Measurement and Reduction of In-Orchard Dust Generation from Harvesting

Project No.: **07-ENVIR4-Giles**

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Interpretive Summary:

Previous work has established that an opacity monitoring system can be used to compare relative, visible dust intensity during in-field nut handling operations. This opacity measurement system provides an efficient tool to assess field operating conditions and management or cultural practices that can minimize dust intensity. Results from tested conditions can be analyzed immediately, that is, during the actual test run.

Methods for assessing dust during agricultural operations can also be based on filter deposition measurements of airborne particulate matter. Field measurements since the 2006 season have used a gravimetric sampler (MiniVol™ Portable Air Sampler, Airmetrics, Eugene, OR) during field test runs. The device is used by researchers including the California Air Resources Board for PM10 and PM2.5 measurements at high particulate concentrations. When used to measure particulates from agricultural field work, the device can provide relative measurements.

The opacity and gravimetric methods used in this research are useful as a field-oriented guide to assess grower practices, machinery operations and machinery development and provide recommendations for reducing dust intensity that can be adopted by growers in the relatively short term (1 – 3 years).

Overall, the field data collected during the 2007 season have confirmed the value of both reducing ground speed of harvesters and using the natural filtering benefits of orchard rows to reduce the amount and appearance of discharged dust near orchard boundaries, especially those near dust sensitive areas. Results from cooperative testing found that harvest ground speeds at 2 mph operation produced 42% and 40% less PM10 and TSP mass, respectively, than speeds at 4 mph. Additionally, by reducing ground speed of the equipment and driving harvesters in the direction so that the air discharge is directed inward to the orchard for the outermost 3 to 4 rows, the visible dust concentrations can be reduced by approximately 50 to 75% at 2 mph and 4 mph harvester ground speeds, respectively, with only minor loss of harvest efficiency.

Objectives:

The objectives addressed during this reporting period were:

1. Using gravimetric samplers, measure PM_{10} and TSP dust concentrations within orchards and within the discharge air from harvesters.

2. Investigate dust generation from harvesters using gravimetric and optical (opacity) methods and determine the degree of filtering provided by trees and foliage.

3. Provide cooperative measurements with other researchers during harvesting operations.

Materials and Methods:

The first set of testing conditions this year included a cooperative effort with ABC-funded researchers from Texas A&M University (TAMU) in Wasco, CA. A standard, commercial harvester (Flory 850) was operated at 2 and 4 mph during these tests. TAMU's emission factor measurement equipment was set-up at the end of the orchardtest block. Simultaneously with the TAMU emission factor measurements, UC Davis placed four minivol portable air samplers *within the center of the TAMU test block*. Two of the minivol samplers were configured to sample PM10 mass (particles with diameter < 10 μm) and two samplers were configured to sample TSP (total dust) mass. The measurements of PM10 and TSP particulate mass within the center of the test block was done to establish the relative effects of tree scrubbing on initial dust generated during harvest and the resultant decrease in emissions at the edge of the orchard.

A second series of harvest tests to measure relative dust intensity (opacity) and TSP mass were done independently of the TAMU tests but within the same area of Wasco, CA. The focus of these tests was to establish the benefit of orchard trees in attenuating opacity (visible dust concentration) produced by the harvester at different ground speeds. These tests also used the standard, commercial harvester (Flory 850) operated at 2 and 4 mph. The trailer-mounted opacity instrument was positioned 1, 2, 3 and 4 rows over from the harvester discharge during pick-up operations as the harvester moved down the row (Figure 1). Figure 2 shows the opacity instrument in the

orchard rows during the approach of the harvester and during the time of interaction between the plume and the instrument. In addition to the opacity instrument, the gravimetric samplers were positioned at the bases of trees at 2, 3 and 4 rows over from the harvester as shown in Figure 1.

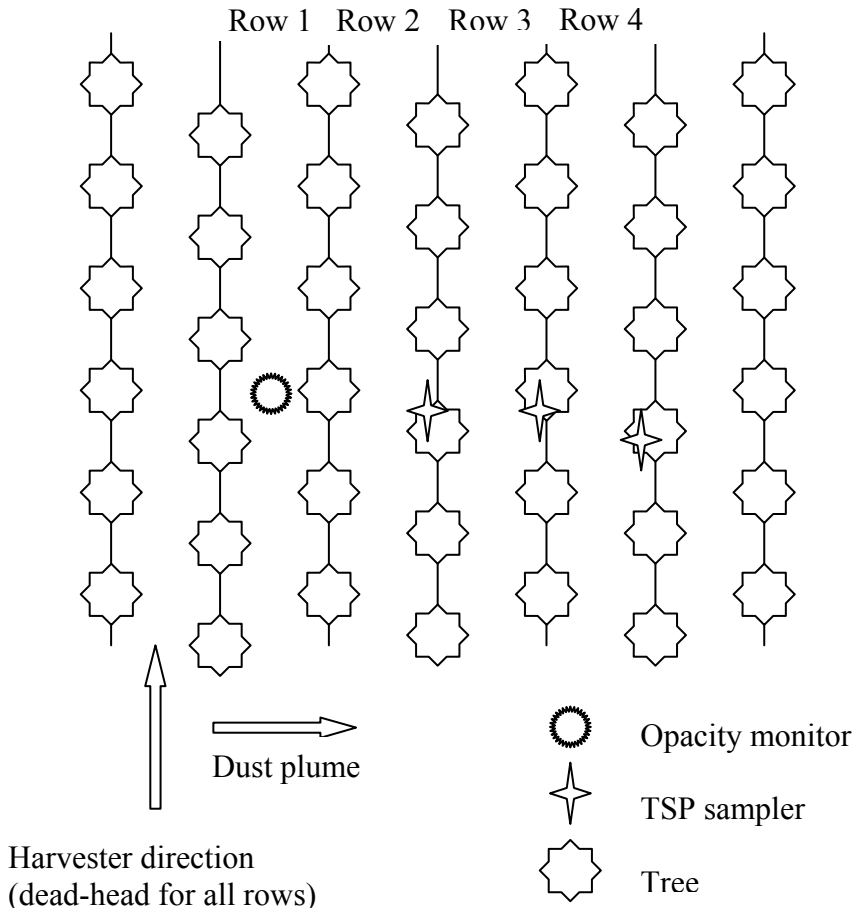

Figure 1. Field equipment set-up for harvester ground speed tests. Set-up shown is for first replicate test; during subsequent test runs, the opacity monitor was moved, sequentially, to adjacent rows further from the harvester to sample 2, 3 and 4 rows over.

Figure 2. Approach of harvester to the opacity sampler (left image) and harvester discharge plume sampled by instrument (right image). In both cases harvester is in row to right of sampler.

Results and Discussion:

Results from the cooperative testing with TAMU are shown in Table 1 and support previous field opacity test results: dust levels within the orchard are related to ground speed of the harvester. That is, slower speeds produce less dust. In the present study the 2 mph operation produced 42% and 40% less PM10 and TSP mass, respectively, than the 4 mph operation. These results can be correlated with results from TAMU tests.

Table 1. Average filter deposition mass data from Wasco harvest tests coinciding with TAMU measurements. PM10 and TSP samplers were set within the center of the TAMU testing block. Harvested land area was equal for each test and allows direct comparisons and accounts for the harvest time difference that result from different ground speeds.

Harvester Speed	PM10 mass mg	TSP mass mg
2 mph		
Average	0.322	0.980
Minimum	0.302	0.924
Maximum	0.354	1.035
4 mph		
Average	0.558	1.619
Minimum	0.330	1.338
Maximum	0.709	1.974

Independent testing by UC Davis on harvester ground speed established the benefit of distance and tree foliage in mitigating airborne dust from the harvester outlet in terms of concentration and visual appearance. Results from mass measurements during the harvest operations found that mass decreased by 40% over three rows at the 2 mph ground speed. The 4 mph results found that mass slightly increased (25%) over three rows for this test block. Figure 3 and 4 shows that visible dust concentration from the harvester plume, measured as opacity, was reduced by 50% at the 2mph ground speed and 75% at the 4 mpg ground speed within three tree rows.

Table 2. TSP mass measured at successive rows away from harvester for different ground speeds.

Testing conditions	Row 2	Row 3	Row 4
2 mph harvester speed			
Average TSP mass, mg	1.158	1.213	0.701
Plume time, s	32.0	17.0	21.0
4 mph harvester speed			
Average TSP mass, mg	2.694	3.291	3.349
Plume time, s	65.0	69.0	62.0

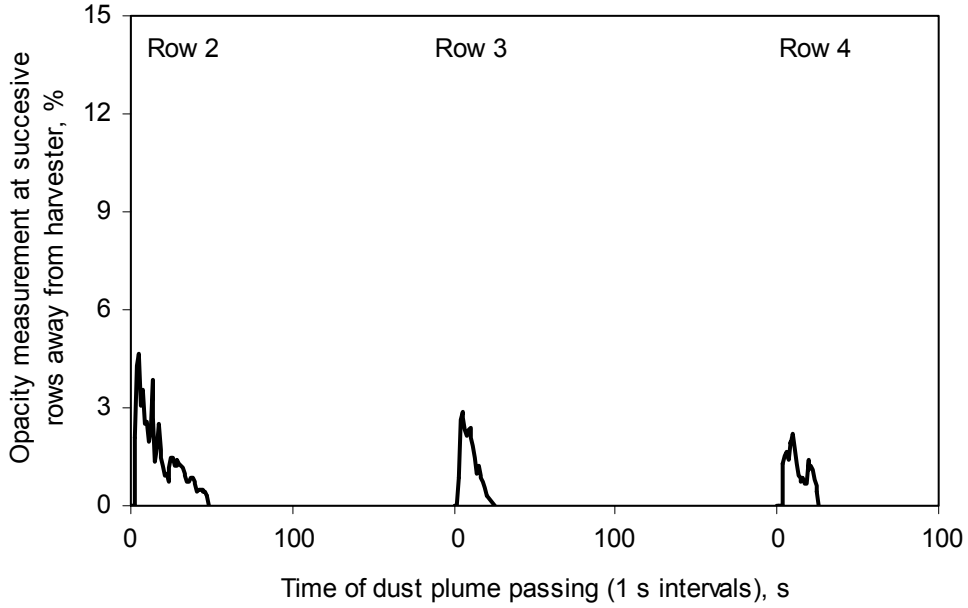

Figure 3. Opacity measurements at successive rows away from the harvester at 2 mph ground speed.

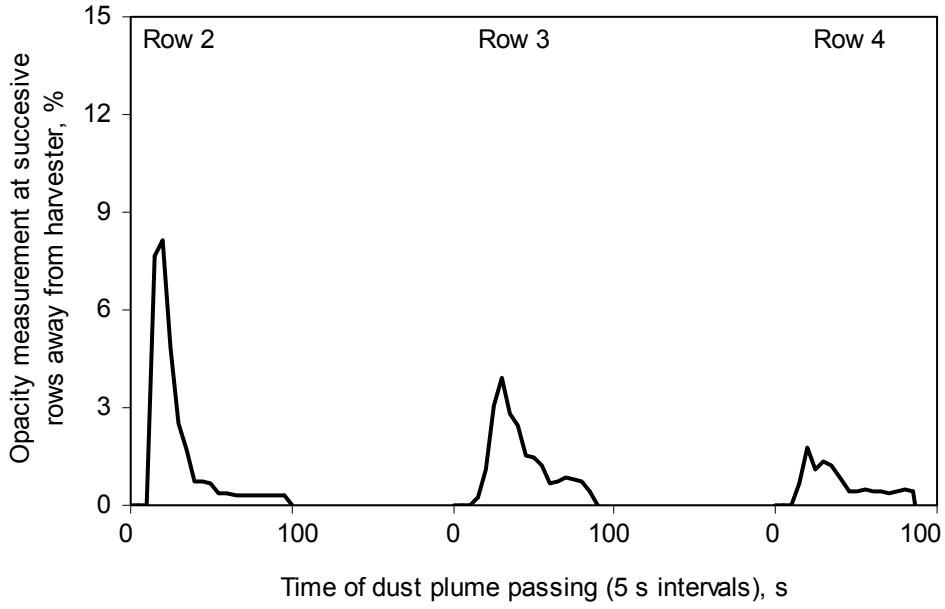

Figure 3. Opacity measurements at successive rows away from the harvester at 4 mph ground speed.

The opacity results confirm the benefits of harvester speed in reducing visible dust and dust levels within the orchard during harvesting operations. Duration and intensity of generated dust in the orchard is reduced with ground speed. It was observed that the gravimetric results differed in trends from the opacity, i.e., lower sample mass nearer

the harvester. It is suspected that this is a result of the high speed air flow from the harvester being incompatible with the low inlet speed of the samplers. This emphasizes the value of isokinetic sampling for high speed air streams and the limitations of low-volume samplers. It is recognized that slower speeds result in more operational time in the orchard, potentially offsetting benefits in total emissions.

Recent Publications:

Downey, D., D.K. Giles and J.F. Thompson. 2008. In situ transmissiometer measurements for real-time monitoring of dust discharge during orchard nut harvesting. J. Environment Quality. 37:574-581

Giles, D.K., M.W. Yore and D. Downey. 2008. Test stand for opacity and dust concentration measurements: system description and validation. Trans. ASABE. 51(3):845-855.