Spray Drift Study in Grapes to Support Orchard and Vineyard Airblast Drift Modeling Effort

Peter Ako Larbi

Our single objective in this project was to conduct airblast spray trials in the field to generate spray drift data that will be used to validate a computer model. The model is intended to be used by regulators for evaluating spray drift risk of airblast spray applications by estimating pesticide exposure values. This work is of significant relevance in the sense that the ability of regulators to evaluate drift exposure values more realistically will minimize the severity of regulations affecting growers. In the project period covering May 1, 2020 to April 30, 2021, we pursued and obtained all funding required to replicate the study in three crops (almond, citrus, and grape) sharing resources. We built sampling structures needed for the field experiment, purchased shared resources, and configured/tested meteorological instruments for the field data collection. We set up the experiment in a commercial 'Vintage Red' table grape vineyard in Del Rey, CA from the second half of October 2020 through the first week of November. We carried out the field experiment following an EPA-approved protocol to be used in all three crops. Samples collected were analyzed at the UC ANR Agricultural Application Engineering Laboratory to obtain the drift data along with processed weather data. The complete data generated will be made available, along with associated reports, for incorporation into the orchard and vineyard airblast spray drift model.

Unified Grant Management for Viticulture and Enology
ANNUAL/FINAL REPORT FORMAT 2020-2021 FUNDING CYCLE

CALIFORNIA TABLE GRAPE COMMISSION (CTGC)
WASHINGTON STATE WINE (WSW)
E & J GALLO WINERY

1. **Summary**:
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2. **Annual or Final Report**: This report is the final report.

3. **Project Title and UGMVE proposal number**: Spray Drift Study in Grapes to Support Orchard and Vineyard Airblast Drift Modeling Effort, Y20-4996.

4. **Principal Investigator**: Peter Ako Larbi, University of California Agriculture and Natural Resources, 9240 S Riverbend Ave, Parlier, CA 93648, (559)-646-6577, palarbi@ucanr.edu.

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5. **Objective(s) and Experiments Conducted to Meet Stated Objective(s)**:
The project goals and objective are summarized in Figure 1 below. The objective of this study was to generate data from grape airblast applications for validation of a mechanistic model being developed to assess risk from airblast spraying by estimating exposure values. Measurements were made to facilitate the assessment of drift related to key application and meteorological systems.

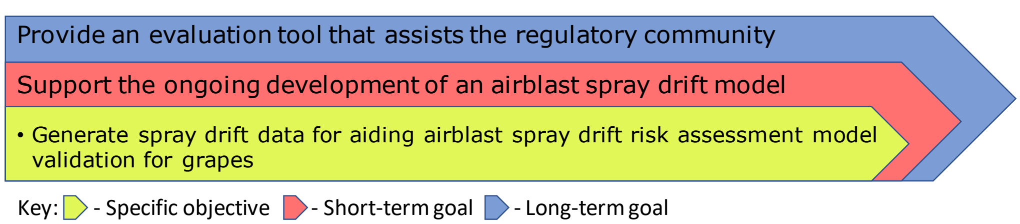

Figure 1. Project goals and objective.

The study was conducted in accordance with an EPA-approved protocol as described in the proposal. Figure 2 portrays the field layout for the data collection. We acquired all the grape-specific sampling supplies, prepared samplers, and completed building sampling structures according to Figure 2. A summary of the prepared samplers is as follows: ~1000 pieces of 2 in. x 2 in. flat cards; ~900 pieces of 1.5 in. long artificial foliage (Christmas tree); ~450 pieces of 39.4 in. long horizontal strings; and ~180 pieces of 192 in. long vertical strings. To cater for contingencies, the quantity of each sampler included extra pieces. We labeled zipper bags according to the sample configuration for all 20 trials. We built the sampling structures needed for the field experiment, purchased shared resources (supplies, materials, equipment, & instruments), and configured/tested the instruments for the field data collection. Furthermore, we assembled and configured the meteorological instruments in the lab and tested them to gain familiarity with the data collection and to fix any issues ahead of the field experiment.

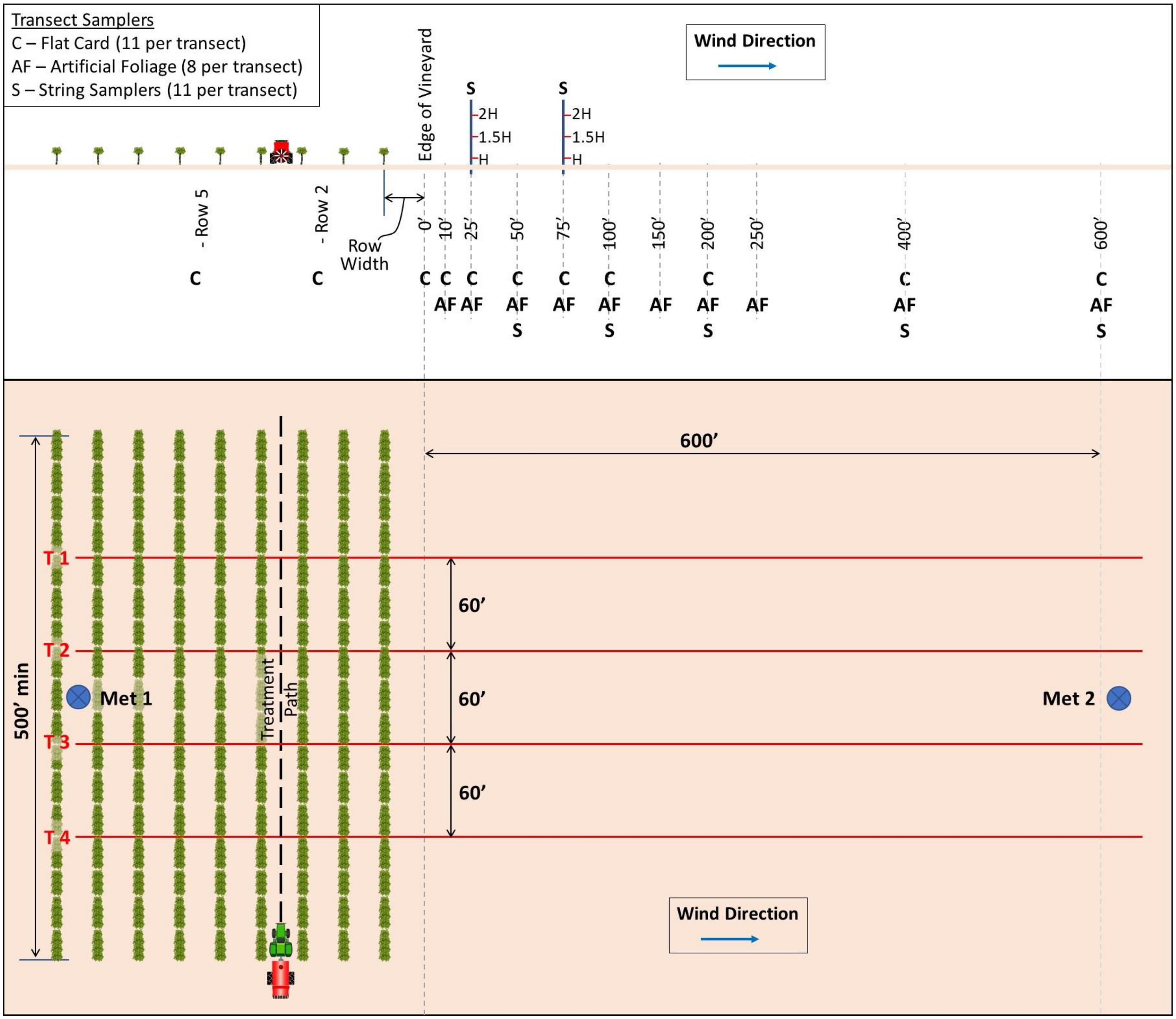

Figure 2. Sampling transect layout.

The study site was a commercial 'Vintage Red' table grape vineyard located in Del Rey, California. The grape vines were supported on a 'closed gable' trellis system (see figure 3). The average height of the canopy across the vineyard was about 8 feet from the floor of the drive lane. The vines crossed over the mid-row lane forming complete canopy cover with mid-row foliage thickness of about two feet. However, about 2 ft wide strip along the mid-row canopy was removed for easy access for harvesting prior to the experiment. The 10-acre vineyard had 12 ft row spacing by 8 ft vine spacing within rows. In conformity with the protocol, the rows were more than 500 ft long in East-West direction and the vineyard had an adjacent bare ground of over 600 ft downwind in the South-North direction.

Figure 3. Table grape vines: a) view along outer row; b) view from edge of row before experiment; and c) view from edge during experiment showing removed strip of canopy. *Photo credits: Peter Larbi.*

The experiment was set up between mid-October and the first week of November 2020. This involved measuring canopy foliage density, calibrating the spray equipment for the experiment, and setting up all the sampling structures and two weather stations (Met 1 and Met 2). Canopy characterization of the vineyard was accomplished using a LAI-2200C Plant Canopy Analyzer (LI-COR Biosciences, Lincoln, NE, USA). The sprayer for the experiment (figure 4) was a commercial airblast sprayer (GB-2/32, Air-O-Fan, Reedley, California) with five open nozzles per side. It was determined to deliver spray at an application rate of ~58.5 gallons per acre traveling at 3 mph.

Figure 4. Airblast sprayer used in experiment: left – sprayer-tractor hook-up; right – back view showing air profile depicted with marking tape. *Photo credits: Peter Larbi.*

Figure 5 shows an aerial view of the field setup. The installed sampling structures on the four transects can be seen as white objects. Figure 6 shows the field setup of horizontal sampling structures (for flat card, artificial foliage, and string) and vertical string sampling structures. Figure 7 shows three different types of sampling structures built that hold different combinations of horizontal samplers in accordance with the protocol: a) holds flat card, artificial foliage, and horizontal string; b) holds flat card and artificial foliage; and c) holds either flat card or artificial foliage.

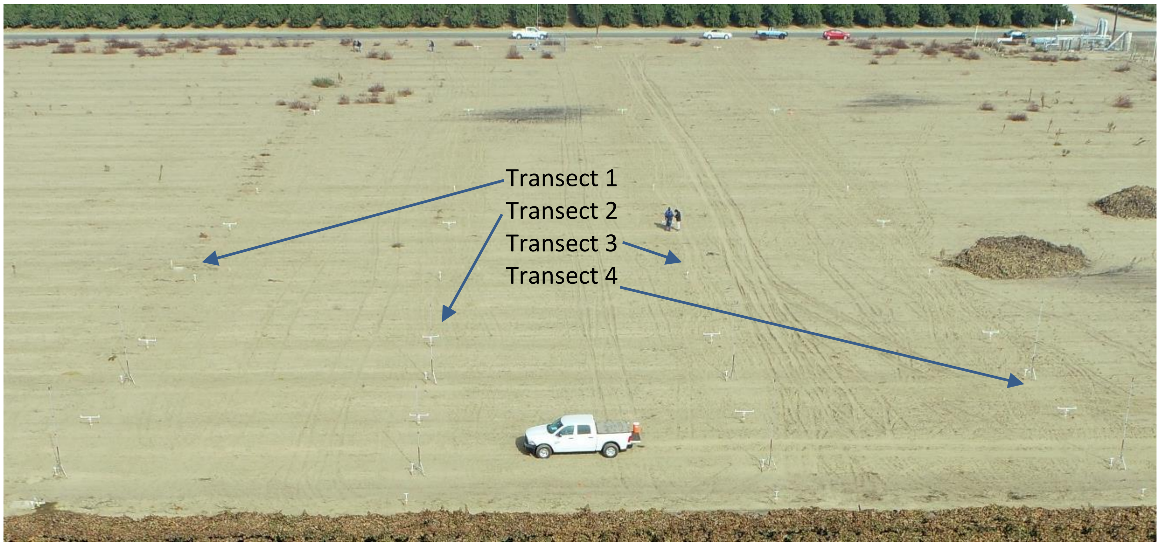

Figure 5. Aerial view of the field setup showing four transects with installed sampling structures (white objects). *Photo credit: German Zuniga-Ramirez.*

Figure 6. Views of the field setup showing installed horizontal sampling structures and vertical string sampling structures. *Photo credits: Peter Larbi.*

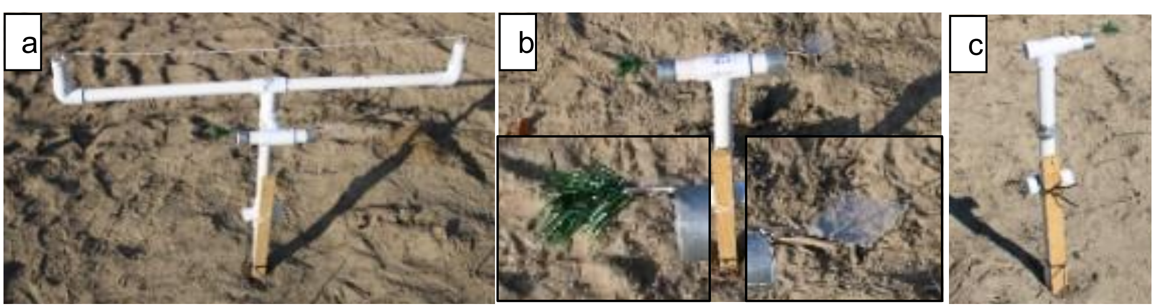

Figure 7. Built sampling structures for different sampler combinations: a) holds flat card, artificial foliage, and horizontal string; b) holds flat card and artificial foliage; and c) holds flat card or artificial foliage. *Photo credits: Peter Larbi.*

The weather instruments were installed at three heights for Met 1 (4, 8, and 16 ft) and four heights for Met 2 (3, 6, 10, and 30 ft). Each height had a 3D sonic anemometer (Young's 3D Ultrasonic Anemometer, R.M. Young Company, Traverse City, MI) and an all-in-one weather sensor (ATMOS 41, METER Group, Inc., Pullman, WA). The instruments were all connected to data loggers (Zentra ZL6, CR1000, and CR1000X) and powered by 12 volts power sources. Data was logged at one-minute interval. Figure 8 shows the meteorological instrumentation: a) lab assembly and configuration; and b) field installation during experiment.

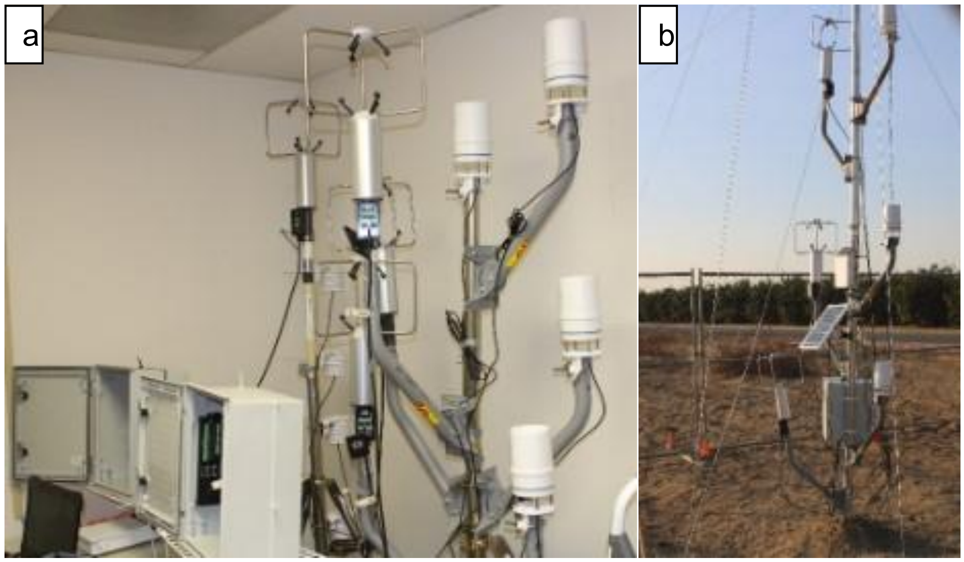

Figure 8. Meteorological instrumentation: a) assembled and configured in the lab; and b) installed in the field during experiment. *Photo credits: Peter Larbi.*

The experiment was performed from November 9 to 20, 2020, consisting of 20 trials (replications) with field assistance support from UCCE farm advisors and staff and Coalition for Urban Rural Environmental Stewardship (CURES) staff. Aerial photography support for documentation, reporting, and dissemination purpose was provided by the UC Davis Digital Ag Laboratory. For each trial, a complete set of samplers were installed prior to spraying and then collected after spraying. The data from the ATMOS 41 instrument at 6 ft at Met 2 was monitored in real time to determine when to start spraying. The sprayer traveled in four passes in the third drive lane from the downwind edge of the vineyard applying spray, after which the samples were collected into the prelabeled zipper bags, stored in a cooler. Out of the 20 trials, 17 trials (2-11 and 13-19) involved applying a solution of pyranine fluorescent tracer dye (at a target concentration of 2000 ppm) whereas three trials (1, 12, and 20) were blank applications (no dye in water). Tank samples were obtained at different stages of the data collection to be used for quality control/quality assurance assessment and reporting as well as for normalizing the drift data. At the end of the day, the samples were transported to the lab and stored in a refrigerator while awaiting sample analysis. The weather data were retrieved at the end of the trials.

Sample analysis at the UCANR's Agricultural Application Engineering (AgAppE) Laboratory begun early December 2020 but was impacted by the then ongoing Covid-19 pandemic and the lab shut down in mid-December of 2020. The lab resumed on January 4, 2021. Fluorometric sample analysis was accomplished by transect and by replication, implying that all samples for Transect 1 were analyzed by replication before Transect 2, 3, and 4. Each sample bag was filled with 40 g of DI water, shaken vigorously, and the liquid content emptied into a 50 ml glass beaker. The beaker was then placed in a fluorometric system to measure and record the fluorescence. Dilutions of the liquid samples were done as necessary. The fluorescence data was converted to dye concentration using a calibration curve for the dye, and then to dye deposition. The meteorological data were retrieved and processed. Time series plots of each weather parameter for each spray trial were created and included in a meteorological report. Summary statistics were computed and averaged.

The tank samples were analyzed to determine the actual concentration and also assess the stability of the solution over the course of the data collection. The actual spray application rate for each trial was determined and the data were combined with the tank concentration data to normalize the spray drift data. The weather data would be regressed on the spray drift data to determine if there was any significant effect of weather parameters on spray drift. Sample analysis was completed and most of the data analyses is complete. The complete data generated will be made available, along with associated reports, for incorporation into the orchard/vineyard airblast spray drift model.

6. **Summary of Major Research Accomplishments and Results by Objective**

Our single objective in this project was to conduct airblast spray trials in the field to generate spray drift data that will be used to validate a computer model. This work in table grapes was supported in part by the funds received for grape from the California Table Grape Commission, the Washington State Wine Commission, and E & J Gallo Winery, the total of which a portion caters for grape-specific effort and another portion contributes one-third to funds needed for resources shared with almond and citrus. During the project period, we successfully secured the remaining two-thirds of the required funding for shared resources from the Almond Board of California and the Citrus Research Board. This enabled us to conduct the field experiment and associated laboratory analyses as described above. A representation of the results from the completed sample and data analysis are shown subsequently.

Average canopy foliage density (leaf area density) prior to the experiment was measured to be 3.19 m^3/m^2 for within row and 2.83 m^3/m^2 for between rows. This indicates that there was more foliage in the canopy directly above the trunk line than that over the drive lane. These values are expected to have changed quite significantly especially for the second half period of the experiment as the vines lost leaves with the season change. However, we did not measure the canopy foliage density again during or after the experiment.

Variation in the actual application rate was observed among the trials based on the actual volume sprayed (Fig. 9). This variation is most likely due to variation in the actual travel speed and/or actual operating pressure used for each trial. However, the dye concentration was quite stable in tank solutions used for multiple trials. A summary of the normalized mean spray drift data collected with different samplers from all sampling transects is shown in figure 10. The plots for artificial foliage and horizontal string samplers show logarithmic decay of spray drift deposits with downwind distance from the application line. The complete data will be further processed, and statistical analysis done accordingly to determine the effect of weather parameters on drift deposit obtained at different downwind distances.

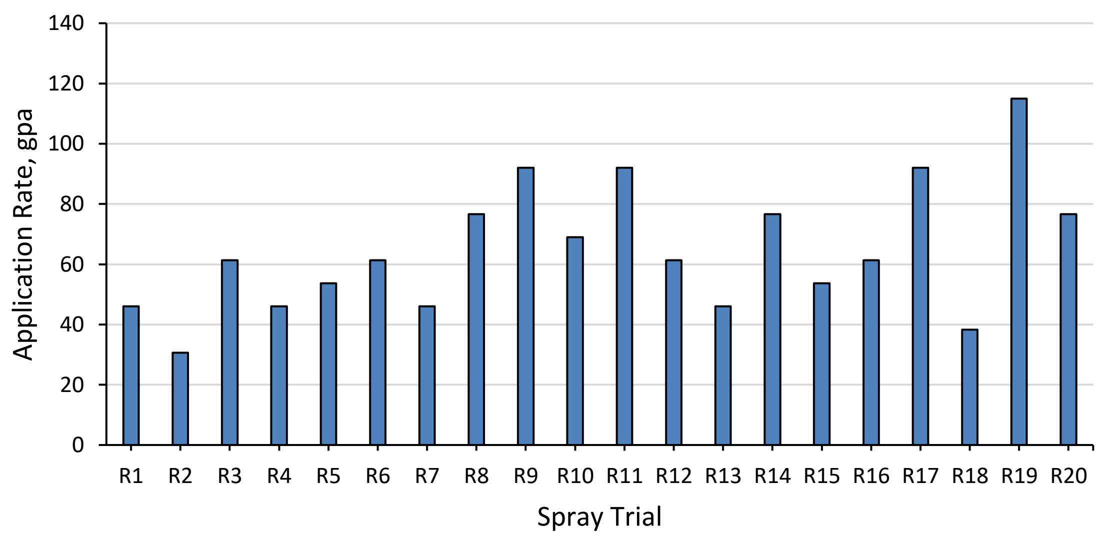

Figure 9. Actual spray application rate observed in experiment.

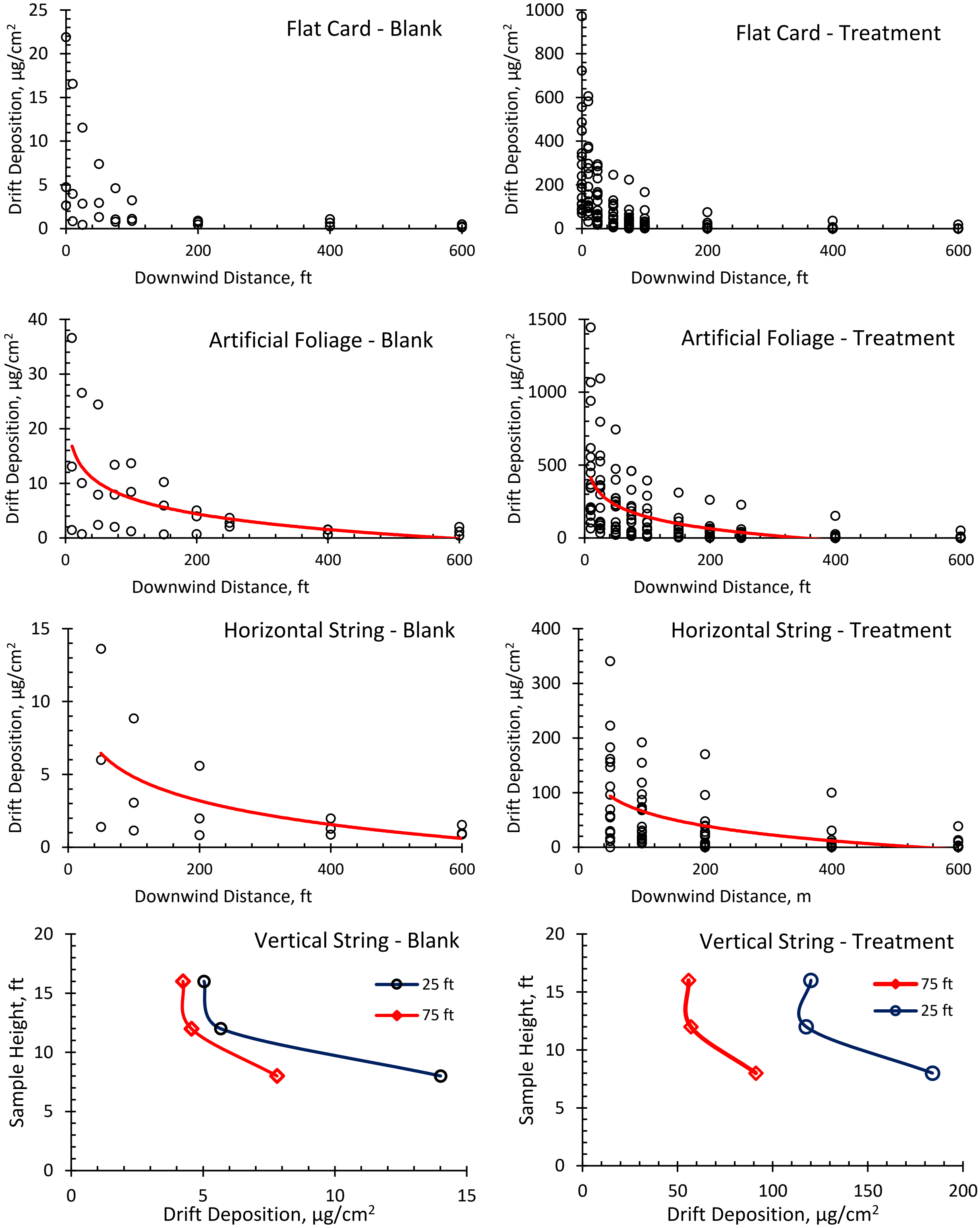

Figure 10. Normalized mean spray drift data (left – blank; right – treatment) for all sampling transects collected with different samplers.

A sample of the meteorological data collected at 8 ft high for Met 1 (inside canopy) and at 6 ft high for Met 2 (outside canopy) are shown in figure 11. They show the variation of solar radiation, wind speed, and air temperature. The complete meteorological data will be analyzed to determine the effects of different parameters on spray drift.

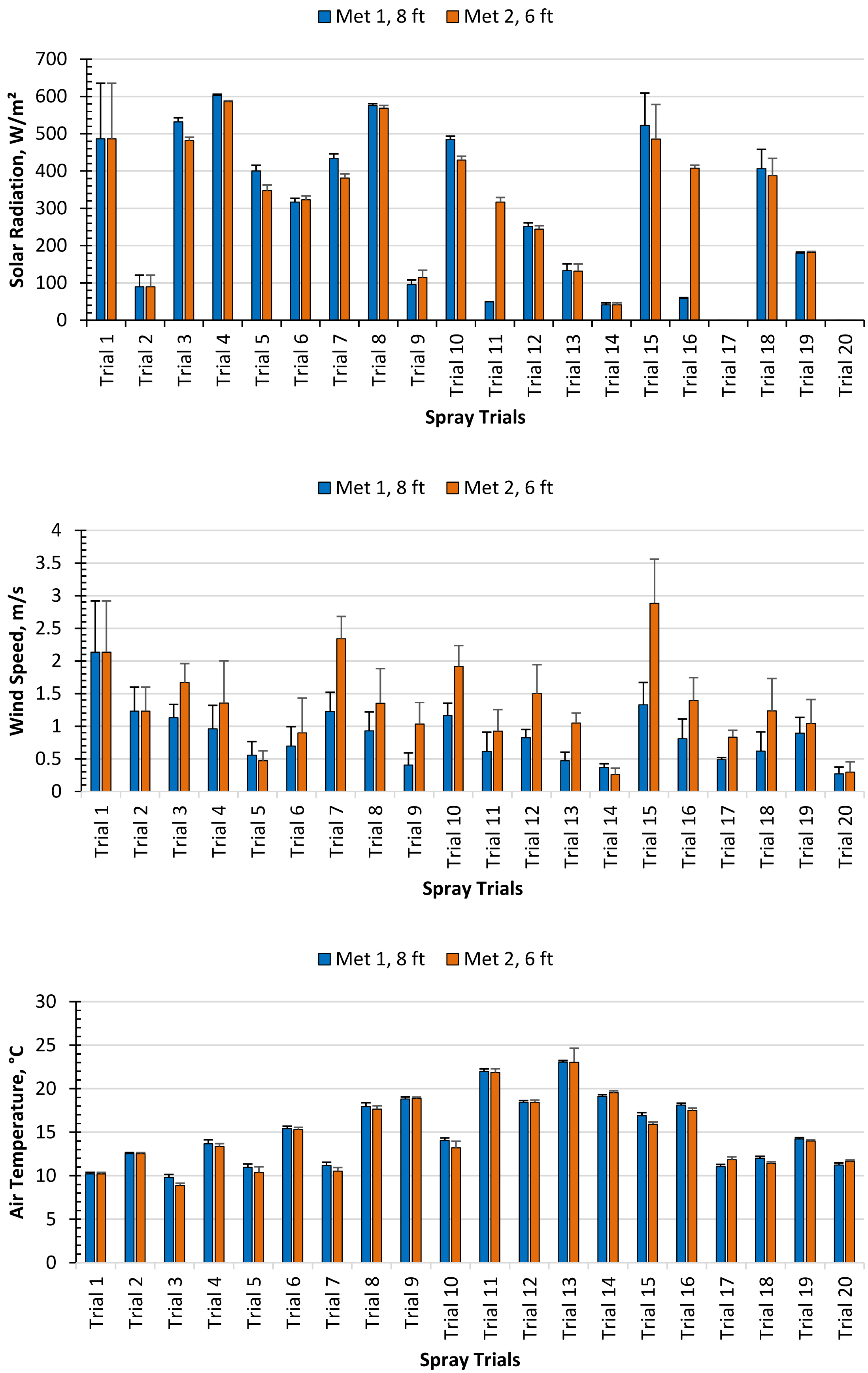

Figure 11. A sample of meteorological data measured at 6 ft at Met 2 during spray experiment: solar radiation (top), wind speed (middle), and air temperature (bottom).

7. **Outside Presentations of Research**: No presentation of the research itself has been presented at this point. However, as a related activity, we conducted an airblast sprayer calibration demonstration in grape on February 15, 2021 at the Kearney Agricultural Research and Extension Center in Parlier, CA which was recorded in the form of videos and photographs for use in virtual sprayer calibration demos/trainings in lieu of in-person hands-on calibration training. A 1-hour virtual training utilizing the recordings was provided by PI Larbi to the San Joaquin Valley Winegrowers Association on February 16, 2021.

8. **Research Success Statements**: The successful completion of this research to generate spray drift data in California grape airblast sprayer applications will directly contribute to an ongoing model validation. The generated data will be used in refining the model parameters specific to grapes. The data can be modeled to represent different types and varieties of grape. As the completed model will be made available in the near future for regulatory processes, the research will indirectly provide the U.S. Environmental Protection Agency (EPA) and the California Department of Pesticide Regulation (DPR) with new grape vineyard data for purposes of estimating off-site movement for pesticide risk assessments and re-evaluations. The new model is envisaged to replace the 20-year-old AgDrift® model for evaluating pesticide exposure from airblast sprayer applications. The AgDrift model uses data generated from young dormant apple trees, a much different structure from foliated grape canopies, and potentially overestimates drift that can occur in vineyards. This leads to regulations of the viticulture industry that are possibly stricter than needed. Hence, the grape-specific data which has been generated in this project will be directly used in pesticide risk assessment decision-making and will directly impact the severity of regulations affecting the viticulture industry. Potentially, it will result in easing of regulations related to pesticide drift.

9. **Funds Status**: The funds from the three sources were directed towards the different budget items. Funds from Table Grape Commission were mainly used toward sampling and lab materials and supplies, personnel, and one-third of the shared resources. Funds from Washington State Wine went toward personnel and partly toward shared materials. Funds from E & J Gallo Winery were directed toward personnel, travel, and other costs such as sprayer operator and temporary fence rental which was needed to provide security for the Met 2 meteorological station.