FINAL PROJECT REPORT

Project Title: Data to Model Apple Airblast Spraying Drift Exposure Levels

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Budget: Year 1: $96,108 Year 2: $66,334

Other funding sources

Agency Name: U.S. Forest Service
Amt. requested/awarded: $39,315
Notes: equipment cost share

Agency Name: Washington State Specialty Crop Block Grant (SCBG) for FY2017-FY2019
Amt. requested/awarded: $120,000
Notes: To fund the modeling effort (see 'Justification'). Awarded to Washington Tree Fruit Research Commission (Lead: Mike Willett)

Agency Name: USDA Office of Pest Management Policy
Amt. requested/awarded: $187,000
Notes: To fund the modeling effort (see 'Justification').

Agency Name: U.S. Forest Service
Amt. requested/awarded: $23,000
Notes: To fund the modeling effort and canopy characterization (see 'Justification').

Total in-kind and other funding sources: $369,315

Budget 1

Organization Name: WSU-IAREC **Contract Administrator:** Katy Roberts
Telephone: 509-335-2885 **Email address:** arcgrants@wsu.edu

Item	2018	2019
Salaries	21,000	21,840
Benefits	11,668	12,134
Wages	14,880	15,475
Benefits		
Equipment	12,000	
Supplies	34,955	15,280
Travel	1,605	1,605
Miscellaneous		
Plot Fees		
Total	96,108	66,334

Footnotes: (Year 1) Salaries of $21,000 plus $8,364 benefits will support a postdoctoral researcher who will work closely with the PIs in planning and conducting field experiments, laboratory analysis, data analytics and reporting. $12,318 (including 22.2% benefit) requested to support field work pertinent to field deposition studies (20 trials/crop/season) and canopy characterization (8h/day/person x 7 personnel x 12 days). Additionally, $5,866 requested to support lab work (fluorometry analysis) pertinent to field deposition trials (8 h/day/person x 4-person x 10 days). $1,605 is requested to travel to field sites (100 mile return trip @ 0.535/mile x 15 trips with two vehicles). $34,955 is requested for material and supplies that include procurement of deposit samplers (flat cards, string samplers, artificial foliage samplers), fluorescent tracer, labels, gloves, zip ties, general field supplies, vials, ethanol, chem-wipes and general lab supplies as well as the tractor & sprayer rentals. The material cost also includes $12,675 procurement of 8-m string tower drift poles ($3975+250 S&H/set of 3 x 3 sets). Funds of $12,000 are requested to procure Plant Canopy Analyzer (LAI-2200C) from LI-COR Biosciences.

Year 2 cost includes all the above except the cost of equipment and material supplies available in year-1. Please note that salaries are inflated 4% rate in year-2.

1. OBJECTIVES

The primary objective of this project is to generate data for validation of ***a mechanistic airblast spray drift model*** currently being developed (see 'Justification' of original proposal) to estimate exposure values to assess risk from airblast spraying in 'central leader' apple. Such model would be more accurate than **'worst-case scenario'** estimates currently used by EPA. Overall, during the two year project, measurements were made up to 600 ft downwind from the apple block (central leader) to assess drift and relate it to key meteorological parameters. Studies were conducted at dormant (***obj. #1 year-1 efforts***) and in full canopy (***obj. #2 year-2 efforts***) growth stages. The fluorometry analysis-based deposition data along with the pertinent canopy and environmental conditions has been collected to validate the mechanistic model being developed to estimate airblast sprayer drift/exposure levels.

Table 1. Project activity schedule and quarterly benchmarks (*Planned activities; √ Completed activities).

Objectives	Year 1-2				Year 2-3			
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
1. Airblast sprayer drift/exposure levels assessment up to 600 ft downwind from 'central leader' apple blocks during dormant stage								
Task 1.1: Field block scouting and setting up of the field samplers and metrological stations	√	√	√					
Task 1.2: Canopy mapping via standard ground-reference methods, data processing		√	√					
Task 1.3: Conduct field trials (20 runs)		√						
Task 1.4: Fluorometry analysis, data digitization and statistical analysis		√	√					
2. Airblast sprayer drift/exposure levels assessment up to 600 ft downwind from 'central leader' apple blocks at full canopy stage								
Task 2.1: Use block from 1.1 and setting up of the field samplers and metrological stations				√	√			
Task 2.2: Canopy mapping via standard ground-reference methods, data processing					√	√		
Task 2.3: Conduct field trials (20 runs)					√			
Task 2.4: Fluorometry analysis, data digitization, processing and statistical analysis					√	√		
Data from obj. #1 & #2 for USDA-FHAAST and EPA team developed drift model validation			√	√		√	√, *	√,
Reports and publication			√	√	√	√	√, *	√, *

2. SIGNIFICANT FINDINGS

Year-1 (Dormant stage)

The field data collection for dormant stage was conducted in Winter (November 27-through December 2, 2018). Major findings from this trial are given below.

- Spraying was done in row-3 upwind the orchard edge row. There was considerable spray deposition on the within row ground deposit samplers located on either sides of the spray row, i.e., at row-2 and row-5. For example, the average spray deposition (of 17 trials) on deposit samplers [cards] located in row-5 (at 45' inside the orchard) and row-2 (at 18' inside the orchard) was 4204 ng cm^{-2} and 3463 ng cm^{-2}, respectively. However, spray deposition on the ground at the edge of the orchard was reduced down to 14% (average deposition = 548 ng cm^{-2}) compared to 45' inside of the orchard.
- The spray deposition decreased exponentially along the sampled downwind distances up to 600'. It was minimal (0.35 ng cm^{-2}) at 600' downwind from the orchard edge.

- The deposition on vertical strings showed exponentially decreasing trend with the increase in height above ground level (AGL). The average spray deposition (of 17 trials) at 0-12’, 12’-18’, and 18’-24’ sections was 457, 290 and 186 ng cm^{-2}, respectively at 25’ downwind from orchard edge. Similarly, the spray deposition at 75’ away from the orchard edge and for above respective heights was 152, 104, and 81 ng cm^{-2}.
- Pertinent weather, canopy attributes and spray deposition data has been transferred to the modeler for development and validation of the ‘mechanistic spray drift’ model.

Year-2 (Full canopy stage)
The field data collected for full canopy growth stage (May 13-16, 2019) showed similar trends as in the dormant stage. Results are summarized below.

- The average spray deposition on ground deposit samplers [cards] at 45’ and 18’ inside the orchard was 3592 ng cm^{-2} and 1385 ng cm^{-2}, respectively. Data showed 91% reduction (deposition = 336 ng cm^{-2}) in ground spray deposition at the edge of the orchard.
- Overall, the spray deposition showed exponential decreasing trend with 0.48 ng cm^{-2} deposited at 600’ downwind distance.
- The spray deposition on vertical strings located at 25’ downwind showed exponentially decreasing trend with the increase of height AGL. The average deposition (of 17 trials) at 0-12’, 12’-18’, and 18’-24’ vertical sections was 764, 698, and 576 ng cm^{-2}, respectively. At 75’ ft downwind from the orchard edge, pertinent vertical string sections had deposition of 237, 206, and 164 ng cm^{-2}, respectively.
- Pertinent weather, canopy attributes and spray deposition data has been transferred to the modeler for development and validation of the ‘mechanistic spray drift’ model.

Overall, dormant stage and full canopy stage spray deposition data was significantly not different at 5 % level. However, the spray deposition on vertical strings was almost doubled in full canopy stage (year-2) compared to dormant stage (year-1). The year-1 study was conducted at winter season (no leaves) in lower ambient temperatures and high humidity conditions, whereas year-2 study was conducted in spring season, where the ambient temperatures were higher (60.6-75.0 °F) and humidity was lower (22.8-48.8%). Further details on the spray deposition trends at two growth canopy stages are given under the results & discussion section.

3. RESULTS and DISCUSSION

Sprayer characteristics
The spray trials were conducted using an airblast sprayer (Powerblast Pultank, Rears Mfg. OR, see Fig. 1). It was a PTO driven conventional airblast sprayer with 400 gal tank size. The axial fan on rear of the sprayer had six blades and was operated to supply air-assist velocity to the spray mix. The fan diameter was 2.8’. It rotates in anticlockwise direction (looking from rear end of the sprayer). At 540 rpm of PTO, the fan speed was 2074 rpm and resulting air flowrate was 25, 426 ft^3 min^{-1} (12 m^3 s^{-1}). The air outlet area per side was 1.94 ft^2 (0.18 m^2). During the trials, the sprayer was operated at 90 psi to have 100 GPA application rate and had 10 active nozzles on each side. Sprayer was equipped with hollow cone disc-core nozzles (TeeJet Technologies, USA) (see Table 1 for details)

Fig. 1. Airblast sprayer used in the study

Table 1. Sprayer nozzle attributes.

Nozzle number and type	Droplet classification*	Sprayer side[x]			
		Left		Right	
		Nozzle orientation/Exit angle (° w.r.t. ground)	Flow rate (L min^{-1})	Nozzle orientation/Exit angle (° w.r.t. ground)	Flow rate (L min^{-1})
1 – not used	-	-	-	-	-
2 – D4, DC 25	Medium	66.7	1.77	61.6	1.66
3 – D4, DC 25	Medium	58.4	1.75	54.4	1.62
4 – D3, DC 25	Very coarse	25.3	1.12	52.1	1.11
5 – D3, DC 25	Very coarse	48.1	1.09	46.2	1.12
6 – D3, DC 25	Very coarse	40.3	1.10	37.5	1.13
7 – D3, DC 25	Very coarse	39.8	1.11	30.2	1.03
8 – D3, DC 25	Very coarse	31.3	1.15	21.6	1.16
9 – D3, DC 25	Very coarse	19.9	1.08	11.4	1.13
10 – D3, DC 25	Very coarse	20.1	1.17	8.8	1.08
11 – D3, DC 25	Very coarse	7.0	1.21	4.8	1.11
12 – not used	-	-	-	-	-

* From manufacturer which color codes the discs per the ASABE Standard S572.1, actual droplet size may vary with pertinent disc-core combination; [x] looking from back of the sprayer.

Prior to field trails, the sprayer air-assist velocities and spray liquid delivery patterns were assessed using two calibration tools; the WSU team custom developed Smart Spray Analytical System – SSAS (Bahlol et al., 2019) and commercial vertical spray patternator (AAMS Salvarani BVBA, Maldegem, Belgium).

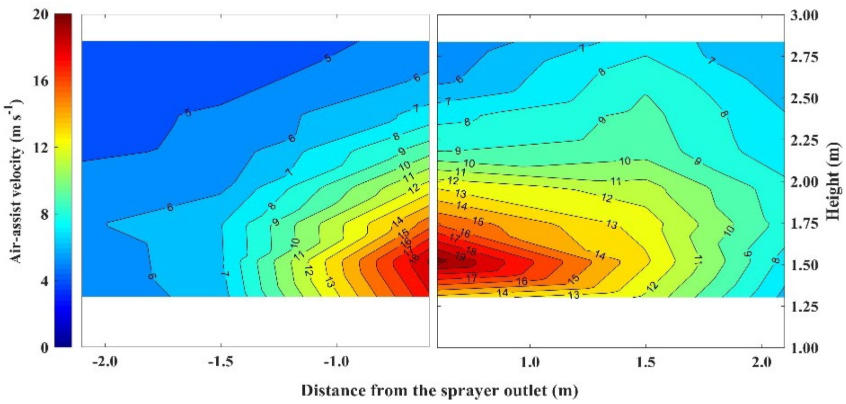

Fig. 2. Airblast sprayer air-assist velocity patterns derived from the SSAS data.

The air-assist velocity patterns derived from the data collected by SSAS are shown in Fig. 2. The spray liquid delivery patterns derived from the data collected by both the SSAS and commercial vertical spray patternator are shown in Figs. 3 and 4, respectively. Overall, sprayer had asymmetric air-assist velocity distribution with right side delivering higher velocities compared to the left. This can be attributed to the

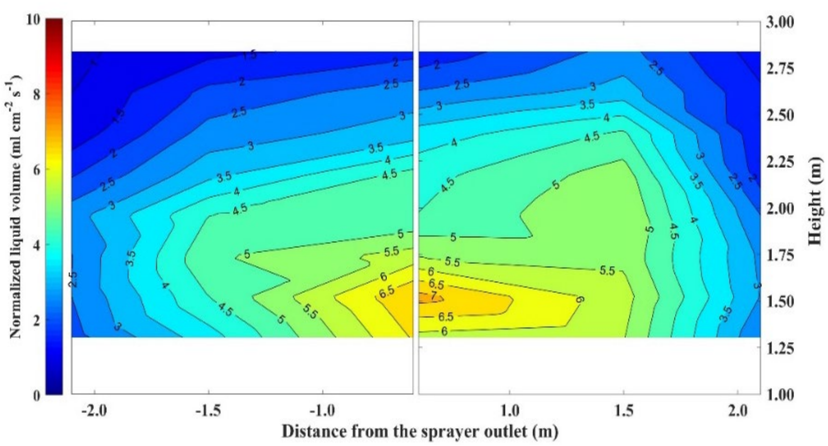

Fig. 3. Airblast sprayer spray liquid delivery patterns derived from the SSAS data.

counterclockwise rotation of axial-fan, despite the presence of an air straightener behind the rotating fan. Differences would have likely been greater without the straightener. Such effect was propagated in the spray liquid volume delivery patterns.

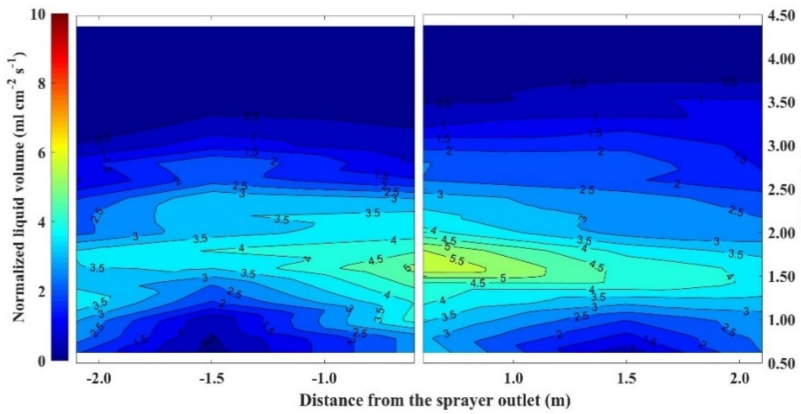

Fig. 4. Airblast sprayer spray liquid delivery patterns derived from the commercial vertical spray patternator tests.

Metrological condition

Field was instrumented with three main weather stations (MET) (see Fig. 5). MET 1 was inside the orchard at 60’ from the spraying row at upwind direction. It consisted of 3D sonic anemometers at 3’, 6’, 12’ and 24’ AGL (One 3-axis 81000 from R.M. Young sonic and three 3-axis Vx probe sonics from Applied Technologies, Inc., CO). MET 2 was located downwind at 600’ away from the orchard edge in an open field. It consisted of 2D sonic four anemometers at 3’, 6’, 12’ and 24’ AGL (ATMOS 41, Meter Group, WA). MET3 was located at the same row as MET1 but 120’ further away to be closer to the end of orchard row. It was fixed with four anemometers (ATMOS 22, Meter Group, WA) similar heights of 3’, 6’, 12’ and 24’ AGL. Pertinent information recorded by a station at 600’ downwind open field conditions during spray trails is summarized in table 1.

Fig. 5. Weather stations setup inside the field (left) MET 1 at 87’ upwind from the edge of the orchard; (middle) MET 3 at 120’ away towards the end of orchard from MET 1 in the same row; and (right) open field MET 2 at 600’ downwind.

During the dormant stage spray trails, the mean wind speed was in the range of 0.87-8.08 mph (0.39-3.61 m s^{-1}) and wind direction was between 351° to 2.5° from the North, and within ± 30 degrees downwind direction. The average air temperature varied between 37.4 and 48.0 °F (i.e., about 3.0 to 8.9 °C). The relative humidity was in the range of 72.8 to100%. Overall, weather during trials can be characterized as ‘unstable’ (see table 1 stability class) with low ambient air temperatures and high relative humidity.

During full canopy stage spray trials, mean wind speed was in the ranges of 3.18-10.29 mph (1.42-4.60 m s^{-1}) and wind direction was between 347° to 17° from the North. The average air temperature was in the range of 60.6-75.0 °F (15.8-24.0 °C). The relative humidity varied between 22.8 and 48.8%. Overall, for 13 out of 17 trials, weather can be characterized as ‘unstable’ (see table 1 for details).

Table 2. Metrological data recorded at 600' downwind open field location

	Apple canopy Growth stage									
	Dormant					Full canopy				
Trial	Stability Ratio	Stability Class[a]	Mean Wind Speed (m/s)	Average Temp. (°C)	Average RH (%)	Stability Ratio	Stability Class[a]	Mean Wind Speed (m/s)	Average Temp. (°C)	Average RH (%)
1	-0.63	Unstable	2.78	7.7	95.1	-0.36	Unstable	2.63	16.5	40.9
2	-0.49	Unstable	3.61	7.3	94.3	-0.41	Unstable	3.15	18.3	37.6
3	-1.06	Unstable	2.79	8.9	92.1	-0.40	Unstable	2.84	19.6	32.9
4	-0.83	Unstable	2.74	7.8	93.1	-0.40	Unstable	2.43	20.4	29.4
5	-3.60	Unstable	1.18	8.1	86.0	-0.48	Unstable	2.17	21.1	30.2
6	4.23	Very stable	0.39	8.4	84.6	-0.74	Unstable	1.94	21.6	32.0
7	0.60	Stable	0.60	8.6	83.6	-0.48	Unstable	2.48	22.6	28.0
8	-19.0	Unstable	0.79	5.1	100.0	-0.68	Unstable	1.92	24.0	22.8
9	-2.41	Unstable	1.76	5.8	97.4	0.13	Stable	2.08	16.3	45.5
10	-2.94	Unstable	1.85	5.3	100.0	-0.06	Neutral	2.60	15.8	48.8
11	-1.48	Unstable	2.85	6.3	98.4	-0.23	Unstable	2.80	17.0	45.9
12	-1.23	Unstable	2.84	7.7	81.5	-0.11	Unstable	3.64	18.3	41.1
13	-0.06	Neutral	0.90	8.4	72.8	-0.11	Unstable	4.60	20.2	35.0
14	-8.16	Unstable	1.26	2.5	99.6	0.17	Stable	1.42	10.3	77.6
15	-7.25	Unstable	1.48	4.1	96.7	0.02	Neutral	2.34	10.0	80.7
16	-2.10	Unstable	1.91	3.0	93.4	-0.11	Unstable	3.04	9.83	85.7
17	-30.82	Unstable	0.55	3.0	97.6	-0.67	Unstable	1.71	10.1	84.1
18	-17.93	Unstable	0.52	3.5	95.1	-0.09	Neutral	4.10	13.2	66.3
19	-9.05	Unstable	1.00	3.4	100.0	-0.09	Neutral	3.55	14.0	63.0
20	-6.77	Unstable	1.03	3.9	99.1	0.09	Neutral	1.01	11.3	98.3

[a] Based on the stability classifications given in Fitz (2006) and Yates et al. (1974). Unstable: -1.7 to -0.1, Neutral: -0.1 to 0.1, Stable: 0.1 to 1.2, Very stable: 1.2 to 4.9.

Canopy characteristics

The field experiments were conducted at cooperating grower (Olsen Brothers) field site (46°18'57.6" N, 119°34'36.8" W) located near Benton City, WA. It is ~9.24 acre (760' x 530') 'Gala' (M9-337 rootstock) apple block planted in 2005. Rows were spaced at 9' and trees trained in 'central leader' canopy architecture were spaced at 3'. Downwind the orchard had 22.4 acre (780' x 1250') bare field (see Fig. 6) block making an ideal location for this study.

Fig. 6. Experimental field site.

At each growth stage (dormant and full canopy), total of 30 random trees along the spraying row were measured for determining the canopy characteristics. Average height of trees was 12' (3.66 m) and the average tree trunk diameter was 2.5" (0.064 m). The average width of a tree was about 4' (1.25 m). The leaf area index (LAI) as a function of tree height was measured in dormant and full canopy growth stages using PAR measurement sensor (AccuPAR LP-80, Meter Group, WA). Pertinent data is shown in Fig. 7.

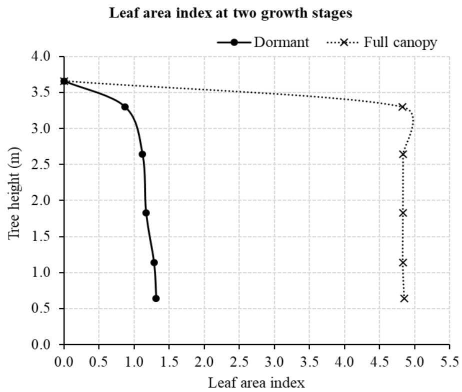

Fig. 7. Apple tree canopy attributes.

Fig. 8. Apple tree canopies at two growth stages (a) dormant and (b) full canopy.

The LAI at dormant growth stage varied from 0 (top of the canopy) to 1.32 (at the lowest trellis at 25" [0.64 m] AGL. The LAI at the topmost trellis (130" [3.3 m]) was 0.87. In full canopy growth stage, the LAI at topmost trellis was 4.82 while the LAI at the lowest trellis was 4.85. Overall, trees at full canopy stage were uniform and had dense foliage with LAI difference of about 0.03. The typical canopies at two growth stages are shown in the Fig. 8.

Spray deposition

There were four types of drift catching samplers; Mylar cards (2"x2"), Artificial foliage (Hedge slats of 1.5" length), Horizontal strings (1 m length), and Vertical strings (sectioned at 12', 18' and 24'). The string samplers were made from 1.8 mm dia. white color spear gun spectra cord (SGT Knots, Mooresville, NC). The arrangement of Mylar card, artificial foliage and the horizontal string samplers in the field is shown in Fig. 9.

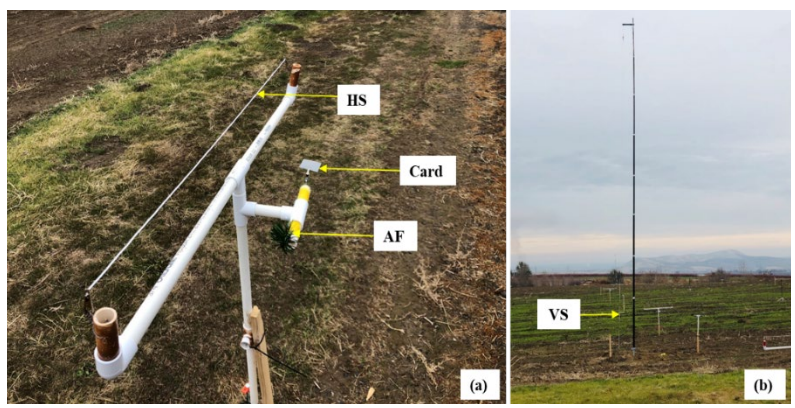

Fig. 9. Arrangement of different samplers at the field setting; (a) horizontal string-HS, artificial foliage-AF and the Mylar card (card); (b) vertical string-VS set-up with a telescopic pole.

The dormant (at leaf drop stage) and full canopy stage data collection was conducted per the experimental protocol given in the original proposal. There were three blank trails and 17 spray trials that were conducted at each of the growth stage (total of 40 trails). Each trial involved spraying four passes of spray mix that had fluorescent tracer dye at 2 g L^{-1} (Pyranine 10G, Keystone Inc.). Spraying was done in the third row from the edge.

Collected deposit samples, 2320 at each growth stage, were analyzed using the fluorometry analysis. The details of the fluorometry analysis has been reported in Salyani (2000) and Khot et al. (2012). Briefly, a known volume of deionized water will be added to the plastic bags containing the deposit samples. The sample bags were then shook for 1-min using a mechanical shaker, to thoroughly mix the tracer deposit into deionized water in the sampler bags. The rinsate was then transferred into two

10- ml matching cuvettes (Fisher Scientific, Hampton, NH). Each cuvette was analyzed twice for fluorescence intensity using the fluorometer (Model: 10AU, Turner Designs, San Jose, CA). The fluorometry analysis-based deposition results (as amount of tracer per sample in mass/area) were summarized and transferred to ‘Spray Drift Task Force’ to validate an orchard airblast ‘spray drift model’.

The ground spray deposition during dormant and full canopy stages and on each type of sampler is shown in Figs. 10a-c. Overall, there was exponential decay in ground deposition on cards along the downwind distance at both dormant ($y=1191e^{-0.7x}$, $R^2=0.99$) and full canopy ($y=1063e^{-0.7x}$, $R^2=0.99$) growth stages (Fig. 10a). The average depostion at the edge of orchard (0’) at dormant and full canopy growth stages was 591 ng cm^{-2} and 336 ng cm^{-2}, respectively. However, at 600’ (183 m) downwind the orchard edge, the average depostion on cards was 0.42 ng cm^{-2} at dormant and 0.48 ng cm^{-2} at full canopy growth stage.

In dormant growth stage, the average deposition on artificial foliage samplers at 10’ (3 m) from the orchard edge was 591 ng cm^{-2} and found decreased to 2.54 ng cm^{-2} at 600’ downind. At the full canopy stage, the pertinent sampler had average deposition of 526 ng cm^{-2} at 10’ and 1.60 ng cm^{-2} at 600’ downwind from the orchard edge. At both stages, the deposition data showed exponentially decreasing trend (Dormant stage: $y=5748e^{-0.6x}$, $R^2=0.98$; Full canopy stage: $y=9405e^{-0.6x}$ $R^2=0.98$; Fig. 10b).

The horizontal strings were placed at five locations (50’, 100’, 200’, 400’, and 600’) along the

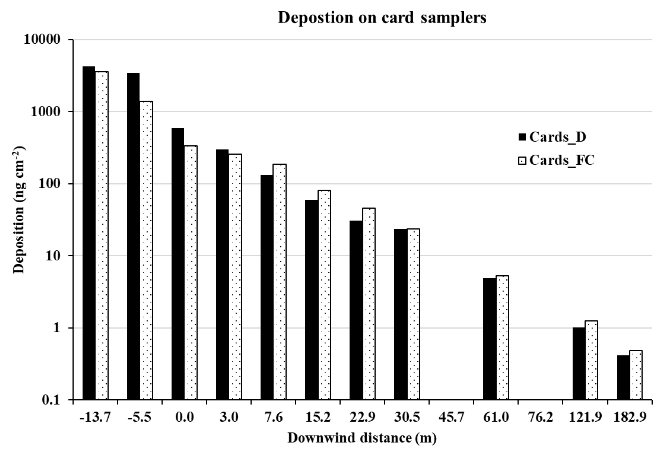

Fig. 10a) Average (n=17) deposition on Mylar card samplers along the downwind distance (D-dormant and FC-full canopy growth stage).

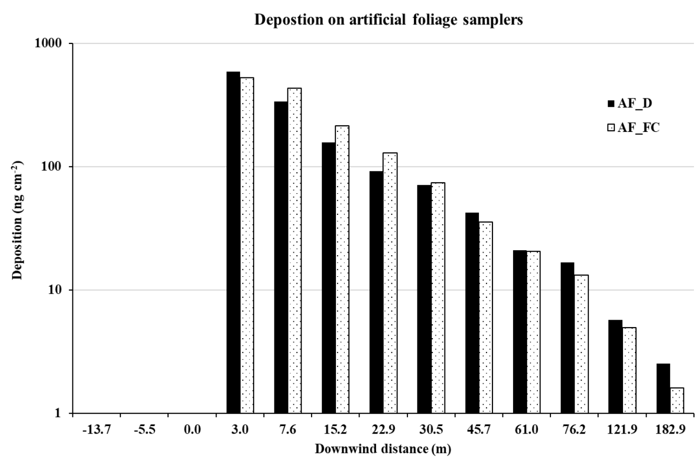

Fig. 10b) Average (n=17) deposition on artificial foliage samplers along the downwind distance (D-dormant and FC-full canopy stage).

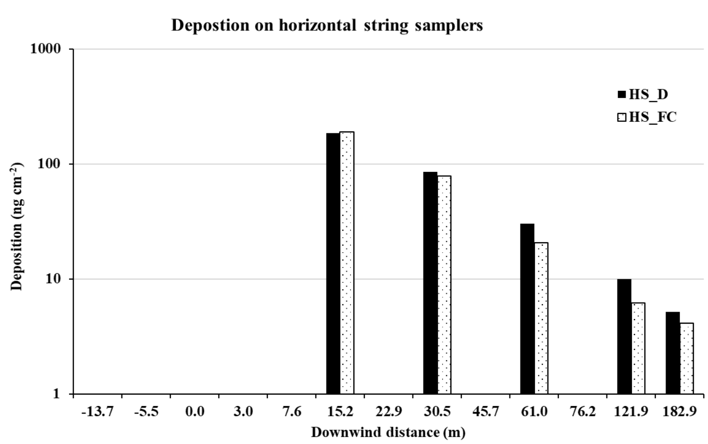

Fig. 10c) Average (n=17) deposition on horizontal string samplers along the downwind distance (D-dormant and FC-full canopy growth stage).

downwind distance. Similar to the Mylar cards and artificial foliage samplers, the depositions along the downwind distance decreased exponentially (Dormant stage: $y=4601e^{-0.5x}$, $R^2=0.93$; Full canopy stage: $y=6234e^{-0.6x}$, $R^2=0.99$; Fig. 10c). At dormant growth stage, the average deposition on strings at 50’ and 600’ downwind distances was 185 and 5.18 ng cm^{-2}, respectively. Similarly, at full canopy growth stage, the respective average depostion for pertinent downwind distances was 189 and 4.11 ng cm^{-2}.

The spray deposition on vertical string samplers at each growth stage (dormant and full canopy) is shown in Fig. 11.
On vertical strings, the spray deposition decreased with the increase of height AGL and downwind distances. At the dormant growth stage, the deposition decreased with the increase of height (0-12’, 12’-18’, and 18’-24’) and downwind distance (from 25’ to 75’) ($y=585e^{-0.3x}$, $R^2=0.99$). Furthermore, at full canopy stage, reduction in deposition was much faster along the downwind distance ($y=1248e^{-0.4x}$, $R^2=0.92$).

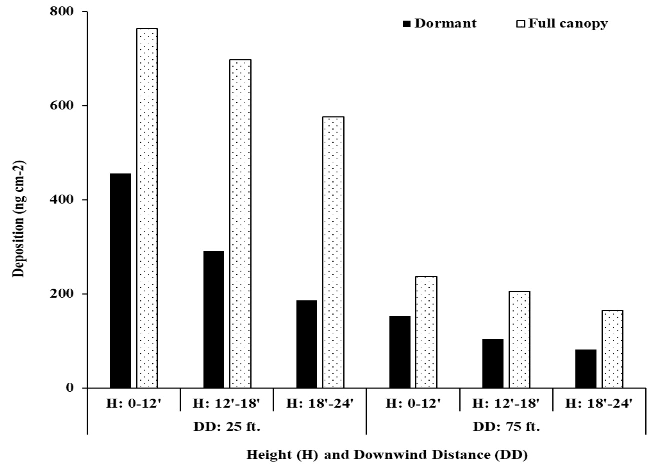

Fig. 11. Average (*n*=17) deposition on vertical string samplers (sectioned as 0-12’; 12’-18’; and 18’-24’ heights at each sampling location, D-dormant and FC-full canopy stage).

During the study, three different types of samplers (Mylar cards, artificial foliage, and horizontal strings) were placed along each transects for ground deposition assessment. At five locations along each transect had all three types of samplers. Therefore, the deposition per unit area on each sampler would provide an indication on the collection efficiency of the pertinent sampler type. Fig. 12 shows the average deposition on each sampler along the downwind distance at dormant (left plot) and full canopy (right plot) growth stages.

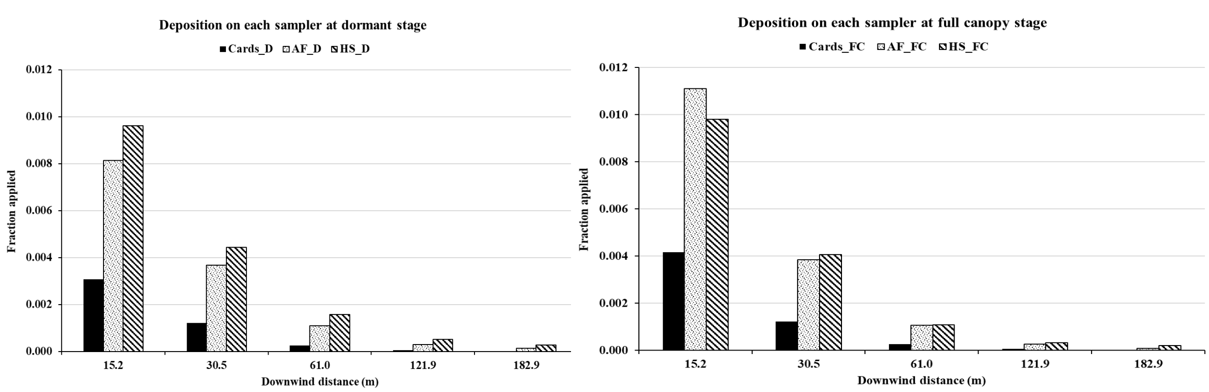

Fig. 12. Deposition as fraction applied on each sampler along the downwind distance at dormant (left) and full canopy (right) growth stages (D-Dormant, FC-Full canopy, Cards- Mylar cards, AF-Artificial foliage, HS-Horizontal strings).

The overall comparison suggested that the artificial foliage and horizontal string samplers have significantly higher collection efficiency, at 5% level, compared to the Mylar cards. In terms of field data collection, the handling of strings would require extra caution due to longer length. Therefore, the artificial foliage samplers would be more effective as drift catching samplers compared to Mylar cards.

References:

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EXECUTIVE SUMMARY

Project title: Data to Model Apple Airblast Spraying Drift Exposure Levels

Key words: Apple, airblast, deposition, spray drift, mechanistic model

Abstract: Study generated field data for validation of a mechanistic spray drift model to help assess pesticide drift and human exposure risks from airblast sprayer applications in ‘central leader’ apple. Such data driven models will help change regulatory rules that currently consider the worst-case scenario, resulting unnecessary label restrictions.

Summary:

This project was conducted to generate data for the validation of a mechanistic airblast spray drift model currently being developed to estimate exposure values and assess risk from airblast spraying in ‘central leader’ apple orchards. Spray drift measurements were collected up to 600 ft downwind from the apple orchard edge-row and relate it to pertinent meteorological parameters at both dormant and full canopy growth stages. The field data collection for the dormant and full canopy growth stages was conducted in winter 2018 and in spring 2019. Four types of drift catching samplers (Mylar cards, Artificial foliage, Horizontal strings, and Vertical strings) were used in the study. Three blank trials and 17 spray trials were conducted for each of the growth stages. Each trial involved spraying four passes of spray liquid containing 2 g L^{-1} fluorescent tracer dye. In total, 2320 samplers were collected for each growth stage. Collected deposit samplers were analyzed using the fluorometry analysis.

The dormant stage trial was conducted at winter season (no leaves) in lower ambient temperatures (37.4-48.0 °F) and higher humidity (72.8-100%) conditions; whereas the full canopy stage trial was conducted in spring season, where the ambient temperatures were higher (60.6-75.0 °F) and humidity was lower (22.8-48.8%). The comparison of all data (dormant stage and full canopy growth stage) showed that there was no significant difference in drift collected from various locations at 5% level at two growth stages. The analysis of card, artificial foliage, and horizontal string deposit samplers showed an exponential decay in ground deposition along the downwind distance at both dormant and full canopy growth stages. However, the spray deposition on vertical strings almost doubled in the full canopy stage compared to the dormant stage. The overall comparison on the different ground deposit samplers suggested that the artificial foliage and horizontal string samplers have significantly higher collection efficiency, at 5% level, compared to the Mylar cards. In terms of field data collection, the handling of strings required extra caution due to longer length. Therefore, the artificial foliage samplers would appear to be the most effective drift-catching samplers in this study.

In order to relate the drift data, the nature of the canopies at two growth stages was characterized by leaf area index measurements (LAI). The LAI at the dormant stage was in the range 0-1.32 (from the treetop to bottom trellis at 25” above ground level) with no leaves present, and that in full canopy growth stage varied from 4.85-4.82 with a highly dense foliage.

The Rears Powerblast Pultank 400 gal sprayer used for spray applications was assessed for air-assist velocities and spray liquid delivery patterns using commercial and custom developed vertical patternators. Overall, the sprayer had asymmetric air-assisted velocity distribution with right side delivering higher velocities compared to the left. This can be attributed to the counterclockwise rotation of axial-fan, despite the presence of an air straightener behind the rotating fan. Such effect was propagated in the spray liquid volume delivery patterns.