HS1345

Implementation of Anaerobic Soil Disinfestation in Florida Tomato Production[1]

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What is anaerobic soil disinfestation?

Anaerobic soil disinfestation (ASD), also known as biological or reductive soil disinfestation or soil reductive sterilization, is a nonchemical soil treatment alternative to chemical fumigation for the management of soilborne diseases, nematodes, and weeds (Blok et al. 2000; Katase et al. 2009; Momma et al. 2013; Rosskopf et al. 2015; Shinmura et al. 1999). This concept was developed in Japan (Shinmura et al. 1999) and the Netherlands (Blok et al. 2000) for small-scale farming and protected culture. Large-scale open-field research is currently underway in Florida and California to determine the effectiveness of ASD in conventional and organic crop production systems. This preplant method consists of creating anaerobic soil conditions by incorporating readily decomposable carbon (C) sources and soil amendments, irrigating the soil to field capacity, and covering the soil with gas-impermeable mulch for a period of approximately three weeks (Butler et al. 2012; Di Gioia et al. 2016; Guo et al. 2017). ASD is effective against numerous soilborne plant pathogens, plant-parasitic nematodes, and weeds because the process depletes available soil oxygen, shifts soil microbial composition to facultative anaerobes, lowers soil pH, and releases short-chain fatty acids (e.g., acetic, butyric, lactic, citric, isovaleric, and propionic acids), aldehydes, alcohols, ammonia, metal ions (Mn^{2+} and Fe^{2+}), and other volatile organic compounds (Guo et al. 2018; Johns et al. 2017; Momma 2008; Momma et al. 2006; Oka 2010; van Agtmaal et al. 2015).

Different C sources, additional soil amendments, temperature, and application methods (Paudel et al. 2018) have high impacts on the success of ASD. Commonly used C sources include rice or wheat bran, green manure, molasses, and ethanol (Strauss and Kluepfel 2015). Locally available and affordable C sources are important to reduce the cost of ASD. Preplant fertilizers may be needed to stimulate microbial activity, depending on the amount of available nutrients from the C source and soil amendment (Di Gioia et al. 2017). The following ASD implementation procedure, which combines the application of composted poultry litter (CPL, soil amendment) with molasses (C source), is currently used in Florida. Yields in field trials of this method have demonstrated comparable or higher tomato marketable yield compared to standard chemical soil fumigation practices (Table 1).

1. This document is HS1345, one of a series of the Horticultural Sciences Department, UF/IFAS Extension. Original publication date November 2019. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

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How does one implement anaerobic soil disinfestation in field tomato production?

The implementation of ASD involves a series of steps starting with applying the treatment, then covering raised beds with totally impermeable film (TIF) and applying drip irrigation, all of which have to occur on the same day. The most common waiting period between ASD application and transplanting tomato is three weeks. After three weeks, growers can punch planting holes in the TIF and follow other normal field planting procedures.

1. *First Step*:

Three weeks prior to transplanting, broadcast the bottom mix fertilizers (containing 10%–20%, 100%, and 10%–20% of the total season nitrogen, phosphorus, and potassium fertilizers, respectively) on the surface of the soil where beds will be located (Figure 1).

Figure 1. Bottom mix fertilizer application.
Credits: F. Di Gioia

2. *Second Step*:

Form the false beds approximately 4 inches high (Figure 2) and apply CPL and molasses (Table 2; Figures 3 and 4).

The soil amendments and C sources may be broadcast applied to the entire soil surface or banded. Soil amendments and C sources are applied only to the bed area in Florida and most locations where raised-bed systems are used. Two different methods for calculating the amount of CPL needed for ASD on a 600-foot-long and 3-foot-wide bed are given below.

Figure 2. False bed formation.
Credits: F. Di Gioia

Figure 3. Composted poultry litter application.
Credits: K. Sattanno, UF/IFAS

Figure 4. Molasses application.
Credits: E. N. Rosskopf

1. **Using the broadcast application rate of composted poultry litter (4.5 tons/acre) and bed width to calculate the actual bed surface:**

    a. A short ton is equivalent to 2,000 lb; therefore, 4.5 tons/acre × 2,000 lb/ton = 9,000 lb/acre

b. There are 43,560 sq ft in one acre, resulting in an application rate *per sq ft* calculated as: 9,000 lb/acre / 43,560 sq ft/acre = 0.207 lb/sq ft

c. For a 600 ft by 3 ft bed, the actual area of the bed is 600 ft × 3 ft = 1,800 sq ft

d. This results in a total amount of material calculated as 0.207 lb/sq ft × 1,800 sq ft = 372 lb

2. **Using the linear bed feet (LBF) system, consider the bed spacing is 6 ft and the bed width is 3 ft, only half of the soil surface is treated, therefore the actual application rate of composted poultry litter to the raised beds is 2.25 tons/acre:**

a. A short ton is equivalent to 2,000 lb; therefore, 2.25 tons/acre × 2,000 lb/ton = 4,500 lb/acre

b. Given that there are 43,560 sq ft in one acre and that the beds are 6 ft apart (from center to center), the LBF/acre is calculated as 43,560 sq ft/acre / 6 ft = 7,260 ft/acre

c. There are 7,260 ft/acre, the application rate per LBF is calculated as: 4,500 lb/acre / 7,260 ft/acre = 0.62 lb/ft

d. The total amount of organic material required is calculated as 0.62 lb/ft × 600 ft = 372 lb

3. *Third Step:*

Till the amended soil to a depth of 8 inches with a rotary cultivator (Figure 5), reform the beds, and cover with TIF while simultaneously placing two drip tapes under the plastic mulch 8 inches from the bed center and 1 inch below the soil surface (Figure 6).

Figure 5. Rotary cultivation of the amended bed.
Credits: F. Di Gioia

Figure 6. Beds covered with TIF plastic mulch.
Credits: J. C. Hong

4. *Fourth Step*:

Irrigate the soil with 2 acre-inches of water (approximately 4–5 hours using two drip lines with 0.65 gpm/100 ft at 10 psi) to fill the pore space. The irrigation amount can be calculated as follows:

a. Water requirement for a 600-foot-long and 3-foot-wide bed (600 ft × 3 ft = 1,800 sq ft): 1,800 sq ft × 2 inches × 0.0833 ft/inch) = 299.88 cubic ft = 2,243.1 gals

b. The flow rate of the drip tape at 10 psi is 0.65 gpm/100 ft (0.0065 gpm/ft); therefore, to irrigate a 600-foot-long bed the flow requirement is: 0.0065 gpm/ft × 600 ft × 2 drip lines = 7.8 gpm

c. Thus, the time needed to run the irrigation will be: 2,243.1 gals/7.8 gpm = 288 minutes = 4.8 hours

Acknowledgements

The authors acknowledge the Areawide Project on ASD funded by USDA, Agricultural Research Service. For updated information about ASD in Florida, including publications, presentations, and reports, visit https://floridafoodandag.com/new-home/anaerobic-soil-disinfestation-asd

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Table 1. Effects of soil treatments on total season marketable tomato yield (three harvests combined) in Immokalee, Florida (adapted from Guo et al. 2017).

Treatment	**Total Season Harvest (25 lb boxes/acre)**			
	XL[z]	**L**	**M**	**TMY**
CSF[y]	1021 c	382 a	161 a	1564 b
ASD 0.5	1325 b	243 b	75 b	1643 b
ASD 1.0	1582 a	286 b	107 b	1975 a

[z] XL = extra-large (> 2.75 in), L = large (2.50 to 2.78 in), M = medium (2.25 to 2.53 in), TMY = total marketable yield.
[y] CSF = Chemical soil fumigation with Pic-Clor 60; ASD 0.5 = Anaerobic soil disinfestation with 741 gal/acre of molasses and 4.5 t/acre of composted poultry litter; ASD 1.0 = Anaerobic soil disinfestation with 1482 gal/acre of molasses and 9 t/acre of composted poultry litter. Means within each column followed by the same letter were not significantly different by Fisher's Least Significant Difference test at $p \leq 0.05$.

Table 2. Materials that can be used for a feasible field-scale application of anaerobic soil disinfestation in Florida.

Material		**Application Rate (Based on Raised-Bed Area)**	**Purpose**
Labile carbon sources and soil amendments	Composted poultry litter (CPL)	4.5 tons/acre	Increases water retention and initiates rapid growth and increased respiration of soil microbes, which further deplete soil oxygen
	Sugarcane molasses (C source, water diluted at a ratio of 1:1, v:v)	741 gal/acre (before dilution)	
Plastic mulch	TIF	-	Minimizes gas exchange between the soil and the ambient atmosphere above the polyethylene mulch, and increases soil temperature, which stimulates microbial activity
Irrigation	Two drip tapes per bed	2 acre-inches	Saturates air-filled pore space in the beds, enhances the diffusion of by-products in the soil, and depletes oxygen in the area under plastic mulch

Sources: Di Gioia et al. 2016; Guo et al. 2017; Paudel et al. 2018.