Evaluation of Anaerobic Soil Disinfestation Soil Soil Amendments and Rates for Conventional Tomato Production in Florida

Monica Ozores-Hampton[1], Francesco Di Gioia[2], Bodh Paudel[3], Xin Zhao[3], Jason Hong[4], and Erin N. Rosskopf[4]

[1]Southwest Florida Research and Education Center, University of Florida, Immokalee, FL
[2]Plant Pathology Department, University of Florida, Gainesville, FL
[3]Horticultural Sciences Department, University of Florida, Gainesville, FL
[4]USDA-ARS, US Horticultural Research Laboratory, Fort Pierce, FL

UF IFAS UNIVERSITY of FLORIDA

USDA ARS

Introduction

Florida leading fresh-market tomato in the USA with 28,000 acres harvested generating a production value of US$382 million in 2016.

Previously, Florida tomato growers relied on methyl bromide as a broad spectrum soil fumigant against soil-borne diseases, weeds, and nematodes.

Anaerobic Soil Disinfestation (ASD) History

- ASD is an emerging alternative to the soil fumigation effective against soilborne pests in several cropping production systems.
- Developed as alternative to Methyl bromide fumigation in Netherlands and Japan primarily for greenhouse production.
- Controls range of soilborne pathogens, nematodes and some weeds.

Florida Traditional ASD Method

1. Composted poultry manure at 9 to 4.5 ton/acre and molasses at 1,482 – 741 gal/acre
2. Polyethylene TIF mulch
3. Two acre inches of water-with the 8-inch emitters (4 hours at 10 psi)
4. Planting 3-weeks after treatments
5. The temporary shift of the soil environment (aerobic to anaerobic) stimulates the growth of facultative and obligate anaerobic microorganisms decomposing the available C-source, producing organic acids, aldehydes, alcohols, ammonia, metal ions, and volatile organic compounds, that are suppressive or toxic for several soil-borne pests and diseases

Objectives

To evaluate the effects of different soil amendments for ASD on cumulative soil anaerobiosis, plant growth, fruit yield, and postharvest quality of fresh-market tomato.

Materials and Methods

Treatments

Treatment	Products	Application rate	Application mode
UTC (untreated)	Reflex	1 pint/acre in 30 gal/acre	Applied at bed formation, before plastic
	Initial water	2 inches	Drip (4 hours)
CSF (control)	Pic-Clor 60	200 lb/acre	Bed fumigation
	Reflex	1 pint/acre in 30 gal/acre	Sprayed at bed formation, before plastic
	Initial water	none	
ASD 0.5	Composted poultry litter	4.5 ton/acre	Incorporated into the bed
	Molasses	741 gal/acre	Incorporated into the bed
	Reflex	1 pint/acre in 30 gal/acre	Sprayed at bed formation, before plastic
	Initial water	2 inches	By drip (about 4 hours)
SSA	Soil Symphony	Weekly	Incorporated into the bed
	Reflex	1 pint/acre in 30 gal/acre	Sprayed at bed formation, before plastic
	Initial water	2 inches	By drip (about 4 hours)
YW12	Yard waste compost	12 tons/acre	Incorporated in the bed
	Reflex	1 pint/acre in 30 gal/acre	Sprayed at bed formation, before plastic
	Initial water	2 inches	By drip (about 4 hours)
YW12+M	Yard waste compost	12 tons/acres	Incorporated into the bed
	Molasses	741 gal/acre	Incorporated into the bed
	Reflex	1 pint/acre in 30 gal/acre	Sprayed at bed formation, before plastic
	Initial water	2 inches	By drip (about 4 hours)
YW6+M	Yard waste compost	6 tons/acre	Incorporated into the bed
	Molasses	741 gal/acre	Incorporated into the bed
	Reflex	1 pint/Acre in 30 gal/acre	Sprayed at bed formation, before plastic
	Initial water	2 inches	By drip (about 4 hours)
YW12+SSA	Yard waste compost	12 tons/acre	Incorporated into the bed
	Soil Symphony	Weekly	Incorporated into the bed
	Reflex	1 pint/acre in 30 gal/acre	Sprayed at bed formation, before plastic
	Initial water	2 inches	By drip (about 4 hours)

CSF: Chemical soil fumigation; ASD: anaerobic soil disinfestation

Location	Immokalee FL (SWFREC).
Experimental design	RCBD (4 replications)
Irrigation	Drip irrigation with 2 drip tapes (8” emitter spacing)
Plot size	60 ft × 1 bed = 60 ft
Harvest unit	10 plants
Total area	60 ft x 8 trt x 4 reps = 1,920 ft
Plastic laying and fertilization	22 Aug. 2016
Plastic mulch	TIF White/black (top/underneath)
Planting date	12 Sept. 2016
Variety	Tribute (Sakata)
Linear ft per acre	7,260
Bed spacing (center to center)	6 ft
Plant population	4,840 plants
Bed height	8 inches
Plant spacing	18 inches
Bed width	36 inches
Bottom mix	1,000 lb/acre (3-10-4)
Fertigation	220 lb/acre of N and 360 lb/acre of K_2O
Harvest date	
1st	2 Dec. 2016
2nd	9 Dec. 2016
3rd	20 Dec. 2016
Planting to 3rd harvest	120 days

Data Collection

- Data logger oxidation for 3 weeks
- Biometric assessment 30 and 60 days after transplant (DAT) on 2 representative plants from each plot (leaves, stems, fruit and total plant dry weight).
- Tomato fruit were manually harvested: graded into marketable yield size categories for extra-large, large, medium (USDA, 1997) and unmarketable tomatoes
- Postharvest quality as soluble solids content, titratable acidity, pH, color, firmness, dry matter content at first harvest.

Cumulative Soil Anaerobiosis

Soil treatment	Cumulative redox potential (mVhr)
UTC	0 b
CSF	0 b
ASD05M	19,445 a
SSA	30 b
YW12	0 b
YW12M	7,636 b
YW6M	4,779 b
YW12SSA	34 b
Sig.	**

[z]Within columns, means followed by different letters are significantly different according to Duncan's multiple range test at 5%. NS, *, **, ***, Non-significant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

Plant Biomass

Treatment[z]	Dry weight (g/plant)			
	27 Sept. 2016 (30 DAT)			
	Stem	Leaves	Fruit	Total
UTC	3.19d	11.13c	-	14.31d
CSF	6.03bc	19.99ab	-	26.01abc
ASD0.5	8.59a	23.93a	-	32.51a
SSA	4.63cd	14.19c	-	18.81cd
YW12	4.88cd	14.38c	-	19.27d
YW12+M	6.96ab	19.95ab	-	26.91ab
YW6+M	5.40bc	16.31bc	-	21.71bcd
YW12+SSA	4.51cd	14.78bc	-	19.29cd
P-value	0.003	0.01	-	0.007
Significance	**	*	-	**
	25 Oct. 2016 (60 DAT)			
UTC	32.06	74.93	75.76b	182.74d
CSF	53.90	112.95	102.61ab	269.46ab
ASD0.5	61.53	127.11	111.57ab	300.20a
SSA	43.13	86.88	94.81ab	224.81bcd
YW12	39.58	84.70	86.62ab	210.90cd
YW12+M	46.43	98.41	98.48ab	243.32abc
YW6+M	48.55	107.09	114.55a	270.19ab
YW12+SSA	44.91	94.39	97.79ab	237.09bcd
P-value	0.55	0.11	0.02	0.03
Significance	NS	NS	*	*

[z] Within columns, means followed by different letters are significantly different according to Duncan's multiple range test at 5%.
NS, *, **, ***, Non-significant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.


ASD 0.5H
I

Yield Results: First Harvest

Treatment[z]	Marketable yield (25-lb boxes/acre)				
	Extra-large	Large	Medium	Total	Unmarketable
UTC	402b	13d	0b	415b	45
CSF	728a	67ab	0b	795a	45
ASD0.5	613ab	74a	18a	705a	64
SSA	587ab	23cd	4b	613ab	49
YW12	583ab	50abc	0b	634ab	54
YW12+M	800a	55ab	0b	855a	66
YW6+M	738a	24cd	0b	761a	42
YW12+SSA	805a	42bcd	0b	847a	65
P-value	0.02	0.001	0.002	0.008	0.93
Sig.	*	***	**	**	NS

[z]Within columns, means followed by different letters are significantly different according to Duncan's multiple range test at 5%.
NS, *, **, ***, Non-significant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

Yield Results: Second Harvest

Treatment[z]	Marketable yield (25-lb boxes/acre)				
	Extra-large	Large	Medium	Total	Unmarketable
UTC	385b	242	57	683c	59
CSF	691a	338	74	1,103a	76
ASD0.5	607a	357	84	1,048a	100
SSA	642a	267	81	990ab	77
YW12	399b	271	59	713bc	92
YW12+M	556ab	331	78	965ab	90
YW6+M	643a	340	59	1,042a	107
YW12+SSA	594a	286	71	951ab	61
P-value	0.007	0.55	0.91	0.01	0.58
Sig.	**	NS	NS	**	NS

[z]Within columns, means followed by different letters are significantly different according to Duncan's multiple range test at 5%.
NS, *, **, ***, Non-significant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

Yield Results: First and Second Harvest

Treatment[z]	Marketable yield (25-lb boxes/acre)				
	Extra-large	Large	Medium	Total	Unmarketable
UTC	787c	254	57	1,098c	104
CSF	1,419a	406	74	1,898a	120
ASD0.5	1,220ab	431	101	1,752a	164
SSA	1,229ab	290	85	1,603ab	126
YW12	982bc	321	59	1,347bc	145
YW12+M	1,356a	386	78	1,820a	156
YW6+M	1,381a	364	59	1,803a	148
YW12+SSA	1,399a	328	71	1,798a	127
P-value	0.005	0.22	0.69	0.001	0.85
Sig.	**	NS	NS	***	NS

[z] Within columns, means followed by different letters are significantly different according to Duncan's multiple range test at 5%.
NS, *, **, ***, Non-significant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

Yield Results: Third Harvest

Treatment[z]	Marketable yield (25-lb boxes/acre)				
	Extra-large	Large	Medium	Total	Unmarketable
UTC	141c	294	304	739b	66
CSF	278ab	320	281	879b	79
ASD0.5	316ab	458	402	1,175a	114
SSA	207bc	340	308	855b	112
YW12	270ab	302	243	815b	144
YW12+M	291ab	389	323	1,003ab	114
YW6+M	242abc	368	255	865b	91
YW12+SSA	338a	337	245	921ab	114
P-value	0.02	0.09	0.43	0.05	0.21
Sig.	*	NS	NS	*	NS

[z] Within columns, means followed by different letters are significantly different according to Duncan's multiple range test at 5%.
NS, *, **, ***, Non-significant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

Yield Results: Total Harvest

Treatment[z]	Marketable yield (25-lb boxes/acre)				
	Extra-large	Large	Medium	Total	Unmarketable
UTC	928c	548	361	1,837d	170
CSF	1,697ab	726	354	2,777ab	199
ASD0.5	1,535ab	889	503	2,927a	278
SSA	1,436bc	630	393	2,458bc	238
YW12	1,252ab	623	302	2,162c	290
YW12+M	1,647ab	775	402	2,824ab	270
YW6+M	1,623abc	732	314	2,668ab	239
YW12+SSA	1,738a	665	316	2,719ab	241
P-value	0.02	0.09	0.43	0.0001	0.21
Sig.	*	NS	NS	***	NS

[z] Within columns, means followed by different letters are significantly different according to Duncan's multiple range test at 5%.
NS, *, **, ***, Non-significant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

Postharvest Quality

Soil treatment	Color	Firmness	Dry matter	Titratable acidity (TA)	Total soluble solids (TSS)	TSS/TA ratio	pH
	a*	N	(g kg^{-1} FW)	(g 100 mL^{-1})	(°Brix)		
UTC	30.1 a	9.3	4.2	0.42 ab	3.8	9.2	4.4
CSF	28.2 bc	9.9	4.3	0.37 b	3.6	10.0	4.4
ASD05M	28.7 abc	9.1	4.3	0.50 a	3.8	7.5	4.4
SSA	29.3 ab	10.5	4.3	0.39 b	3.8	9.8	4.4
YW12	29.0 abc	10.0	4.2	0.41 ab	3.6	9.2	4.4
YW12M	29.1 abc	9.6	4.2	0.50 a	3.7	8.0	4.4
YW6M	29.3 ab	9.3	3.6	0.50 a	3.8	7.8	4.3
YW12SSA	27.7 c	9.9	4.4	0.41 ab	3.4	8.3	4.4
P-value	0.05	0.49	0.17	0.05	0.13	0.36	0.24

[z]Within columns, means followed by different letters are significantly different according to Duncan's multiple range test at 5%.
NS, *, **, ***, Non-significant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

Conclusions

Anaerobic soil disinfestation applied using alternative composted amendments and molasses can be a sustainable alternative to CSF producing comparable plant growth, marketable yield, and fruit quality.

Acknowledgements

Jessy Watson
ShawronWeingarten
Alec Tasi
Gilma Castillo
Qiang Zhu

UF | IFAS
UNIVERSITY of FLORIDA