Great Lakes Fruit, Vegetable & Farm Market EXPO
Michigan Greenhouse Growers EXPO

December 4-6, 2018

DeVos Place Convention Center, Grand Rapids, MI

1 Ag Tech

Where: Grand Gallery Overlook Room C
MI Recertification Credits: 2 (COMM CORE, PRIV CORE)
CCA Credits: PM (1) CM (1)
Moderator: Ben Phillips, Michigan State University

9:00 AM **Cultivation Equipment of the Past and Future**
- Sam Hitchcock Tilton, K.U.L.T. Kress LLC

9:30 AM **Mastering the Anaerobic Soil Disinfestation Technique**
- Sally Ann Miller, The Ohio State University

10:00 AM **Utilizing Drones**
- Ian MacRae, University Of Minnesota

10:30 AM **The PlantTape Transplant System**
- Cliff Riner, G&R Farms

11:00 AM **Session Ends**

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ANAEROBIC SOIL DISINFESTATION FOR MANAGEMENT OF SOILBORNE DISEASES IN MIDWESTERN VEGETABLE PRODUCTION

HYG-3315
Agriculture and Natural Resources
Date: 12/04/2017

Anna L. Testen and Sally A. Miller

Soilborne diseases are increasingly problematic in intensive vegetable production. Several pathogens may occur together in a disease complex, which is very difficult to manage. Anaerobic soil disinfestation (ASD) is a method of soilborne disease management effective against a wide range of soilborne pathogens, including bacteria, fungi and nematodes. ASD is a three-step process in which soil is amended with a carbon source, irrigated to saturation, and tarped with plastic sheeting for several weeks. In ASD, beneficial soil microbes break down the added carbon source, depleting oxygen in the soil and producing toxic byproducts that kill soilborne pathogens.

Tomato Soilborne Pathogens Sensitive to ASD Treatment

- Fungi: *Fusarium spp., Verticillium dahliae, Rhizoctonia solani, Sclerotium rolfsii, Pyrenochaeta lycopersici, Colletotrichum coccodes*
- Oomycetes: *Phytophthora* and *Pythium* spp.
- Nematodes: Root knot nematodes (*Meloidogyne* spp.) and lesion nematodes (*Pratylenchus penetrans*)
- Bacteria: *Agrobacterium tumefaciens, Ralstonia solanacearum*

ASD is a Three-step Process

1. Soil amendment: Soil is first amended with a carbon source, providing nutrients for beneficial soil microbes. These carbon sources are applied at high rates from 4.5 to 9 tons per acre (9 tons per acres is equivalent to 0.413 pounds per square foot). Commonly used carbon sources, such as wheat bran or molasses, can be purchased at feed mills. Cover crops may be practical for on-farm production of carbon sources. Carbon sources should be rapidly broken down by soil microbes, so amendments such as straw or residues from older crops do not make effective ASD carbon sources.

Carbon sources should be spread evenly over the area to be treated. Carbon sources should be incorporated to a depth of 6 to 8 inches using either a hand-pushed or tractor-drawn rototiller (Figure 1). If molasses is used as a carbon source, it must first be diluted 1:3 to 1:4 with water prior to application (Figure 2). For systems using raised beds, the carbon amendment is applied and worked into the soil prior to bed formation.

Figure 1

Figure 2

2. Soil irrigation: The second step of ASD is soil irrigation during which soil pores are filled with water, reducing available oxygen in the soil. The objective of this step is to saturate soils to the depth of carbon source incorporation (6 to 8 inches). The irrigation step takes at least 4 hours and usually takes longer depending on soil type. Soil should be irrigated until water ponds on the soil surface and soils should not be completely flooded during treatment.

3. Soil tarping: The third and final step of ASD is to tarp the treated area with plastic mulch to prevent air exchange. Plastic mulch, either black or clear, should be laid over the treated area as soon as possible after irrigation is complete (Figure 3). The edges of the mulch must be buried in the soil or covered to prevent air exchange. A heavier grade plastic mulch should be used, and an embossed mulch can help to prevent tearing. Older plastic sheeting, such as construction sheeting or high tunnel coverings, can be reused so long as any holes are sealed with additional plastic and duct tape. Biodegradable mulch is not suitable for use in ASD. Soils can be covered before irrigation if drip tape is placed under plastic sheeting and used for irrigation.

Figure 3

Once tarped, soils should remain covered for three to five weeks. A strong odor indicates that the soil has become anaerobic and is normal to the treatment. Plastic sheeting should then be removed. After plastic removal, planting should be delayed five to seven days to allow time for the soil to dry and breathe. If ASD is applied to raised beds, holes can be cut into the plastic to allow the soil to breathe prior to transplanting.

Soil Temperatures and Tarping Duration

As a general rule of thumb, ASD treatments are more effective with warmer soil temperatures and longer tarping periods. In Ohio, a four-week-long tarping period has been used successfully. A tarping period of three weeks should be effective for most pathogens if soil temperatures are consistently greater than 85 degrees Fahrenheit.

Timing ASD Treatments

Since ASD requires at least one month from treatment initiation to planting, some planning is needed to incorporate the treatment into production schedules. For protected culture production, a spring (March or April) or fall application (September or October) may be ideally incorporated into production schedules. For open field production, it is most ideal to perform a late spring, summer or early fall ASD application.

Combining ASD with Other Soilborne Disease Management Strategies

ASD is effective in reducing soilborne disease populations but may not completely eradicate all soil pathogens. It is good practice to combine ASD with other soilborne disease management practices, such as use of disease resistance, grafting, crop rotation, sanitation and other cultural practices.

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IDENTIFICATION AND MANAGEMENT OF SOILBORNE DISEASES OF TOMATO

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Anna L. Testen and Sally A. Miller

Growers who have grown tomatoes in a single location for several years may notice stunting, yellowing and reduced yields. These symptoms may indicate soilborne diseases. Soilborne disease complexes, composed of two or more soilborne pathogens, may reduce yield and quality of tomato crops, particularly in long-term protected culture production. Soilborne disease complexes consisting of Verticillium wilt, Fusarium wilt, corky root rot, black dot root rot, and root knot nematodes are present in tomato production operations in Ohio. Other soilborne diseases that may be present are Rhizoctonia root rot, Pythium root rot and Sclerotinia white mold.

Symptoms

Verticillium wilt: Distinctive V-shaped lesions form on the edges of leaves, with V-shaped dead tissue surrounded by a yellow halo (Figure 1). Plants wilt and have yellowing and dieback. Plants may wilt during the day and recover overnight. The inside of the stem has brown discoloration (Figure 2).

Figure 1. V-shaped necrosis and yellowing of leaves characteristic of Verticillium wilt.

Figure 2. Vascular discoloration of tomato plants consistent with Fusarium wilt or Verticillium wilt.

Figure 3. Tomato plant with Fusarium wilt. Note the yellow discoloration on one half of the plant.

Fusarium wilt: Plants have yellowing, dieback and wilting. Sometimes only half a leaf or leaves on only one half of the plant turn yellow and die (Figure 3). The inside of the stem has brown discoloration near the soil line and discoloration may continue up the stem (Figure 2). Roots may look brown and rotten. Fusarium wilt can be distinguished from Fusarium crown rot (*F. oxysporum* f. sp. *radicis-lycopersici*), in that discoloration in crown rot remains limited to the lower portion of the stem.

Corky root rot: Plants may appear slightly yellow and have weakened growth. Roots appear to be dry, brown and cracked, and have a similar appearance to tree bark. Cracked areas usually occur in distinctive bands and may be swollen (Figures 4 and 5). Dark brown cracking may occur on the crown and taproot of the plant.

Figure 4. Roots with severe case of corky root rot. Note the cracked, corky, bark-like roots.

Figure 5. Characteristic banding pattern of corky root rot.

Black dot root rot: Roots are discolored, usually a honey-brown to grayish-brown, and are speckled with black dots (Figure 6).

Figure 6. Roots with sclerotia of Colletotrichum coccodes, the causal agent of black dot root rot. The honey-brown discoloration is also characteristic of this disease.

Root knot nematodes: Roots are misshapen with small to large galls (Figure 7). Galls may range in size from pin-head sized to finger-sized. Golden-brown dots (egg masses) may appear on the outside of galls. Plants may appear stunted and weak.

Figure 7. Tomato roots with severe root knot nematode galling.

Rhizoctonia and Pythium root rots: Roots display a generalized rotting, including discoloration and deterioration of the roots and “rat-tail” symptoms.

Causal Organisms

Verticillium wilt is caused by the fungus *Verticillium dahliae*, which has an extremely broad host range. There are two races of *V. dahliae* that infect tomatoes.

Fusarium wilt is caused by the fungus *Fusarium oxysporum* f. sp. *lycopersici* and there are three races that infect tomatoes. The pathogen is an excellent soil survivor.

Corky root rot is caused by the fungus *Pyrenochaeta lycopersici* and survives in soil via microsclerotia that form on roots.

Black dot root rot is caused by the fungus *Colletotrichum coccodes*, which also causes anthracnose on tomato fruits. The pathogen is capable of surviving in soil by microsclerotia that form on infected fruit and roots (the black dots).

Root knot nematodes belong to the genus *Meloidogyne*. Both the northern root knot nematode (*Meloidogyne hapla*) and southern root knot nematode (*Meloidogyne incognita*) have been found in Ohio tomato production. In general, *M. hapla* forms smaller, distinct galls on tomato roots, while *M. incognita* tends to form larger, fused and malformed galls. Both species of nematodes have extremely broad host ranges.

Soilborne Disease Management in Tomato Production

When managing soilborne diseases, practices that prevent existing soilborne pathogen populations from increasing should be combined with others that actively reduce pathogen populations in the soil.

1. Prevention: Always use clean planting materials. Ensure that transplants are healthy before transplanting. Maintain proper fertility and watering to ensure healthy seedling development, and maintain adequate nutrient and water levels throughout crop development.
2. Sanitation: Remove diseased plants and diseased plant parts. Clean soil from boots and equipment between fields and high tunnels. Do not move from soilborne disease-affected fields to non-affected fields.
3. Rotation: Rotate out of the same plant family when possible. For pathogens with extremely wide host ranges, such as *Verticillium* sp. and *Meloidogyne* spp., it is difficult to rotate to a suitable non-host crop.

Since most soilborne pathogens are excellent soil survivors, rotations of three to five years are usually necessary to reduce pathogen populations adequately.

4. Host resistance and grafting: Resistant varieties should be selected whenever possible and resistance to Verticillium wilt and Fusarium wilt is incorporated into most modern tomato varieties. Grafting a disease-susceptible scion onto a disease-resistant rootstock can reduce damage due to soilborne diseases. Many commonly used rootstocks have resistance to Verticillium wilt, Fusarium wilt, corky root rot, and some resistance to root knot nematode.
5. Soil disinfestation: Several soil disinfestation options are available that vary in cost, efficacy and environmental impact. Chemical fumigation and steam sterilization are two options that have been commonly used historically, but are often not feasible for use on vegetable farms. Anaerobic soil disinfestation is a newer method of soil disinfestation that involves amending, saturating and tarping soil. Soil solarization uses solar-generated heat trapped under plastic sheeting to kill soilborne pathogens, but this technique is not often effective under Midwestern production conditions. Soils can be flooded or left fallow to kill pathogens over a period of time, but these methods are often ineffective due to the survival structures of most soilborne pathogens.
6. Chemical or biological control: Few options are available and many biological control options are still experimental.