Project Title:
Optimizing Anaerobic Soil Disinfestation to Increase Ohio Strawberry Productivity

Project Leader(s):
Dr. Melanie Lewis Ivey and Rachel Medina
Address: 1680 Madison Ave,Wooster, OH 44691
Phone: 330 263-3849 Fax: 330 263-3841
Email: ivey.14@osu.edu and medina.72@osu.edu

Producer(s) and Location of Farm(s): Catalpa Grove Farm
Name: Craig Mercer
Address: 41473 St RT 14, Columbiana, OH 44408
Phone: 330-831-1187

Project Description:
Black root rot of strawberry is a common disease found in nearly all strawberry producing regions in the United States, including Ohio. The disease is a complex of multiple fungal pathogens including *Fusarium* spp., *Rhizoctonia* spp. and *Phythium* spp. (Particka and Hancock 2005; Manici et al. 2005). Black root rot can occur on strawberry production using matted rows and black plastic (Miles et al. 2018). In 2017, a preliminary survey of strawberry production fields in Ohio revealed that 33% of the fields had diseased plants with at least one of these pathogens associated with them (Lewis Ivey and Medina, unpublished). Black root rot symptoms are generally first observed during the dry heat of summer. Above ground symptoms include stunting, slight wilting, scorching of leaves and decreased fruit production. However, it is the below ground symptoms that give the disease its name. The roots of infected plants are covered with brown to black lesions and the root system is generally smaller than those on a healthy plant. Roots eventually turn black and rot from the outside in. Plants that are stressed due to poor soil drainage, repeated freezes, drought, or flooding are more susceptible to black root rot.

Soil fumigation is the primary method used to control black root rot and other soilborne diseases of strawberry, weeds, soilborne insects, and nematodes (Goud et al. 2004). However, soil fumigants have been associated with stratospheric ozone layer depletion, serious health effects, ground water contamination and a reduction in soil biodiversity (Rosskopf et al. 2015). The search for alternatives to fumigants has been ongoing since the phase-out of methyl bromide in 1992. Chemical and non-chemical alternatives for strawberry production have been evaluated including breeding for disease resistance, compost, containerized transplants, biological control and anaerobic soil disinfestation (ASD) (Noling and Becker, 1994; Rieger et al. 2001; Lopez-Medina 2003). Among these ASD, is the most promising.

Anaerobic soil disinfestation is the process of encouraging the natural microbial communities within the soil to decrease the pathogens present within infested soils. Anaerobic soil disinfestation has been adapted in California and

Tennessee as an alternative to chemical soil fumigation (Muramoto et al. 2014, Shennan et al. 2018). Additionally, ASD has been shown to be equally as effective as chemical control in controlling diseases in multiple cropping systems including strawberry, vegetables, and cover crops (Lopez-Medina et al. 2003; Lamers et al. 2010; Butler et al. 2014; Muramoto et al. 2014). The success of this method is highly dependent on the carbon source used, the incubation time of the treatment, the pathogens being targeted, and the geographical climate of the growing region (Muramoto et al. 2014, Shennan et al. 2016). For example, this method has shown great success in the soil disinfestation of nematodes and some weed seeds but has varying success with fungi that create protective structures such as sclerotia (Garrido et al. 2011; Butler et al. 2012; Shrestha et al. 2016). Anaerobic soil disinfestation will not sterilize the soil, thus some soil microorganism diversity is maintained. The mechanism for this process is not yet fully understood but theories include shifts in pH to favor one microorganism over another and/or variation in phenolic chemicals released by plant residues (Rosskopf et al. 2015). Because the soil is not sterilized, repeated applications of ASD are required and additional disease management strategies are recommended such as crop rotations, biocontrol strategies or rescue fungicides. However, Testen and Miller (unpublished) have shown that ASD is effective for up to three years when used to manage soilborne diseases of tomatoes produced in high tunnels with low to moderate infestation levels. Therefore, yearly ASD treatments for the control of strawberry soilborne diseases may not be necessary.

Anaerobic soil disinfestation may be a practical way for strawberry producers to managing black root rot, especially in annual plastic culture production systems. The initial step for ASD is the application of a carbon source over the soil. This can include molasses, wheat bran, rice bran, composted broiler litter, ethanol, pomace, or green manure. Ideally, the carbon source would be inexpensive and locally available. The soils are then fully saturated with water to fill air spaces within the soil and then the soil is tarped with plastic for four to six weeks (Shennan et al. 2014). This process creates an oxygen depleted and highly volatile environment for pathogen microbes residing in the soil. Anaerobic soil disinfestation has been evaluated in major strawberry growing regions such as California but its efficacy and economic feasibility have not been evaluated in Ohio (Shennan et al. 2009; Muramoto et al. 2014). The effectiveness and availability of carbon sources, as well as climate optimization need to be better understood in order for this method to be recommended to Ohio growers. This method has the potential to replace the use of fumigants and the potential for long-term efficiency using renewable resources.

Ohio produces 600 acres of strawberries annually with a farm value of $4 million annually (USDA-NASS, 2015). Following the 2017 survey of strawberry diseases found across 11 counties in Ohio, it became apparent that our strawberry growers need additional options for managing soilborne diseases including black root rot. The long-term goal of this project is to provide a sustainable, cost-effective tool for strawberry growers in Ohio to manage black root rot and other soilborne diseases of strawberry. We aim to optimize ASD technology to Ohio’s climate, cultivars, and grower practices. Our objectives for this research are:

1. To evaluate the efficacy of regionally available carbon sources in reducing black root rot disease of strawberries produced in Ohio.
2. To estimate the cost differential between the various carbon sources.

Methods: The proposed on-farm studies will occur in a commercial production field in Ohio (Catalpa Grove Farm, see letter of support) with the support of the Ohio Produce Grower and Marketing Association (OPGMA). The OPGMA has provided funding to conduct greenhouse bioassays to evaluate the efficacy of ASD against other soilborne diseases of strawberry. In addition, strawberry growers are supportive of this work and have contributed to the design of the proposed study.

Anaerobic soil disinfestation. Annual strawberry plants are planted in early fall. Six to eight weeks prior to planting, selected carbon sources (Table 1) will be incorporated into the soil, the soil will be saturated with water and then immediately covered with black plastic. Soil temperature will be monitored using soil temperature probes. Five probes will be placed randomly in the treatment plots and the average soil temperature over the treatment time will be calculated. After 4-5 weeks the plastic will be removed and strawberry plugs (cv. Chandler) will be planted into the treated soil. Plants will be produced using commercial practices. A non-ASD treatment control and a standard fumigant treatment will be included in the study. Treatment plots (10 ft by 3 ft) will be arranged in a randomized complete block design with six replicates.

Table 1: Treatments for ASD on farm trials

Treatments	Carbon Source	Rate (Per Acre)
1	Wheat Bran (WB)	9 ton
2	Molasses (M)	4.5 ton
3	Mixture (50% WB/M)	9 ton
4	Chloropicrin	3 fl oz
5	Nontreated control	-

Disease assessment. Disease incidence (percent plants diseased) will be assessed beginning two weeks after transplanting. At the end of the experiment (~6-8 weeks post ASD treatment) diseased and non-diseased plants will be collected from all treatments and reps, pooled and a minimum of five plants per treatment will be assessed for root damage (lesion severity on a scale of 0-100% and root mass (g)).

Data analysis. Differences in disease severity and incidence between treatments will be determined using data appropriate statistics (parametric or non- parametric). Data appropriate correlation statistics will be used to determine if there is a correlation between soil temperature and carbon source.

Use of results. The goal of the fruit pathology lab at The Ohio State University is to provide stakeholders with decision support tools for the sustainable and economical management of fruit diseases. Results of this study will be used to make personalized disease management programs for the collaborating farm and other strawberry producers in Ohio. The results of this study will also be published in Ohio Fruit News (OFN), which is distributed both electronically and through printed copies to fruit growers throughout the state. Additionally, the results will be presented at regional fruit grower meetings such as Ohio Produce Network (location to be determined for 2019) and Mid-West Produce Grower Meeting (Mt. Hope, OH).

Project timeline. Because new strawberry plantings are planted in the fall (September to October), the anticipated grant period is July 2018 to March 2019. Recognizing that this does not fit into the granting period of the Paul C. and Edna H. Warner Endowment Fund for Sustainable Agriculture **we request that the *final report* be allowed to submitted no later than April 1, 2019**. A project report summary that includes items described in this request for proposals would still be submitted by December 29, 2018.

The anticipated grant period is 07/01/18 to 3/1/19.

Task	**Month(s)**
ASD Treatment	July to August 2018
Strawberry Planting	September to October 2018
Disease Assessment	October 2018 to February 2019
Data Analysis	March 2019
Research Conclusion	March 2019