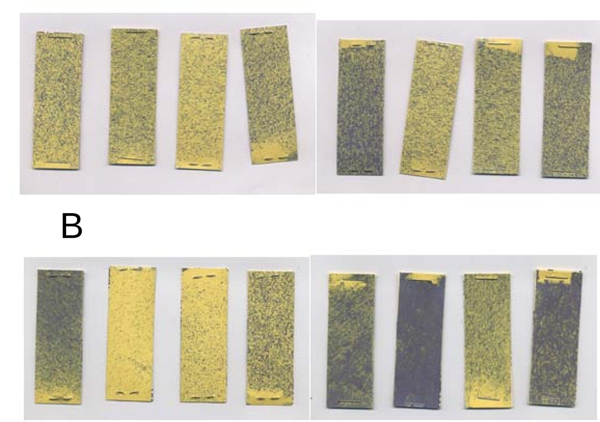


Figure 9. Low canopy deposition on WSP for treatment 1 (A) and treatment 2 (B).

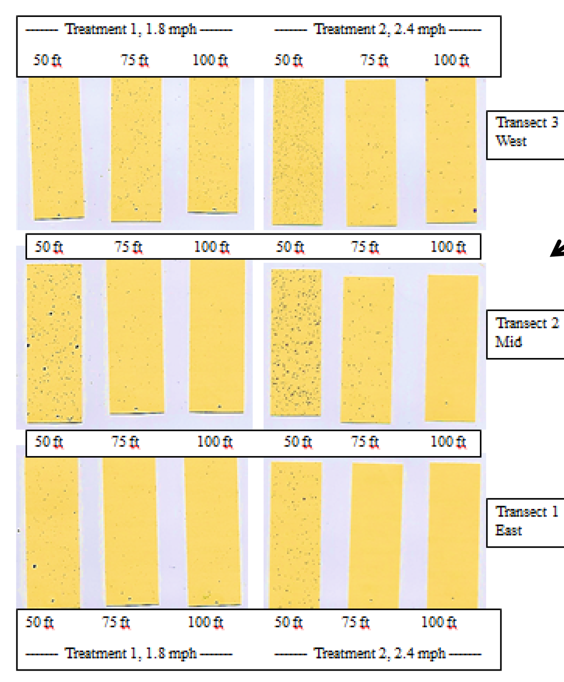


Figure 10. Deposition on WSP from drift sedimentation.

Figure 11. In-orchard ground deposition on WSP.

Deposition Results

Deposition on WSP showed good coverage within the low canopy for both treatments. Treatment 1 at the slower ground speed appeared to have more ground deposition droplets on the WSP versus the faster ground speed along the driving row. In all cases drift showed more deposition at the 50 ft location off the orchard foot-print compared to the other distances; the eastern boundary transect off the orchard foot-print showed the lowest amount of droplets on the WSP (wind was generally from the east-northeast for both tests). In terms of the application rate, on a percentage basis, combined ground deposition on steel plates within the orchard captured 1.1% and 10.8% of the application rate for treatments 1 and 2, respectively. Steel mesh cylinders (four replicates within one tree) within the lower canopy captured 17.1% and 26.4% of the application rate for treatments 1 and 2, respectively. Leaf punches (forty ¼ in. diameter leaf discs from four replicate trees) captured 13.3% and 11.4% of the application rate for treatments 1 and 2, respectively, within the lower canopy. For treatment 1 whole leaf samples from the lower canopy captured 9.2% of the application rate versus 5.3% for the upper canopy. Treatment 2 whole leaf samples resulted in deposition of 9.1% of the application rate for the lower canopy versus 6.7% for the upper canopy. Spray deposition on nuts (10 nuts per replicate tree within each test block) averaged 5.2 and 11.6 µg/nut of molybdenum (treatment 1) and manganese (treatment 2), respectively, within the lower canopy. Results from deposition on steel plates due to off-orchard drift were inconclusive. Alpha-cellulose sheets recovered 0.12%, 0.05% and 0% of the application rate at the 50, 75 and 100 ft distances off the orchard foot-print. For treatment 2 alpha-cellulose sheets recovered 1.1%, 1.0% and 0.6% of the application rate at the same locations.

NOW Results

NOW eggs were both "pinned" to the hull, simulating oviposition, or "tucked" within the open suture of sampled nuts collected 1 and 14 DAT from the respective treatment blocks and canopy height (low and high). Pooling all control nuts (low and high canopy, pinned and tucked egg placement) resulted in an overall survival of 45.6% from NOW egg placement.

1 DAT. Survival for treatment 1 (**1.8 mph**) found no significant difference between egg placement or canopy height; survival was 1.1%. For treatment 2 (**2.4 mph**) there was no significant difference in survival between low and high canopy nuts, however there was a significant difference between egg placement; tucked eggs were 3.3 times more likely to survive. Pooled survival for treatment 2 was 1.5%. There was no significant difference between the two treatments 1 DAT; Altacor exposure reduced survival by 97% when compared to the pooled control nuts survival.

14 DAT. Results indicated that there was no difference between egg placement or canopy height for treatment 1 (**1.8 mph**) and overall survival was 3.7%. However, using the control survival (45.6%), survival was reduced to 91.8%. Also, eggs in treated nuts for treatment 1 were 3.1 times as likely to survive when compared to results from 1 DAT. For treatment 2 (**2.4 mph**) there was no difference between egg placement, however a significant difference was found with canopy height. Eggs placed within the high canopy nuts (12.9% survival) were 3 times as likely to survive versus low canopy nuts (4.3% survival). Population reduction was 90.7% and 71.7% in the low and high canopy nuts, respectively.

A comparison of the two treatments 14 DAT found that there was no significant difference in survival between the two treatments (i.e., ground speeds) within the low canopy nuts and overall survival was 3.8%. However, there was a significant difference in survival between the two treatments within the high canopy nuts. Eggs were 3.1 times more likely to survive within the upper canopy versus the low canopy at the faster ground speed. No differences in survival was observed between egg placement within the high canopy. Failure of the treatment starts within the upper canopy and is exacerbated by increased ground speed during the spray application. Altacor provided protection at 14 DAT, however, efficacy was decreased when compared to the 1 DAT results.