Sources, characteristics, and management of agricultural dust, San Joaquin Valley, California, USA

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Abstract
Crop production systems in California's San Joaquin Valley (SJV) are significant contributors to atmospheric dust, including PM10 (particulate matter with aerodynamic diameter less than 10 micrometers), and contribute to violation of US air quality standards during most years. Ten years of field studies show that conservation tillage practices in cotton-tomato rotations reduce PM10 by 50% or more, compared to conventional systems. Dust mineralogy is similar to soil clay and silt mineralogy. Follow-up lab studies using a laboratory dust generator show that soil water content, soil texture, and soil aggregation all affect dust production. High dust production occurs on soils with low water content, high silt/clay ratios, and low degree of aggregation.

Key Words
Air quality, soil management, soil properties.

Introduction
For much of the past decade, California's San Joaquin Valley (SJV) has been a United States Environmental Protection Agency serious non-attainment area for PM10 and other dust size fractions. At certain times of the year, PM10 is composed mostly of soil-derived material. The correspondence of air quality violations with intense tillage activities and PM10 composition has focused attention on row crop agriculture as a potential major contributor to PM10. This paper reports on studies of conservation tillage systems as a means to reduce PM10 and related dust fractions in the SJV and follow-up studies based on simulations with a laboratory dust generator to investigate dust production as a function of soil properties.

Methods
Conservation tillage field studies
Field plots were established at the University of California West Side Research and Extension Center in Fresno County in 1999. The plots simulated a typical irrigated row crop rotation of cotton and tomato (Mitchell *et al.* 2008). Standard tillage systems included typical field operations. Conservation tillage systems maintained cropping beds and traffic lanes throughout the field experiment. Dust was collected in the field on Teflon filters connected to battery-operated vacuum pumps. Dust concentrations were calculated from pre- and post-filter weights, pump flow rates, and sampling time (Baker *et al.* 2005, Madden *et al.* 2008). Dust was characterized by scanning electron microscopy and X-ray diffraction.

Lab dust generator and lab studies
Field investigations of dust production are complicated by environmental conditions during sampling. We developed a lab dust generator to allow control of experimental conditions and more detailed investigations of the impact of soil properties on dust generation (Domingo *et al.* in press). Lab dust generation experiments were conducted on a wide array of soils mapped in the San Joaquin Valley.

Results
Conservation tillage field studies
Conservation tillage (CT) systems reduced the number of in-the-field operations, and reduced total and respirable dust (Figure 1, after Baker *et al.* 2005). Cover cropped systems produced more dust compared to no-cover-crop treatments and more organic matter in the dust (Figure 2).

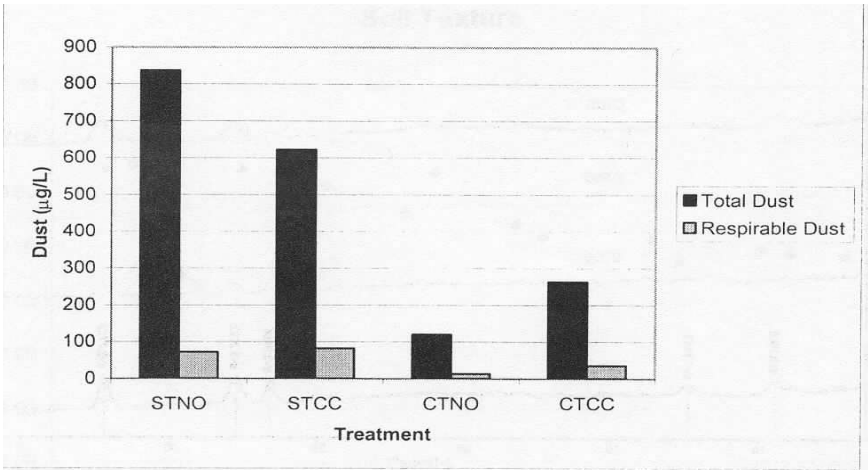

Figure 1. Cumulative total (less than 100 micrometers) and respirable dust (less than 4 micrometers) production from standard and conservation cotton-tomato rotation tillage systems with and without cover crops.

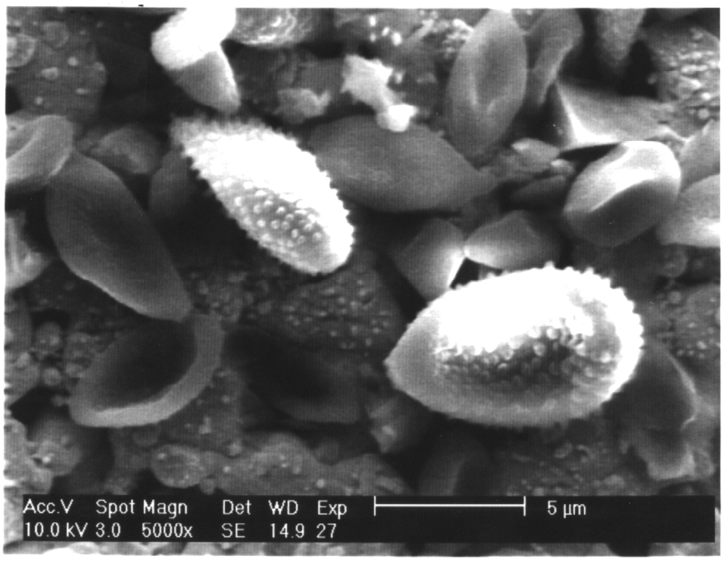

Figure 2. Scanning electron micrograph of mineral and organic particles in respirable dust from planting operations in a conservation tillage with cover crop treatment.

Lab dust generator and lab studies

Lab experiments with the dust generator (Figure 3) show that soil properties, including soil water content and potential, soil aggregation, and soil texture, in particular the silt to clay ratio (Figure 4, after Madden *et al.* 2009), have a significant influence on dust generation, and must be taken into account when devising dust mitigation strategies.

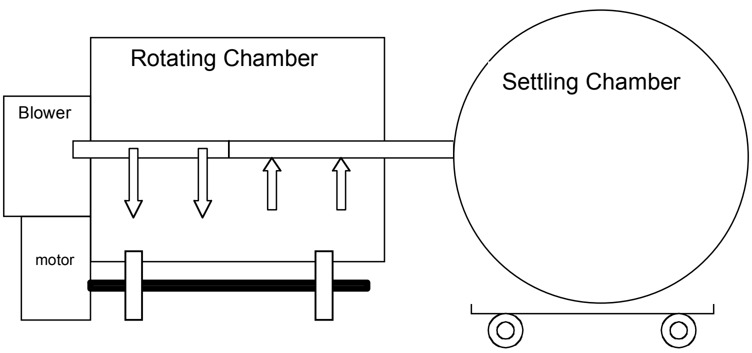

Figure 3. Schematic diagram of the laboratory dust generator.

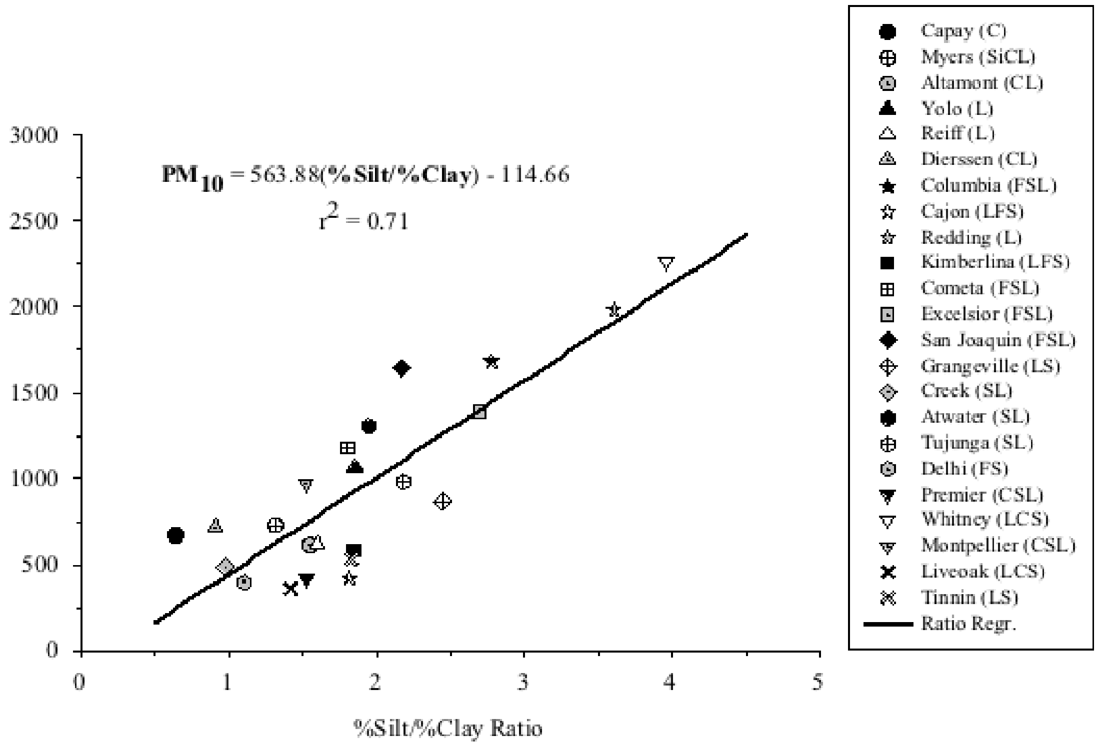

Figure 4. Laboratory generated dust as a function of silt-to-clay ratio.

Conclusions

Conservation tillage reduces dust by about 50 to 90% compared to standard tillage. Cover crops increase dust production. Soil water content, aggregation, and texture affect dust production. As soils dry, they reach a dust production threshold that is dependent on the particle size distribution. Soil dust production increases as soils become less aggregated with repeated tillage operations, especially at low water contents. The silt-to-clay ratio was the best predictor of dust production at water contents below the dust production threshold. Soil properties must be taken into account when devising dust mitigation strategies.

References

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