Integrated Nematode Management for Organic Strawberry Production in Florida

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Summary

(1) cultivars: Brilliance, Festival and Sensation had the highest yields under organic management. (2) all cultivars yielded much higher under conventional management with Brilliance and Festival again having highest yield. (3) organic nematicides: limited effect was noted on nematodes and fruit yield in field trials at GCREC and in organic grower fields.

Background

Several organic strawberry fields in Florida have seen significant problems with sting nematodes in the past years, and in some fields root knot and stubby root nematodes have also been found to cause visible damage. Sting nematode is one of the main problems for organic strawberry production in Florida. Without fumigants, options for nematode management are limited, which is why an integrated approach targeting all aspects of strawberry production is especially important. This includes (1) monitoring nursery transplants, (2) evaluating organic nematicides/amendments, (3) comparing cultivars, (4) evaluating cover crops and (5) looking into other off-season practices, including fallowing and biological soil disinfestation practices.

Methods

(1) Cultivar comparisons: cvs. Florida 127, Beauty, Pearl 66 and 109, Brilliance, Radiance, Festival, and Medallion were planted (a) at the GCREC organic certified field in plastic beds and grown under organic conditions (fish fertilizer via drip, sprays with OMRI products; field has low nematode pressure) and (b) in a conventionally managed and fumigated field (Telone-C35) at the GCREC with high sting nematode pressure.

(2) Nematicide OMRI evaluations: OMRI nematicides were evaluated at GCREC in the same conventionally and organically managed fields at GCREC as in (1); treatments are shown in Table 4.1 and 5.1, and fumigant Telone-C35 was included in the conventional field to half of the beds. OMRI nematicides were all applied via the drip irrigation system.

(3) Organic nematode management programs were evaluated by monitoring nematode populations in three organic grower fields by installing valves in at least six rows (~ 350 ft long) and sampling soil for nematodes in these rows, as well as adjacent rows with no valves.

Results

(1) **Cultivar comparisons**:

Organic field trial: weeds were a major problem in the organic field, as well as chili thrips and diseases. The poorest crop stands were noted for cvs. Beauty and Radiance. The cultivars Brilliance, Festival and

Sensation looked better in terms of yield. Medallion and Pearl 109 were intermediate and cvs. Beauty and Radiance had the lowest yield (Table 2).
Conventional field trial: The cultivars Brilliance and Festival had highest yield, followed by Medallion and Pearl 66, with cvs. Beauty and Radiance having the lowest yield (Table 3).

(2) **Nematicide evaluations at GCREC**:
Conventional field trial: Fumigated beds had consistently higher yields. Velum treatment had higher yield compared to organic OMRI nematicide treatments (Table 4.2). Sting nematode was the main nematode in the trial, with the highest populations at mid-season and lower populations towards the end of the season. Fumigation and Velum had the lowest sting nematode population at mid-season, but not at the end of the season (Table 4.3). Fumigation with C-35 also reduced the free-living nematode population at mid-season but not at the end of the season.
***Organic field trial*:** Strawberry yields in this trial were low due to disease and weed pressure. Sting and root-knot nematodes were the main nematodes in this field. Sting nematode population was similar during the trial, but root-knot population increased towards the end-season. No clear effect of organic nematicides was observed (Table 5).

(3) **On-farm testing** in two organic and one conventional fields (Table 6): two of the farms had severe sting nematode infestation (Wimauma and Plant City) (Table B1 and C1, our experiment was in the infested part in these farms). The other field in Duette had moderate sting nematode damage in the experimental area (but high nematode damage was visible in other parts of the farm). Minor differences were noted between the grower's program and the control rows. In one of the farms with measurable sting nematodes, the grower's program slightly reduced sting nematode counts (Table B1). In the other two farms, no effects of the grower's programs were found. Free-living nematodes (bacterial and fungal feeding types) were abundant and not clearly impacted by the grower's program (Table A2, B2, C2).

Takeaways

- Brilliance and Festival had the highest yields in both organic and conventional field, while Sensation also produced relatively well in the organic field.
- OMRI nematicides/amendments did not affect sting and root-knot populations; the effect on yield was minimal.
- A minor effect on (sting) nematodes of in-crop organic nematode management programs was observed on one out of three commercial farms.

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Table 2. Yield of eight strawberry cultivars in an organic field

Cultivar	Yield per plot (kg)			Yield per plant (kg)		
	Mid-yield (Feb)	Late yield (Mar)	Total yield	Mid-yield (Feb)	Late yield (Mar)	Total yield
Beauty	0.05	0.12	0.37	0.003	0.008	0.011
Brilliance	**0.07**	**0.28**	**0.65**	**0.004**	**0.016**	**0.020**
Festival	**0.06**	**0.56**	**0.87**	**0.003**	**0.028**	**0.032**
Medallion	0.03	0.31	0.47	0.002	0.021	0.022
Pearl 66	0.04	0.12	0.34	0.003	0.008	0.011
Pearl 109	0.04	0.21	0.39	0.002	0.011	0.013
Radiance	0.05	0.07	0.32	0.004	0.007	0.011
Florida 127 (Sensation)	**0.08**	**0.39**	**0.81**	**0.005**	**0.022**	**0.027**
P value	0.41	0.07	0.25	0.37	0.23	0.35

**P* value > 0.05 indicates no significant difference between treatment

Table 3. Yield of eight strawberry cultivars in a conventional field (Telone-C35 was injected in this field)

Cultivar	Yield per plot (kg)				Yield per plant (kg)			
	Early yield (Jan)	Mid-yield (Feb)	Late yield (Mar)	Total yield	Early yield (Jan)	Mid-yield (Feb)	Late yield (Mar)	Total yield
Beauty	0.64	2.05	5.82	8.51	0.03	0.11	0.31	0.45
Brilliance	**1.40**	**3.98**	**9.23**	**14.60**	**0.07**	**0.20**	**0.47**	**0.74**
Festival	0.60	**3.33**	**12.33**	**16.26**	0.03	**0.17**	**0.64**	**0.84**
Medallion	0.94	2.17	8.17	11.29	0.05	0.12	0.43	0.60
Pearl 66	0.69	2.84	9.18	12.71	0.03	0.14	0.46	0.64
Pearl 109	0.74	2.00	7.02	9.77	0.04	0.10	0.36	0.50
Radiance	0.80	2.29	6.28	9.37	0.04	0.12	0.33	0.50
Florida 127 (Sensation)	0.85	2.63	6.41	9.89	0.04	0.14	0.33	0.51
P value	<0.0001	0.01	<0.0001	<0.0001	<0.0001	0.01	<0.0001	<0.0001

**P* value > 0.05 indicates no significant difference between treatment

Table 4. Organic OMRI nematicides/products as compared with Velum and with and without fumigation with Telone-C35 in a conventionally managed field at GCREC (2023-24 season)

Table 4.1. Bio-nematicide application timing and rates			
Treatment #	Product(s)	Rate/A	Application timing
1	Velum	6.8 oz	At plant + 30 dap
2	Worm Power Liquid Extract	5 gal	Every 2 wap
3	Worm Power Concentrate	5 gal	Every 2 wap
4	NemaClean	2 lb	At plant + 2 wap + 4 wap + 8 wap
5	Double Nickel	2 qt	At plant + 2 wap + 4 wap + 8 wap
6	Double Nickel	2 qt	At plant + 4 wap
	Nemaklean	2 lb	2 wap + 8 wap
7	WaterMaxx 2	2 qt	2-3 dbp
	Guarda	1 gal	At plant + 2 wap + 4 wap + 8 wap
8	WaterMaxx 2	2 qt	2-3 dbp
	SaniDate HC	0.30%	1 dbp
	TerraGrow (liquid)	20 oz	At plant
	OxiDate 5.0	0.10%	2 wap + 4 wap + 8 wap
	TerraGrow (liquid)	13 oz	2.1 wap + 4.1 wap + 8.1 wap
	AzaGuard	15 oz	
9	OxiDate 5.0	0.40%	1 dbp
	TerraGrow (liquid)	20 oz	At plant
	OxiDate 5.0	0.10%	2 wap + 4 wap + 8 wap
	TerraGrow (liquid)	13 oz	2.1 wap + 4.1 wap + 8.1 wap
	AzaGuard	15 oz	
10	Untreated Control		

AzaGuard (Azadirachtin); CX-10272 (*Purpureocillium lilicanus* strain 11, live fungus); Double Nickel (*Bacilus amylolyquefaciens* strain D747); Guarda (Thyme oil)WaterMaxx 2 (Alkoxylated polyols + Glucoethers); OxiDate 5.0 (Hydrogen Peroxide + Peroxyacetic acid); SaniDate HC (Hydrogen Peroxide + Peroxyacetic acid); TerraGrow (*Bacillus licheniformis* + *B. subtilis* + *B. pumilus* + *B. amylolyquefaciens* + *B. megaterium*); Velum (fluopyram); Wormpower (a liquid extract of earthworm frass).

Table 4.2. Yield of eight strawberry cultivars + effect of 'Telone-C35' in a conventional field									
	Treatment	Yield per plot (kg)				Yield per plant (kg)			
		Early (Dec)	Mid (Jan)	Late (Feb-Mar)	Total	Early (Dec)	Mid (Jan)	Late (Feb-Mar)	Total
Plot	1	2.0	3.5	15.9	21.5	0.07	0.12	0.54	0.73
	2	1.5	2.7	11.2	15.4	0.05	0.09	0.38	0.52
	3	1.8	3.4	13.6	18.9	0.06	0.12	0.46	0.64
	4	1.8	3.4	13.6	18.8	0.06	0.12	0.46	0.64
	5	1.9	3.7	14.2	19.7	0.06	0.13	0.49	0.68
	6	1.8	3.4	13.7	18.8	0.06	0.11	0.46	0.63
	7	1.8	3.5	14.6	19.9	0.06	0.12	0.49	0.66
	8	2.0	3.6	15.2	20.7	0.07	0.12	0.52	0.70
	9	1.8	3.4	12.8	18.0	0.06	0.11	0.43	0.60
	10	1.8	3.5	14.1	19.4	0.06	0.12	0.48	0.66
Row	Nofume	1.8	**2.8**	**9.4**	**14.0**	0.06	**0.09**	**0.32**	**0.47**
	Telone_C35	1.9	**4.0**	**18.3**	**24.3**	0.06	**0.14**	**0.62**	**0.82**
p-value	Product	0.20	0.66	0.36	0.36	0.18	0.61	0.34	0.33
	Fumigant	0.23	0.001	<0.0001	<0.0001	0.18	0.001	<0.0001	<0.0001
	Fumigant*Product	0.17	0.69	0.86	0.84	0.18	0.70	0.91	0.89

Nofume: non-fumigated; **P* value > 0.05 indicates no significant difference between treatment

Table 4.3. Free-living and sting nematode soil population (200 cc soil), conventional field in 2023-2024					
	Treatment	Free-living, Jan	Free-living, March	Sting, Jan	Sting, March
Plot	1	79	71	2	1
	2	85	61	32	7
	3	140	87	17	7
	4	114	78	23	5
	5	109	81	9	3
	6	101	81	18	10
	7	132	93	13	5
	8	84	87	14	5
	9	127	54	24	8
	10	228	72	11	5
Row	Nofume	**169**	87	32	7
	Telone_C35	**71**	66	0	4
p-value	Product	0.59	0.67	0.07	0.08
	Fumigant	0.006	0.22	<0.0001	0.14
	Fumigant*Product	0.27	0.005	0.26	0.86

**P* value > 0.05 indicates no significant difference between treatment

Table 5. Effect of OMRI nematicides/products in an organic field at GCREC (2023-24 season)

Table 5.1. Bio-nematicide application timing and rates

Treatment #	Product(s)	Rate/A	Application timing
1	FMC W8S11	13.7 oz	At plant drench (11/3) + every 2 wap
2	Worm Power Liquid Extract	5 gal	Every 2 wap
3	Worm Power Concentrate dilution	5 gal	Every 2 wap
4	CX-10272 (NemaClean PL11)	2 lb	At plant + 2 wap + 4 wap + 8 wap
5	Double Nickel	2 qt	At plant + 2 wap + 4 wap + 8 wap
6	Double Nickel	2 qt	At plant + 4 wap
	CX-10272 (NemaClean PL11)	2 lb	2 wap + 8 wap
7	OxiDate 5.0	0.40%	1 dbp
	TerraGrow (liquid)	20 oz	At plant
	OxiDate 5.0	0.10%	2 wap + 4 wap + 8 wap
	TerraGrow (liquid)	13 oz	2.1 wap + 4.1 wap + 8.1 wap
	AzaGuard	15 oz	
8	UTC		

AzaGuard (Azadirachtin); CX-10272 (*Purpureocillium lilicanus* strain 11, live fungus); Double Nickel (*Bacilus amylolyquefaciens* strain D747); OxiDate 5.0 (Hydrogen Peroxide + Peroxyacetic acid); TerraGrow (*Bacillus licheniformis* + *B. subtilis* + *B. pumilus* + *B. amylolyquefaciens* + *B. megaterium*); Wormpower (a liquid extract of earthworm frass).

Table 5.2. Strawberry fruit yield (kg) in an organic field with OMRI nematicides

Treatment #	Yield per plot (kg)			Yield per plant (kg)		
	Early yield (Feb)	Late yield (March)	total yield (kg/plot)	Early yield (Feb)	Late yield (March)	total yield (kg/plant)
1	0.84	0.97	1.81	0.03	0.03	0.06
2	1.06	0.79	1.85	0.04	0.03	0.07
3	**1.04**	**1.33**	**2.37**	**0.04**	**0.05**	**0.08**
4	0.86	0.86	1.72	0.03	0.03	0.06
5	0.78	0.67	1.45	0.03	0.02	0.05
6	0.79	0.91	1.70	0.03	0.03	0.06
7	0.84	0.95	1.79	0.03	0.03	0.06
8	0.81	0.91	1.73	0.03	0.03	0.06
P value	0.40	0.24	0.35	0.19	0.28	0.26

**P* value > 0.05 indicates no significant difference between treatments.

Table 5.3. Free-living, sting and root-knot nematode soil population (200 cc soil), organic field, 2023-2024						
Treatment	Free-living, Jan	Free-living, March	Sting, Jan	Sting, March	Root-knot, Jan	Root-knot, March
1	338	234	2	3	0	7
2	508	155	4	0	2	5
3	279	270	0	3	0	**68**
4	401	117	1	3	0	3
5	316	226	5	3	1	12
6	325	179	3	4	0	0
7	412	191	1	2	0	7
8	437	162	5	4	1	7
P value	0.52	0.27	0.14	0.65	0.05	0.04

**P* value > 0.05 indicates no significant difference between treatments.

Table 6. Nematode counts from three strawberry farms comparing post-plant nematicide programs

A1. Sting nematode soil population/200 cc soil in 2023-2024 (organic, Duette)							
Treatment	Nov 8 2023	Dec 15 2023	Jan 5 2024	Jan 19 2024	Feb 2 2024	Feb 16 2024	March 1 2024
Grower program	6	2	1	0	2	3	2
Untreated control	2	1	1	0	2	2	1

*Few plant-parasitic nematodes (root lesion and stunt nematodes) were observed in this field.

A2. **Free-living nematode** soil population/200 cc soil in 2023-2024 (organic, Duette)							
Treatment	Nov 8 2023	Dec 15 2023	Jan 5 2024	Jan 19 2024	Feb 2 2024	Feb 16 2024	March 1 2024
Grower program	516	335	333	232	310	308	382
Untreated control	342	272	423	269	412	266	352

B1. Sting nematode soil population/200 cc soil in 2023-2024 (organic, Wimauma)							
Treatment	Nov 8 2023	Dec 22 2023	Jan 4 2024	Jan 19 2024	Feb 2 2024	Feb 16 2024	March 1 2024
Grower program	2	4	6	1	3	9	0
Untreated control	7	3	5	4	4	11	4

*Few plant-parasitic nematodes (root-knot, root lesion and stunt nematodes) were observed in this field.

B2. Free-living nematode soil population/200 cc soil in 2023-2024 (organic, Wimauma)							
Treatment	Nov 8 2023	Dec 22 2023	Jan 4 2024	Jan 19 2024	Feb 2 2024	Feb 16 2024	March 1 2024
Grower program	148	359	364	475	513	329	272
Untreated control	334	305	430	458	754	440	307

C1. Sting nematode soil population/200 cc soil in 2023-2024 (conventional, Plant City)								
Location	Treatment	Nov 8 2023	Dec 22 2023	Jan 5 2024	Jan 19 2024	Feb 2 2024	Feb 16 2024	March 1 2024
McIntosh Rd.	Grower program	22	NA	43	24	32	70	93
	Untreated control	26	NA	19	2	21	57	36
Tanner Rd.	Grower program	15	11	NA	5	31	30	41
	Untreated control	19	10	NA	3	27	22	37

*Few plant-parasitic nematodes (root-knot, spiral and stubby nematodes) were observed in this field.
NA: not available

C2. Free-living nematode soil population/200 cc soil in 2023-2024 (conventional, Plant City)								
Location	Treatment	Nov 8 2023	Dec 22 2023	Jan 5 2024	Jan 19 2024	Feb 2 2024	Feb 16 2024	March 1 2024
McIntosh Rd.	Grower program	357	NA	613	381	530	895	578
	Untreated control	253	NA	526	483	661	929	476
Tanner Rd.	Grower program	529	200	NA	544	670	1038	1064
	Untreated control	289	298	NA	616	678	700	1093

Fig. 1. Sting nematode infestation in two organic strawberry fields, showing stunted plants and short stubby roots (2023-24 season)