Measurement of Harvest Dust Generation Using Opacity and Gravimetric Sampling

Project No.: **09-AIR1-Giles**

Project Leader: Ken Giles
Biological & Agricultural Engineering Department
UC Davis
One Shields Ave.
Davis, CA 95616
(530) 752-0687
dkgiles@ucdavis.edu

Project Cooperators and Personnel:
Daniel Downey, Jim Thompson, and Pimporn Ponpesh,
Biological & Agricultural Engineering Dept., UC Davis

Objectives:

1. Compare differences from conventional and reduced pass sweeping operations by measuring within canopy gravimetric dust, machine time in field and estimated fuel use and determine sweeper efficiency through nut counts prior to and after sweeping.

2. Measure the relative differences of harvester separation fan speeds during windrow conditioning using opacity, gravimetric sampling and sieve analyses of windrows prior to and after conditioning operations.

Interpretive Summary:

Orchard operations during almond harvesting produce dust, components of which have been a regulatory concern for a number of years. Previous studies have shown that operating conditions (ground speed, sweeper head height, separation fan outlet direction) of harvesters and sweepers can minimize this visible component during field operations. In an on-going attempt to characterize the differences in orchards and equipment settings, collaborative work was carried out this year with researchers from Texas A&M University (TAMU). Concurrent sampling for emission determinations by TAMU coincided with standard sampling procedures developed over the years by UC Davis. Experiments were conducted in a commercial almond orchard near Arbuckle, CA

The present study consisted of two main components: establishing if differences exist between a conventional sweeper versus a reduced pass sweeper (supplied by Flory Industries, Salinas, CA) and effects on reduced harvester separation fan speed during windrow conditioning. Preliminary results, shown in **Table 1**, indicate that the reduced pass sweeping operation resulted in approximately 33% less total suspended

particulates (TSP) and particulate matter less than 10 μm in diameter (PM_{10}) within the orchard canopy. However, it should be noted that the different sweeping operations were carried out in two separate orchards. Conventional sweeping was done within a more mature orchard (North orchard) with above ground irrigation while reduced pass sweeping was done within a less mature orchard (South orchard) with subsurface irrigation.

Although conventional and reduced pass sweeping tests were carried out in separate orchards, harvester separation fan speed tests during windrow conditioning were randomized through both orchards. Preliminary results, shown in **Table 2**, from these studies indicated that a slower separation fan speed resulted in 27% less TSP and 30% more PM_{10} within the canopy during conditioning within the North orchard. Slower fan speeds within the South orchard found that within canopy TSP was 33% less than the higher separation fan speed while PM_{10} measurements were similar. In all cases, the South orchard in-canopy measurements of TSP, PM_{10} and opacity signatures were less than the North orchard. Opacity measurements signatures and time spans of dust plumes were of similar magnitude within each orchard when comparing the separation fan speeds, however when comparing the North (more established) orchard to the South orchard, opacity measurements were close to 50% higher and time spans of fan exhaust plume 30% longer.

Preliminary estimates from nut counts for determining the efficiency from the different sweeping operations are given in **Table 3**. Several samples were taken within each orchard prior to the separate sweeping operations; locations for samples are conceptually shown in **Figure 1**. After sweeping operations were completed, sample locations were evaluated for the number of nuts left within the sampled area. The total number of nuts collected from the sample trees were determined by taking three sub-samples, counting the number of nuts (hulls and husks were not separated) in each sub-sample, and determining the mass of the sub-samples. The number of nuts per sample prior to sweeping was determined by dividing the total mass per sample by the average sub-sample mass (with known nut count). Results were averaged for all samples.

From **Table 3**, the data indicate that the average tree within the South orchard produced approximately 60% less product than the North orchard. Additionally, from these data similar numbers of nuts were left within each orchard (end row effects of nuts left after sweeping were not determined). Based on these preliminary estimates, over 99.7% of the product was recovered from both conventional and reduced pass sweeping operations.

Ongoing analyses are under way to determine the fuel efficiency of the different sweepers, based on fuel used, engine hours and time in orchard. Additional analyses are under way to determine the particle size characterstics for windrows prior to and after windrow conditioning.

Table 1. Averaged results (standard deviations in parentheses) from sweeping comparisons for all replicate measurements for all test blocks.

North field: Conventional sweeping Test block Numbers 1 - 8		South field: reduced pass sweeping Test block Numbers 9 - 16	
TSP mg	PM10 mg	TSP mg	PM10 mg
0.56 (0.20)	0.15 (0.03)	0.38 (0.17)	0.10 (0.04)

Table 2. Averaged results from separation fan speed during windrow conditioning (standard deviations in parentheses).

---------- 910 rpm separation fan speed ----------							
----North field: Test blocks 1, 3, 6, 8				South field: Test blocks 10, 12, 13, 16			
TSP mg	PM10 mg	Opacity %	Time span, s	TSP mg	PM10 mg	Opacity %	Time span, s
0.34 (0.28)	0.10 (0.08)	4.0 (1.5)	28 (12)	0.26 (0.12)	0.04 (0.02)	1.8 (0.6)	19 (6)
---------- 1080 rpm separation fan speed ----------							
North field: Test blocks 2, 4, 5, 7				South field: Test blocks 9, 11, 14, 15			
TSP mg	PM10 mg	Opacity %	Time span, s	TSP mg	PM10 mg	Opacity %	Time span, s
0.46 (0.23)	0.07 (0.06)	4.4 (1.5)	26 (3)	0.39 (0.31)	0.05 (0.03)	2.2 (0.6)	20 (4)

Table 3. Estimates for average number of nuts (based on sample area – see **Figure 1**) prior to and after sweeping operations in North and South orchards (averages based on eighteen sub-samples; standard deviations in parentheses).

Mass per tree lbs	Nuts per tree prior to sweeping	Nuts left after sweeping	Nut Recovery %
North orchard – conventional sweeper			
51.02 (4.04)	4898 (573)	6 (3)	99.88
South orchard – reduced pass sweeper			
25.87 (5.11)	1914 (504)	5 (5)	99.74

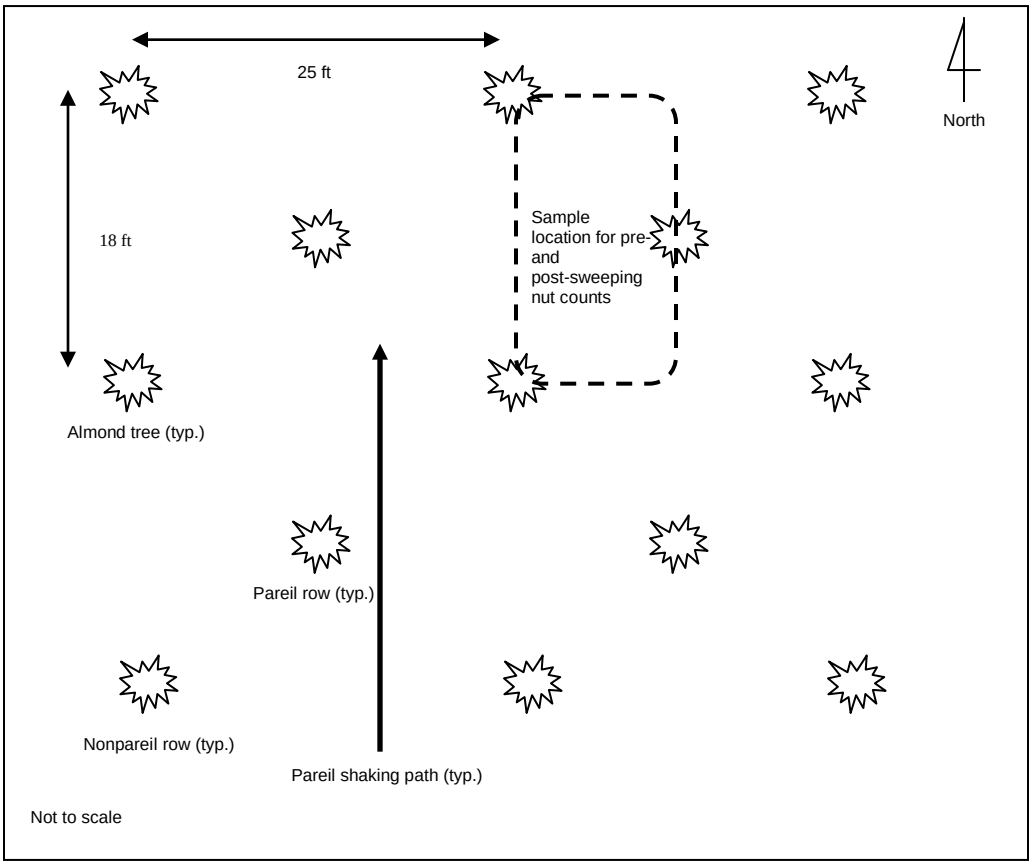

Figure 1. Example of sample locations for nut counts pre- and post-sweeping operations.