

OPTIMIZING ANAEROBIC SOIL DISINFESTATION: AN ALTERNATIVE TO SOIL FUMIGATION?

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Project goals

The goal of this project is to test anaerobic soil disinfestation (ASD) as an economic alternative to MeBr for U.S. growers; using strawberry (coastal California) and pepper/eggplant double crop (southeast Florida) as model production systems. We will manipulate different carbon sources, application methods, irrigation techniques, tarp materials, and timing/length of the tarping period to optimize control of key soilborne pathogens and nematodes. Further we will test a model that predicts the creation of anaerobic conditions and hence pathogen suppression under different soil conditions. The economic feasibility of ASD compared to MeBr treatments will also be assessed for each production system. Most biologically-based pest management systems target one or a few pests only, yet ASD affects a broad range of pest types and species making it functionally similar to current fumigant-based pest management from a grower perspective. The potential commercial application of ASD in the U.S. is extremely high given the relative ease of incorporating ASD into existing production systems.

Background

Soil disinfestation methods using anaerobic decomposition of organic matter were developed in the Netherlands (Blok *et al.*, 2000) and Japan (Shinmura, 2004) as an ecological alternative to MeBr. Anaerobic soil disinfestation (ASD) works by creating a combination of anaerobic soil conditions and readily available carbon pools to stimulate decomposition of organic matter via the anaerobic pathway. These conditions are created by incorporating a carbon source into the soil, irrigating to saturation then covering with an oxygen impermeable tarp. The tarp is then left in place for sufficient time for anaerobic decomposers to create a period of reducing conditions where products of anaerobic decomposition accumulate and are toxic to a range of fungi, nematodes and other microorganisms.

Results and current issues

To optimize ASD for suppressing *Verticillium* wilt in organic strawberries we are conducting a series of field and pot experiments at the Center for Agroecology and Sustainable Food Systems (CASFS) organic research farm at UC Santa Cruz, and in the future will do on-farm trials with grower cooperators. Early results are

very promising. In a replicated flat field application trial, we compared incorporation of different cover crop residues with or without 12 weeks of tarping and found 98% mortality of *V. dahliae* microsclerotia in retrieved inocula in tarped plots regardless of cover crop type ($P=0.0001$) (Fig. 1). The following bioassay with a strawberry crop confirmed significantly lower level of wilting symptoms in tarped plots compared to non-tarped plots (Fig. 2). Successive field and pot experiments found significant reduction of numbers of inoculated *V. dahliae* microsclerotia retrieved even after a tarping period of only 3 weeks. Further, in a recent trial, stronger anaerobic conditions were developed when we adapted ASD to the raised bed system currently used in strawberry production, compared with flat application of ASD (Fig. 3). In this case only the beds are tarped. If consistently effective, a fall-bed ASD treatment would fit into the current winter-planting strawberry production system in California, and fall/winter vegetable production system in Florida, with minimal adjustments.

The major issues to be addressed are:

1. To determine optimal carbon sources and application rates targeted production systems in California and Florida, and water application rates prior to tarping. This will involve comparing both their efficacy for disease suppression and costs of materials and field operations.
2. To determine how effective the technique is against *V. dahliae* in different textured soils – i.e. will it work in well-drained sandy soils often used for strawberry production?
3. Is there a way to predict the length of tarping period required for different environments? We are doing a series of controlled experiments where temperature regime, soil type, moisture level and C sources will be varied. The data will be used to evaluate the utility of a simulation tool that combines a nitrogen dynamics simulation model DNDC (denitrification and decomposition) and a “degree-day Eh” model. The DNDC model predicts the development of reducing conditions in the soil, and the degree-day Eh model will predict the relationship between Eh and *V. dahliae* mortality. Collaborators William Salas and Changsheng Li, the creators of DNDC, will do the modeling component of this work.
4. Can the system work for other crops and pathogenic organisms? In future years we will include analysis of weed seed viability following ASD, and collaborators in Florida, Erin N. Roskopf and Nancy Kokalis-Burelle, will test ASD as a control method for weeds, nematodes and naturally occurring soilborne pathogens in double cropped bell pepper and eggplant production.

References

- Blok, W. J., Lamers, J. G., Termorshuizen, A. J., and Bollen, G. J. 2000. Control of soilborne plant pathogens by incorporating fresh organic amendments followed by tarping. *Phytopath.* 90 (3):253-259.
- Shinmura, A. 2004. Principle and effect of soil sterilization methods by reducing the redox potential of soil. PSJ Soilborne Disease Workshop Report 22:2-12 (in Japanese with English Summary).

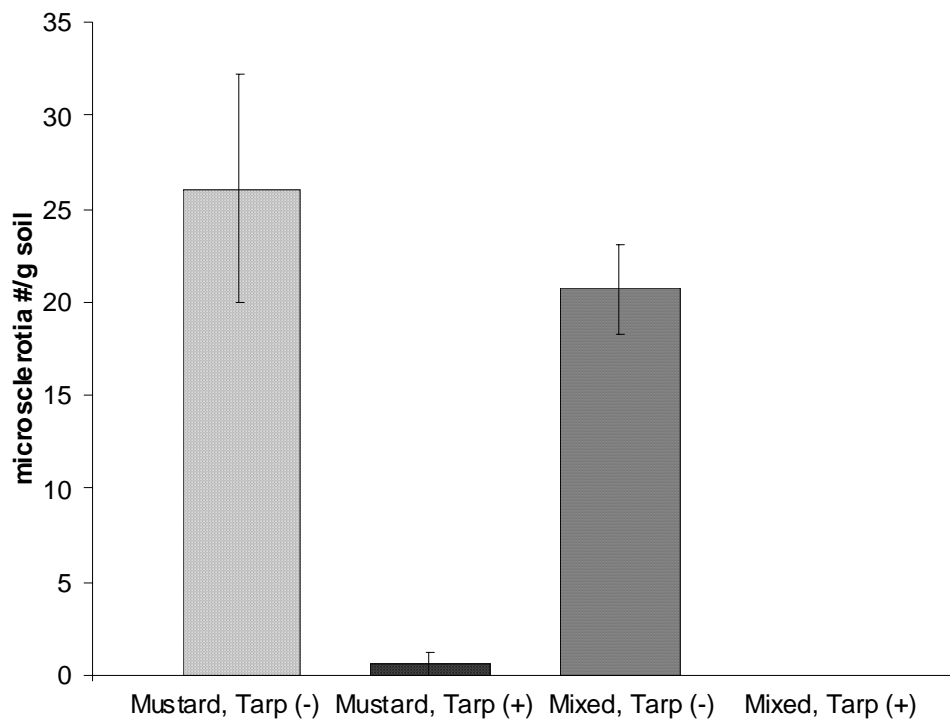


Fig. 1. Number of *Verticillium dahliae* microsclerotia retrieved from soil in ASD field trial at CASFS-UCSC farm. Each bar shows mean \pm SEM.

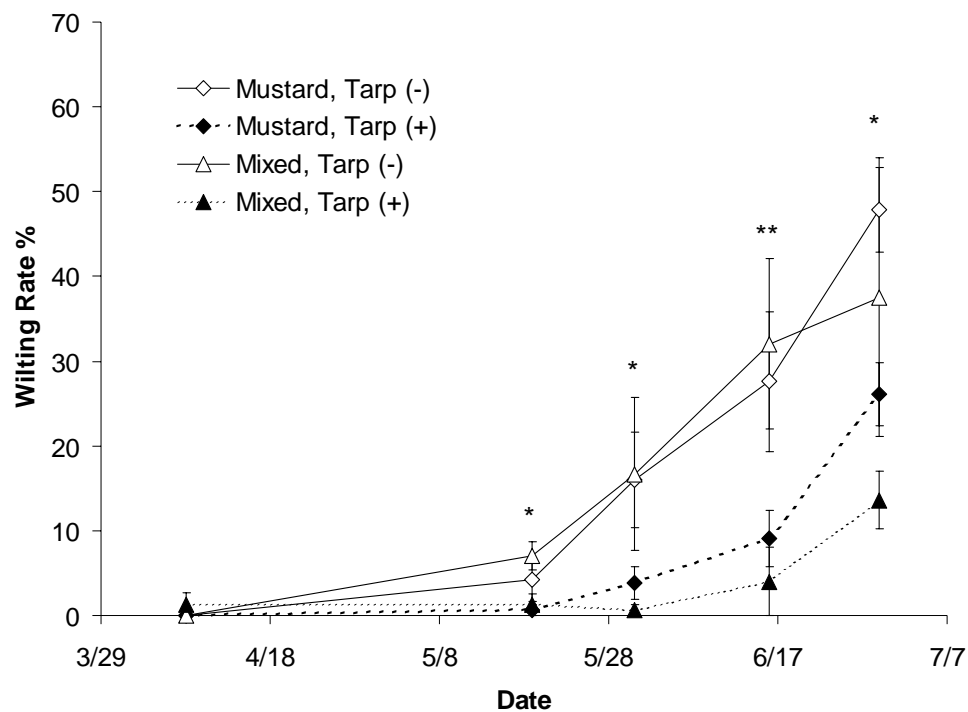
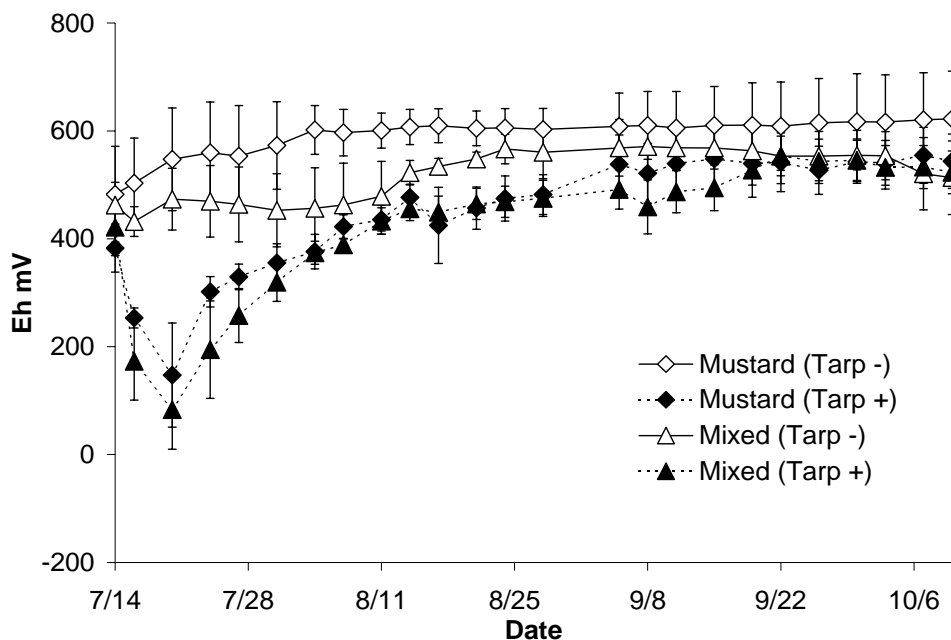
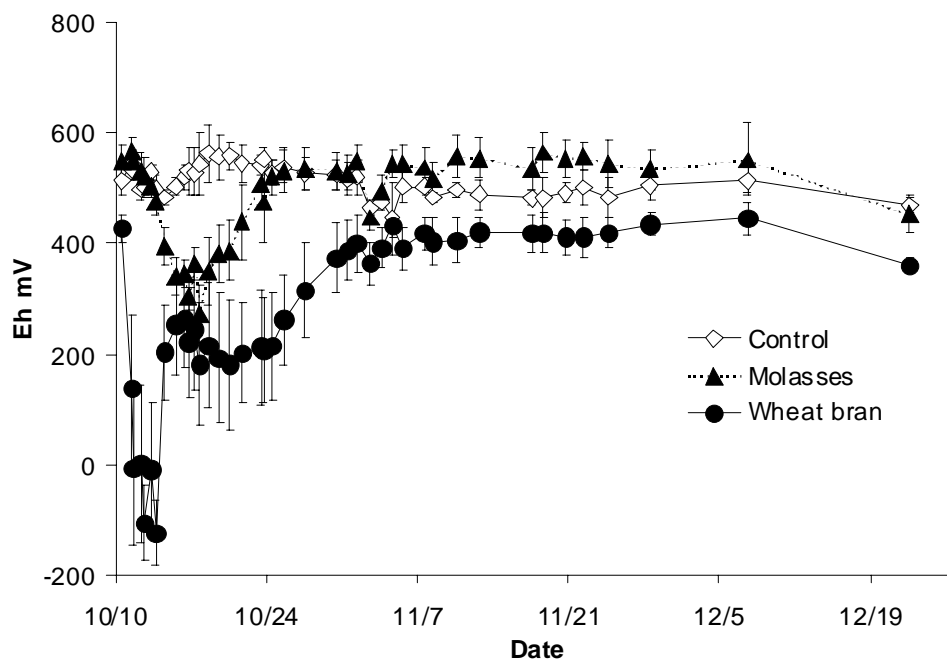


Fig. 2. Strawberry plant wilting rate in ASD field trial at CASFS-UCSC farm. Each plot shows back-transformed mean \pm SEM. Wilting rates on the same date are significantly different by ANOVA at $P=5\%$ (*) or 1% (**).



a) Flat application in the summer of 2004



b) Bed application in the fall of 2006

Fig. 3. Changes in Eh in two ASD field trials at the CASFS-UCSC farm: a) summer 2004, flat tarp application with two cover crops (mustard, buckwheat + Sudan grass mix) with (+) or without (-) tarping; and b) fall 2006 bed application comparing two types of C-sources (molasses, or wheat bran), and control (no C-sources added). All plots were tarped in trial b). Data presented as mean \pm SEM.