

OPTIMIZING ANAEROBIC SOIL DISINFESTATION FOR TENNESSEE

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Treatment by anaerobic soil disinfestation (ASD; also termed biological soil disinfestation or soil reductive sterilization) involves the addition of a labile carbon (C) source to the soil (to stimulate rapid microbial growth and respiration), tarping with plastic to limit gas exchange, and irrigation to saturation of the topsoil (or raised-bed) to flush soil pore space (i.e., not “flooding”). The irrigation provides adequate moisture for microbial growth, allows for transport of decomposition by-products through the soil solution, and limits oxygen diffusion into the soil. Pathogen, nematode, and weed control are achieved in part due to the creation of organic acids (e.g. acetic, butyric) by the anaerobic decomposition of the added C source as well as the lack of available oxygen, biocontrol by anaerobic microorganisms, and the formation of volatile compounds. While considerable progress has been made to adapt this technology to Florida vegetable production systems (Butler et al., 2012a) and California strawberry production (Shennan et al., 2011), there is a need to evaluate and optimize ASD for other production regions in the country where soil types, environmental conditions, and cropping systems can differ markedly.

In Tennessee, as in much of the southeastern U.S. (excluding Florida), tomato, pepper, and cucurbits are the primary vegetable crops utilizing soil fumigation and which maintain critical use exemptions for preplant soil fumigation with methyl bromide. In contrast to Florida vegetable production systems, fumigation for these crops primarily occurs in the mid-spring when soil temperatures are in the range of 15 to 25°C at a 10 to 15-cm soil depth under black polyethylene mulch. As the development of strongly anaerobic soil conditions and creation of anaerobic decomposition by-products in ASD treated soils is largely driven by microbial growth in response to the presence of a labile C source in oxygen-limited soils, soil temperatures lower than the soil microbial growth optimum between 30 to 40°C may hinder effective ASD treatment. To begin the process of evaluating and optimizing ASD for Tennessee and other similar production regions, the goals of this project are to 1) evaluate soil temperature and carbon source impacts on pathogen and weed control during ASD treatment in a series of growth chamber and greenhouse experiments, 2) evaluate carbon sources for ASD treatment impacts on pathogens, weeds, crop performance, and soil properties in a replicated field experiment, and 3) demonstrate optimized ASD methods versus grower standard chemical controls.

Preliminary growth chamber studies indicate that at low soil temperatures (15 to 25°C), higher rates of C amendment are needed to reduce inoculum of *Fusarium oxysporum* as compared to ASD treatments conducted at higher soil temperatures (Fig. 1). Amendment rates as high as 4 mg C g⁻¹ soil may be necessary to provide adequate control of *Fusarium oxysporum* at these lower soil temperatures, although it is unclear whether this holds true for other pathogens of concern. At these low soil temperatures, initial pot study results also suggest that cool-season cover crop and molasses carbon sources for ASD treatment are not effective for control of introduced inoculum of *Rhizoctonia solani* or sclerotia of *Sclerotinia sclerotiorum* at low (~1 mg C g⁻¹ soil) amendment rates. Mortality of introduced sclerotia of *Sclerotium rolfii* averaged more than 75% for all ASD carbon sources, but was similarly high in an irrigated control without added carbon source. Past research of warm-season cover crop amendments at higher soil temperatures (20 to 30°C) indicated that cover crops could be effective ASD amendments for control of inoculum of *F. oxysporum*, *S. rolfii* and *Meloidogyne incognita* at similarly low amendment rates, although control was likely influenced by cover crop biochemical constituents (Butler et al., 2012b).

Initial field studies in Tennessee have been promising, with high accumulations of anaerobic soil conditions (as measured by hourly redox potential below 200 mV) observed from molasses and cover crop carbon sources at rates ranging from 1.0 to 4.2 mg C g⁻¹ soil, especially during the second year of ASD treatments (McCarty, 2012). The increase in anaerobic conditions on sites treated by ASD in consecutive years is consistent with past field studies. In the second year of the field study, lower *R. solani* populations were observed in several ASD treatments compared to an untreated control although only significantly so when a mustard/arugula cover crop was used as an ASD carbon source. However, strong correlation of accumulated anaerobic conditions to pathogen and weed control has generally not been observed in our studies, suggesting that current assessment methods do not adequately represent redox processes occurring within the heterogeneous soil matrix or that production and persistence of toxic decomposition byproducts may be only loosely correlated with accumulation of anaerobic conditions as indicated by redox potential. In 2011, total tomato and bell pepper yields following ASD treatment generally did not differ significantly among treatments, perhaps due to low soilborne pathogen pressure at the research site. On-farm demonstrations in Tennessee are in progress; however, more work is needed to optimize methods prior to expanded larger-scale demonstration activities.

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Figure 1. Response of inoculum of *Fusarium oxysporum* to ASD treatment with increasing rates of carbon at three soil temperature regimes.

