# Summer cover crops as an integrated pest management strategy in Florida strawberry production: relationship between weeds and nematodes

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## Summary

**Planting cover crops during summer between strawberry seasons has many benefits including preventing soil erosion, improving soil fertility and health, and potentially reducing plant-parasitic nematode populations and weeds. This report will summarize data from the GCREC on (1) a cover crop field trial, and (2) a weed greenhouse trial.**

**(1) Cover crops, including mixtures, were evaluated in a small-plot field trial at Balm. All cover crops had greater ground coverage and less purple nutsedge than the weedy fallow. Sting and stubby root nematodes were increased after sorghum sudangrass, and root-knot nematodes were highest in the weedy fallow. There was no effect on total N, and while organic matter was slightly increased for all treaments, soil pH was reduced especially in the weedy fallow. (2) In the weed study, carolina geranium and false daisey were good hosts for all three nematodes tested (sting, root-knot and lesion). Bermudagrass and yellow nutsedge were good hosts for sting and lesion, and purple nutsedge for sting. Carpet weed was a good host for root-knot, and Florida pusley, ragweed and sandbur were poor hosts for all three nematodes. We were unable to set-up summer cover crop trials in grower's fields due to Covid-19 restrictions.**

## Methods

### Small-Plot Field Trial

In Spring 2019, a small-plot field trial was conducted at the Gulf Coast Research and Education Center to identify a summer cover crop mix to suppress plant-parasitic nematodes and enhance soil health. The trial was conducted following a strawberry crop, and on a field with a history of sting nematode infestation and heavy weed pressure.

**Figure 1**. Strawberry field at the Gulf Coast Research and Education Center showing heavy sting nematode damage.

In early April 2019 the previous season's strawberry field was tilled and flattened. Plots (6 feet by 4 feet) were marked off using wooden stakes. Six replicate plots were planted in a randomized complete block design with one of the following cover crop mixes:

1. Sunnhemp (50 lb/A)
2. Sunnhemp (25 lb/A) + Marigold (2.5 lb/A)
3. Southern Pea (15 lb/A)
4. Southern Pea (7.5 lb/A) + Marigold (2.5 lb/A)
5. Sunnhemp (25 lb/A) + Southern Pea (7.5 lb/A)

6. Sunnhemp (16.7 lb/A) + Southern Pea (5 lb/A) + Marigold (1.7 lb/A)
7. Sorghum Sudangrass (30 lb/A)
8. Weedy fallow

In late June 2019 the cover crop was chopped down and tilled into the soil to a depth of 6 inches.

Ground cover was measured weekly using a handheld GreenSeeker™ during the first four weeks of crop establishment. Soil populations of sting and other nematodes were analyzed prior to planting the cover crops, prior to tilling the cover crops, and one month after the cover crops were tilled into the soil. Soil nutrient analyses were performed prior to planting the cover crops as well as one month after the cover crops were tilled into the soil. Weed species growing within plots were quantified prior to tilling the cover crops.

**Common Weed Host Status to Nematodes**

A series of growth chamber experiments were performed from 2019 - 2020 to determine the host range of different weeds to the three most common and most damaging nematodes in Florida strawberries, sting, root-knot, and root-lesion nematodes. We believe this research is essential to understanding the relationship between weeds and nematodes through the summer cropping season to develop better integrated management practices. This study will demonstrate if common weeds found in Florida strawberry fields are acting as a 'refuge' for nematodes during the summer months between winter production seasons.

Steam-sterilized field soil was inoculated with one of three different nematodes: (1) sting nematode (20 *Belonolaimus longicaudatus* per 200 mL soil), (2) root-knot nematode (250 *Meloidogyne hapla* per 200 mL soil), or (3) root-lesion nematode (100 *Pratylenchus penetrans* per 200 mL soil). For each nematode, six replicate 5-inch plastic pots were filled with nematode-infested soil and planted with one of the following weeds: yellow nutsedge, purple nutsedge, carolina geranium, Bermuda grass, purslane, Florida pusley, ragweed, sandbur, false daisy, and carpetweed. A fallow (no crop) treatment as well as pots planted with strawberry were included as controls.

The weeds were grown in a growth chamber at 72 °F for 12 weeks prior to subsequent analysis. At harvest nematode reproductive factor was calculated (final nematode population density/initial nematode population density). The entire experiment was performed twice.

## Results

**Small-Plot Field Trial**

At the time of planting, sting nematode populations did not differ among plots, with population densities ranging from 2-6 nematodes per 200 mL of soil.

**Figure 2**. Small-plot field trial at the Gulf Coast Research and Education Center with different cover crop mixes growing in sting-nematode infested soil.

Pre-till and post-till population densities were not different, except in the Sorghum sudangrass plots, which had higher sting nematode populations than other plots (Table 1). Also stubby root nematodes were increased with Sorghum sudangrass compared to other cover crops (Table 2). Stubby root nematodes are common in strawberry fields, but little is known about their damage potential. Root-knot nematodes (the rice root-knot nematode, *Meloidogyne graminicola*) were also detected, especially in the weedy fallow (Table 3). Unlike the northern root-knot nematode *M. hapla*, the rice root-knot nematode is not knowm to cause damage to strawberries, but is common in turf and was probably associated with nutsedge in the weedy fallow.

Prior to tilling the cover crops into the soil, the abundance of purple nutsedge shoots was significantly lower in the Southern Pea + Marigold treatment relative to that of the Weedy Fallow (Table 4). All cover crop mixes increased ground coverage relative to that of the weedy fallow (Table 5); however, coverage was greatest in the Sorghum Sudangrass treatment. Of all cover crops, marigold had poorest growth.

At the time of planting, pH, soil organic matter content and total nitrogen content did not differ among the plots (Table 6). One month after tilling the cover crops, no effect on total N was noted for any of the treatments. Organic matter was slightly increased for all treaments, with sunn hemp + southern pea having the highest increase. Soil pH was lowest following the weedy fallow, and similar for all planted cover crops (Table 6). Table 7 summarizes the nematode host status of different cover crop species from an earlier greenhouse study (and from which species used in the micro-plot study were selected).

**Common Weed Host Status to Nematodes**

In the nematode-weed study, carolina geranium and false daisey were good hosts for all three nematodes (sting, northen root-knot and northern lesion) (Tables 8, 9 and 10). Bermudagrass and yellow nutsedge were good hosts for sting and northern lesion nematodes, and purple nutsedge was a good host for sting nematode. Carpet weed was a good host for northern root-knot nematode, and Florida pusley, ragweed and sandbur were poor hosts for all three nematodes Tables 8, 9 and 10). **Table 11** summarizes the nematode host status of the different weeds.

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**Table 1**. Impact of summer cover crop mixes on sting nematode population densities, GCREC, 2019.

| | Sting Nematode per 200 mL soil | | |
|---|---|---|---|
| **Cover Crop Mix** | **At Plant** | **Pre-Till** | **Post-Till** |
| Sunnhemp | 3 | 1 b | 3 |
| Sunnhemp + Marigold | 2 | 2 b | 1 |
| Southern Pea | 3 | 5 ab | 3 |
| Southern Pea + Marigold | 6 | 5 ab | 4 |
| Sunnhemp + Southern Pea | 5 | 4 ab | 1 |
| Sunnhemp + Southern Pea + Marigold | 3 | 4 ab | 5 |
| Sorghum Sudan | 2 | 19 a | 9 |
| Weedy Fallow | 3 | 3 ab | 5 |
| ***P*-value** | 0.219 | 0.044 | 0.397 |

**Table 2**. Impact of summer cover crop mixes on stubby root nematode population densities, GCREC, 2019.

| | Stubby Root Nematode per 200 mL soil | | |
|---|---|---|---|
| **Cover Crop Mix** | **At Plant** | **Pre-Till** | **Post-Till** |
| Sunnhemp | 3 | 3 ab | 6 ab |
| Sunnhemp + Marigold | 2 | 3 ab | 5 b |
| Southern Pea | 4 | 2 b | 5 ab |
| Southern Pea + Marigold | 2 | 4 ab | 3 b |
| Sunnhemp + Southern Pea | 5 | 2 b | 6 ab |
| Sunnhemp + Southern Pea + Marigold | 7 | 3 ab | 4 b |
| Sorghum Sudan | 3 | 23 a | 16 a |
| Weedy Fallow | 5 | 5 ab | 7 ab |
| ***P*-value** | 0.485 | 0.037 | 0.023 |

**Table 3**. Impact of summer cover crop mixes on root-knot nematode population densities, GCREC, 2019.

| | Root-knot Nematode per 200 mL soil | | |
|---|---|---|---|
| **Cover Crop Mix** | **At Plant** | **Pre-Till** | **Post-Till** |
| Sunnhemp | 1 | 0 b | 0 |
| Sunnhemp + Marigold | 0 | 0 b | 3 |
| Southern Pea | 0 | 1 ab | 0 |
| Southern Pea + Marigold | 1 | 0 b | 0 |
| Sunnhemp + Southern Pea | 0 | 0 b | 0 |
| Sunnhemp + Southern Pea + Marigold | 0 | 0 b | 1 |
| Sorghum Sudan | 1 | 1 ab | 1 |
| Weedy Fallow | 1 | 11 a | 3 |
| ***P*-value** | 0.548 | 0.046 | 0.195 |

**Table 4**. Impact of prospective summer cover crop mixes on common weeds.

| | Weeds (# per plot) | | | |
|---|---|---|---|---|
| **Cover Crop Mix** | **Purple Nutsedge** | **Crab Grass** | **Pigweed** | **Pusley** |
| Sunnhemp | 53 ab | 25 | 3 | 3 |
| Sunnhemp + Marigold | 79 ab | 16 | 3 | 10 |
| Southern Pea | 58 ab | 24 | 6 | 7 |
| Southern Pea + Marigold | 17 b | 26 | 10 | 10 |
| Sunnhemp + Southern Pea | 56 ab | 16 | 4 | 8 |
| Sunnhemp + Southern Pea + Marigold | 46 ab | 41 | 6 | 9 |
| Sorghum Sudan | 54 ab | 10 | 7 | 13 |
| Weedy Fallow | 122 a | 31 | 4 | 10 |
| ***P*-value** | 0.027 | 0.075 | 0.682 | 0.463 |

**Table 5**. Ground cover by prospective summer cover crop mixes. NDVI refers to normalized difference vegetation index and WAP refers to weeks after planting.

| | Ground Cover (NDVI value) | | | |
|---|---|---|---|---|
| **Cover Crop Mix** | **1 WAP** | **2 WAP** | **3 WAP** | **4 WAP** |
| Sunnhemp | 0.23 ab | 0.50 ab | 0.60 b | 0.63 a |
| Sunnhemp + Marigold | 0.20 bc | 0.43 bc | 0.58 b | 0.62 a |
| Southern Pea | 0.15 de | 0.32 d | 0.61 b | 0.66 a |
| Southern Pea + Marigold | 0.15 e | 0.36 cd | 0.63 ab | 0.67 a |
| Sunnhemp + Southern Pea | 0.20 bc | 0.44 bc | 0.60 b | 0.63 a |
| Sunnhemp + Southern Pea + Marigold | 0.18 cd | 0.44 bc | 0.63 ab | 0.68 a |
| Sorghum Sudan | 0.24 a | 0.55 a | 0.70 a | 0.75 a |
| Weedy Fallow | 0.13 e | 0.27 d | 0.44 c | 0.52 b |
| ***P*-value** | <0.001 | <0.001 | <0.001 | 0.031 |

**Table 6**. Impact of summer cover crop mixes on soil nutrition.

| | pH | | Organic Matter (%) | | Total Nitrogen (%) | |
|---|---|---|---|---|---|---|
| **Cover Crop Mix** | **At Plant** | **Post-Till** | **At Plant** | **Post-Till** | **AtPlant** | **Post-Till** |
| Sunnhemp | 7.2 | 6.8 ab | 0.80 | 0.9 ab | 0.03 | 0.03 |
| Sunnhemp + Marigold | 7.2 | 6.9 a | 0.80 | 1.0 ab | 0.02 | 0.03 |
| Southern Pea | 7.1 | 6.7 ab | 0.80 | 0.8 b | 0.02 | 0.03 |
| Southern Pea + Marigold | 7.2 | 6.9 a | 0.90 | 1.0 ab | 0.03 | 0.03 |
| Sunnhemp + Southern Pea | 7.2 | 6.7 ab | 0.90 | 1.1 a | 0.03 | 0.03 |
| Sunnhemp + Southern Pea + Marigold | 7.2 | 6.7 ab | 0.80 | 0.9 ab | 0.02 | 0.03 |
| Sorghum Sudan | 7.2 | 7.0 a | 0.80 | 1.0 ab | 0.03 | 0.03 |
| Weedy Fallow | 7.1 | 6.2 b | 0.90 | 0.9 ab | 0.03 | 0.03 |
| ***P*-value** | 0.995 | 0.017 | 0.130 | 0.046 | 0.572 | 0.765 |

**Table 7.** Cover crop host status summary to sting nematode, northern root-knot nematode, and northern root-lesion nematode and plant biomass produced.

| | | Nematode Host Status[a] | | | |
|---|---|---|---|---|---|
| **Common Name** | **Genus and Species** | **Sting Nematode** | **Northern Root-Knot Nematode** | **Northern Root-Lesion Nematode** | **Plant Biomass** |
| Buckwheat | *Fagopyrum esculentum* | Good | Moderate | Moderate | Low |
| Goat's Rue | *Tephrosia virginiana* | Poor | Poor | Poor | Low |
| Marigold | *Tagetes patula* | Good | Poor | Poor | Low |
| Mexican Sunflower | *Tithonia diversifolia* | Good | Poor | Good | Low |
| Millet | *Setaria italica* | Good | Poor | Poor | Low |
| Pearl Millet | *Pennisetum glaucum* | Good | Poor | Poor | Low |
| Radish | *Raphanus sativus* | Good | Moderate | Good | Low |
| Sesame | *Sesamum indicum* | Poor | Poor | Moderate | Low |
| Sorghum Sudangrass (AS6201) | *Sorghum bicolor* x *S. sudanese* | Good | Poor | Moderate | High |
| Sorghum Sudangrass (AS6401) | *S. bicolor* x *S. sudanese* | Good | Poor | Moderate | High |
| Cowpea | *Vigna unguiculate* | Good | Good | Poor | High |
| Sugar Beet | *Beta vulgaris* | Poor | Poor | Poor | Low |
| Sunflower | *Helianthus annuus* | Good | Poor | Good | Low |
| Sunnhemp | *Crotalaria juncea* | Poor | Poor | Moderate | High |

[a] Good (reproductive factor >1.0), Moderate (reproductive factor 0.99-0.5), Poor (reproductive factor <0.5).

**Table 8**. Nematode host status of strawberry weeds for lesion nematode (*Pratylenchus penetrans*).

| Crop | *P. penetrans* / 200 mL soil | *P. penetrans* / root system | Reproductive Factor (*Pf*/*Pi*) |
|---|---|---|---|
| Fallow | 3 ab | 0 b | <0.1 c |
| Bermuda Grass | 182 a | 392 ab | 2.2 abc |
| Carolina Geranium | 140 ab | 1204 a | 3.2 a |
| Carpetweed | 4 ab | 1 b | <0.1 c |
| False Daisey | 84 ab | 1159 a | 2.6 ab |
| Purple Nutsedge | 2 b | 30 b | <0.1 c |
| Pusley | 2 b | 6 b | <0.1 c |
| Ragweed | 1 b | 0 b | <0.1 c |
| Sandbur | 14 ab | 154 b | 0.4 bc |
| Yellow Nutsedge | 154 ab | 70 b | 1.4 abc |
| Strawberry | 126 ab | 1232 a | 3.1 a |
| ***P*-value** | <0.001 | <0.001 | <0.001 |

**Table 9**. Nematode host status of strawberry weeds for root-knot nematode (*Meloidogyne hapla*).

| Crop | *M. hapla* / 200 mL soil | *M. hapla* eggs / root system | Reproductive Factor (Pf/Pi) |
|---|---|---|---|
| Fallow | 1 c | 0 d | <0.1 d |
| Bermuda Grass | 3 c | 0 d | <0.1 d |
| Carolina Geranium | 243 b | 6699 b | 3.2 b |
| Carpetweed | 348 ab | 693 cd | 1.0 cd |
| False Daisey | 444 a | 11840 a | 5.6 a |
| Purple Nutsedge | 1 c | 91 d | <0.1 d |
| Pusley | 17 c | 173 d | 0.1 d |
| Ragweed | 1 c | 0 d | <0.1 d |
| Sandbur | 1 c | 0 d | <0.1 d |
| Yellow Nutsedge | 0 c | 0 d | 0 d |
| Strawberry | 476 a | 4641 bc | 2.8 bc |
| ***P*-value** | <0.001 | <0.001 | <0.001 |

**Table 10**. Nematode host status of strawberry weeds for sting nematode (*Belonolaimus longicaudatus*).

| Crop | *B. longicaudatus* / 200 mL soil | Reproductive Factor (Pf/Pi) |
|---|---|---|
| Fallow | 1 c | <0.1 c |
| Bermuda Grass | 87 b | 3.5 b |
| Carolina Geranium | 92 b | 3.7 b |
| Carpetweed | 1 c | <0.1 c |
| False Daisey | 61 bc | 2.4 bc |
| Purple Nutsedge | 49 bc | 1.9 bc |
| Pusley | 1 c | <0.1 c |
| Ragweed | 1 c | <0.1 c |
| Sandbur | 0 c | 0 c |
| Yellow Nutsedge | 38 bc | 1.5 bc |
| Strawberry | 244 a | 9.8 a |
| ***P*-value** | <0.001 | <0.001 |

**Table 11.** Host status summary of common weeds to sting nematode, northern root-knot nematode, and northern root-lesion nematode.

| | | Nematode Host Status[a] | | |
|---|---|---|---|---|
| **Common Name** | **Genus and Species** | **Sting Nematode** | **Northern Root-Knot Nematode** | **Northern Root-Lesion Nematode** |
| Bermuda Grass | *Cynodon dactylon* | Good | Poor | Good |
| Carolina Geranium | *Geranium carolinianum* | Good | Good | Good |
| Carpetweed | *Mollugo verticillate* | Poor | Good | Poor |
| False Daisey | *Eclipta prostrata* | Good | Good | Good |
| Purple Nutsedge | *Cyperus rotundus* | Good | Poor | Poor |
| Florida Pusley | *Richardia scabra* | Poor | Poor | Poor |
| Ragweed | *Ambrosia artemisiifolia* | Poor | Poor | Poor |
| Sandbur | *Cenchrus echinatus* | Poor | Poor | Poor |
| Yellow Nutsedge | *Cyperus esculentus* | Good | Poor | Good |

[a] Good (reproductive factor >1.0), Moderate (reproductive factor 0.99-0.5), Poor (reproductive factor <0.5).