

## OPTIMIZING ANAEROBIC SOIL DISINFESTATION FOR NON-FUMIGATED STRAWBERRY PRODUCTION IN CALIFORNIA

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Soilborne disease management without use of chemical fumigants is a major challenge in California strawberry production. Anaerobic soil disinfestation (ASD) was developed in the Netherlands and Japan as an ecological alternative to methyl bromide fumigation. ASD involves incorporating an organic carbon source, irrigating to saturate the soil and then covering the soil with a plastic tarp to stimulate anaerobic decomposition of the organic carbon. The by products of anaerobic decomposition have proved toxic to many fungal pathogens and nematodes. The goal of this project is to optimize ASD for strawberry production in coastal California. Specifically, we conducted a series of pot experiments, followed by field experiments in Ventura, Moss Landing and Salinas to test the efficacy of ASD across varying soil types, carbon sources, and seasons.

In a series of pot experiments we demonstrated that a standard tarp material was as effective as virtually impermeable film (VIF) and pit tarp for creating anaerobic conditions and reducing the survival of *Verticillium dahliae* propagules (Fig. 1, p=.0004). We also found that anaerobic conditions developed less well in a sandy clay loam than in a clay loam soil. Similarly lower temperatures (15° C) led to poorer anaerobic conditions versus higher (25) soil temperature. However, at 25 °C the active *V. dahliae* population was consistently reduced when CumEh exceeded -50000mVhr at 25 °C, suggesting that this value of CumEh -50000 mVhr could be used as a threshold for effective ASD treatment. At 15 °C, on the other hand, *V. dahliae* population showed no relationship to CumEh even at >50000 mV (Fig. 2); showing that temperature is a critical component of the disinfestation mechanism, and that a different Cum Eh threshold may exist at lower temperatures. A number of different carbon sources, including wheat bran, rice bran, mustard cake, grape pomace and ethanol all produced strongly anaerobic conditions, and have potential to be used at a field scale.

The field experiments yielded mixed results and highlight the challenges when scaling a method up from pots and small plots to the field level. In Ventura, onion waste and rice bran created only weak anaerobic conditions and ethanol had no effect on Eh. Cumulative reducing conditions were much lower than the -50,000 CumEh mVhr target. No treatment effects were found for *V. dahliae* survival of retrieved inocula, levels of *V. dahliae* in native soil, or yield. The lack of

effectiveness of ASD was probably due to inadequate incorporation of the C-source and/or too little irrigation.

At Moss Landing, rice bran at 10 and 20 tonnes/ha created weak anaerobic conditions, but ethanol again was less effective. All CumEh mV values achieved were well below the -50,000 target. No reduction of *V. dahliae* population in retrieved inocula was observed.

In Salinas, cumulative reducing conditions varied greatly among replicates of the rice bran treatment, with an average of -14,000 CumEh mVhr, but over -55,000 in one replicate where soil was more compacted. However, native *V. dahliae* populations were greatly reduced in post-ASD treated soil across all rice bran plots (2.5 microsclerotia/g soil) versus 13.5 in control soil ( $P=0.002$ ) (Fig. 3). Higher water application may have been a key to the success of ASD at reducing *V. dahliae*.

Clearly, there are problems to overcome with ASD in the field, but the system shows promise once material incorporation and water application issues are addressed. In a new 2009 small plot trial in Ventura, rice bran was well incorporated into the soil and highly reducing conditions achieved in contrast to 2008. All three field experiments are being repeated (with appropriate modifications) with the same growers who are extremely interested in ASD.

Figure 1. Active *Verticillium dahliae* population in retrieved inocula after three weeks of ASD treatment with varying plastic tarp types (pot experiment). Values are back-transformed means  $\pm$  SEMs. No significant difference was observed between factors with the same letter by Tukey's HSD test at the  $P=0.05$ .

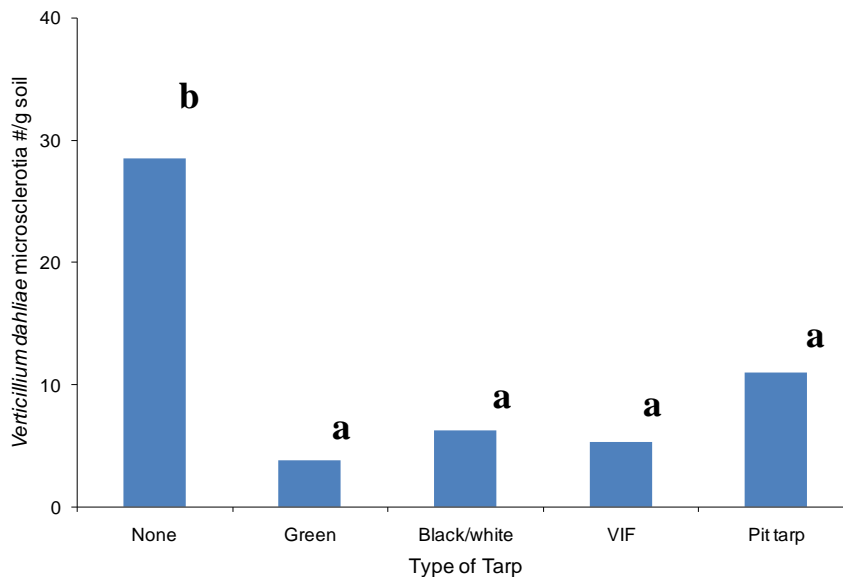


Figure 2. Correlation between *Verticillium dahliae* population in retrieved inocula after three weeks of ASD treatment and cumulative Eh values below 200 mV during the entire incubation period at 25 °C and 15°C (pot experiment).

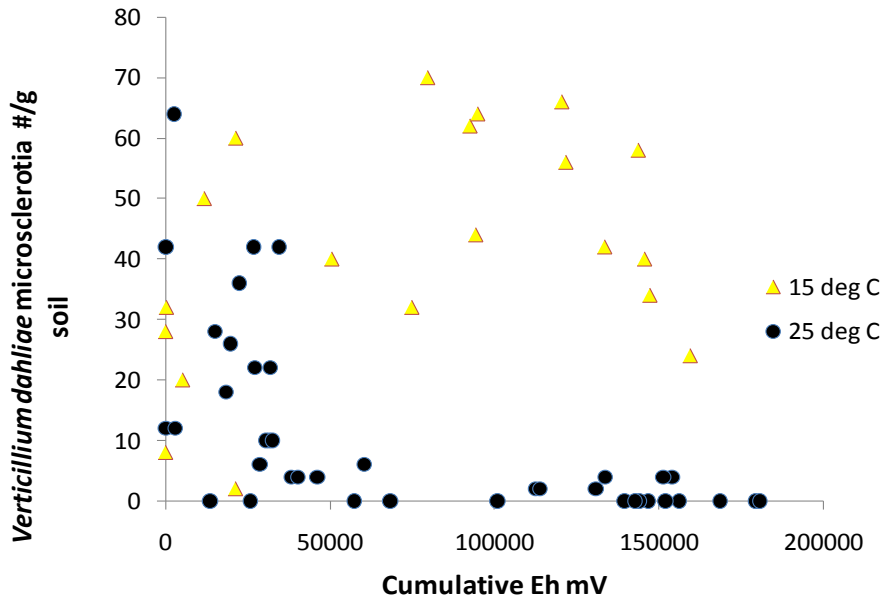


Figure 3. Significant reduction of active *Verticillium dahliae* population in native soils after three weeks of ASD treatment (ANCOVA .  $P=0.002$ . *Verticillium dahliae* population in native soils before ASD treatment was used as a covariate). 10 tons/ha of rice bran was incorporated in ASD treatment prior to bed listing (Salinas, CA).

