Sting Nematode: A Reoccurring Problem in Florida Strawberry and a New Understanding of Why?

J.W. Noling
University of Florida, IFAS, Citrus Research & Education Center,
Lake Alfred, FL 33850

ABSTRACT: In order to determine the cause for such poor and inconsistent crop performance after soil fumigation with a variety of different fumigants, a variety of strawberry field experiments were conducted to characterize the soil depths to which sting and root-knot nematodes reside and the depths to which soil fumigants diffuse. This research has demonstrated that these nematodes, for whatever reason, migrate to deeper soil during the hot summer months. What could be an apparent thermal escape mechanism appears to contribute to the nematodes survival in more ways that just heat avoidance. The presence of a subsurface traffic pan (a dense, highly compacted soil layer), was also shown to form a <u>very effective</u> impermeable layer to gas diffusion defining the fumigant treated zone as only the plant bed and not penetrating to the deep soil profiles below the raised bed where nematodes reside. Nematodes physically escape fumigant treatment because the fumigant never even gets close to them following treatment. Research is currently underway testing a new deep shank fumigant delivery system in which to target soil treatments to the depths where nematode occur in soil.

As everybody knows, the sting nematode is a very destructive and economically important pest of Florida strawberry. Since 1996, we have worked very hard trying to manage Sting nematode populations and the damage it causes within grower fields. I am very aware of the fact that a really good solution has eluded us. In recent years, none of the soil fumigants that we have been field evaluating at FSGA or in demonstration trials within grower fields have consistently provided season-long protection from the sting nematode. In many of these fields, the problem reoccurs even when additional fumigant treatments including spring crop termination and summer broadcast applications of 1, 3-D (Telone) have been used in hopes of preventing its reoccurrence. And need I say, the problem seems to be increasing, not only with expansion of infested acreage within fields where it has been a historic problem but also into new fields.

In order to determine the cause for such poor and inconsistent crop performance after soil fumigation with a variety of different fumigants, field surveys were conducted within these sting nematode problem fields. In these surveys, a compacted zone (traffic pan) was observed to occur just below the base of the raised bed. The presence of subsurface traffic pans (a dense, highly compacted soil layer), was shown to unavoidably cause changes in the downward percolation of water, permeability to fumigant gases, and root penetration into soil. In practical terms, the compaction zone occurs just below the depth of the deepest tillage operation or implement used in the field. Previous research has demonstrated that unless completely destroyed by deep ripping or subsoiling prior to soil fumigant injection, the presence of an undisturbed soil compaction layer almost completely restricts downward diffusion in soil of Telone when it is applied above the restrictive layer.

This past spring we introduced some new equipment into the research program. We commissioned Hartline Fabrication to build the *Probinator*. The Probinator is best described as a deep coring, soil sampling system (**Figure 1**) capable of removing a 4 inch diameter by 40 inch deep soil core using a specialized probe and hydraulic ram system. The Probinator is tractor mounted as a 3 point attachment. The Probinator (Figure 1A) is allowing us to study, without back-breaking effort, the depth distribution of nematodes, spatial movement of soil fumigants from their points of emission, causes of fumigant treatment inconsistency and origins of bed recolonizing populations of nematodes. We have been using the Probinator system to collect monthly census samples to determine the depths to which Sting nematode occurs in soil. We subdivide the core into 1 foot soil increments, and then process and count nematodes within each of the increments from samples taken at the Florida Strawberry Growers Research and Education Foundation Farm (FSREF) in Dover, FL. The June 2014 data reported here derive from soil samples procured from an overall depth of 3 feet, from uncovered fallow, stale beds. Additional soil samples to assess depths and nematode population levels were collected from another farm, the DB Farm, in Barberville, FL. At this farm a drip fumigation treatment with Telone EC (18 gpa) was applied as a crop termination treatment to the previous strawberry crop, the plastic pulled and field disked, and then laid bare fallow for 2 months to reduce Sting and Root-knot nematode populations which had severely damaged the crop in this field.

The nematode assay results from soil census sampling at FSGREF from the fallow, stale (uncovered) beds showed that Sting nematodes could be detected at low levels to a depth of 36 inches from the soil surface (**Figure 2**). Highest nematode population densities were observed immediately below the traffic pan in the 13 to 24 inch soil depth category. Soil population density and depth distribution of the Root-knot nematode *Meloidogyne hapla* within the same 12 inch soil increments at the DB Farm in Barberville is illustrated in **Figure 3**. The results from these samples show the absence of nematode in the surface 12 inches of soil following the Telone EC crop termination treatment and 2 month bare fallow period (**Figure 3**). Surprisingly, highest populations of root-knot nematode were observed at the deepest soil depth of 25 to 36 inch soil depth. It would appear that the fumigant treatment and the summer fallow period were very effective in reducing nematode populations in surface soil horizons, and that *M. hapla* migrates to deeper soil during the hot summer months. It seems that this apparent thermal escape mechanism contributes to the nematodes survival in more ways that just heat avoidance.

The Probinator was also trialed in spring experiments during 2014 to evaluate the diffusion of Telone EC gases throughout the surface to 36 inch soil depth. In the first experiment, Telone EC (12 gpa) was applied at the MB farm on April 2, 2014 as a drip fumigant to terminate the strawberry crop which had been severely damage by the Sting nematode. In the second fumigation experiment, Telone II (18 gpa) was custom applied at the DB farm using deep ripper shanks spaced on 12 inch spacing to a depth of 15 inches. Following shank application, the soil was simply rolled to establish a soil seal over the shank trace to minimize premature escape of fumigant gases. After drip and or deep shank fumigant application, distribution of 1, 3-dichloropropene gases within our soil probe were incrementally measured using a MiniRae® 2000 PID VOC meter. Our intent was to characterize soil air concentrations, retention characteristics of Telone II (1,3-D) over time, as well as relative differences in vertical, gas phase movement of the fumigant with time.

Comparison of Telone gas concentrations in soil strata above and below the 14 inch traffic pan at the MB farm is illustrated in **Figure 4**. At 3 days post application, highest 1,3-D concentrations were contained within the covered plant bed, with concentration diminishing toward the plant holes within the plastic at the surface. Very low soil air concentrations were observed below the traffic pan positioned at a 14 inch soil depth below the top crown of the 12.5 inch raised plant bed. These data would strongly suggest only very limited movement Telone EC in the water phase or as gas diffusion through the highly impermeable traffic pan. An example of typical fumigant concentrations in soil air observed above and below a compacted strawberry traffic pan shortly after drip or shank application of the bed to a soil depth of 8 to 12 inches is illustrated in **Figure 5**. The 14 inch traffic pan forms a very effective impermeable layer to gas diffusion defining the fumigant treated zone as only the plant bed and not penetrating to the deep soil profiles where nematodes reside. Nematodes physically escape fumigant treatment because the fumigant never even gets close to them following treatment.

Similar results were obtained at the DB farm site. At this site, 1,3-D concentrations within the shank trace and midway between ripper shanks to a depth of 36 inches is presented in **Figure 6**. These data show that highest 1.3-D soil air concentrations occur at or near the 15 inch depth of application. However, very little of the gases diffuse either laterally or into deep soil below the injection depth and that the majority of soil gases move up and out of the bed via the poorly sealed shank trace. These results appear to demonstrate that not all growers may benefit from deep shank, broadcast application methods that destroy the gas impermeable traffic pan because of the rapid escape of gases back up the roller sealed shank trace. These results would suggest that new, even deeper application and sealing methods will be required to force fumigant movement deeper in soil to improve overall nematode control, particularly into deeper soil horizons where they are being observed to reside, and also improve crop yield response consistency.

Let me conclude by saying that I think things are looking up. For reasons unknown, we have learned that the sting nematode takes the plunge into deeper soil at the end of the strawberry crop. It could be a simple escape mechanism on the part of the nematode to avoid large swings in temperature and moisture. Who really knows but it sounds good to me. The amazing thing is that it now also escapes the fumigant which it could not have done as easily with methyl bromide which didn't care if there was a traffic pan or not as it raced into deep soil. If you think about the time table of events, we fumigate and then plant 30 days later. We irrigate heavily during the '*living-in period*', leaching all of those scents and bouquets of food above, and then what happens 30 days later, the reported interval required to move 3 feet in soil, the nematode reappears. Now, in a very hungry state. What we need now is a new system in which to target treatments to the subterranean hideouts of the nematode. We have been testing said equipment, we like what we are seeing, and it will form the subject of my next newsletter.

Figure 1. The Probinator (A), a hydraulically operated deep soil probe (B) used to study the depth distribution of nematodes, spatial movement of soil fumigants (C), and to identify causes of fumigant treatment inconsistency and origins of bed recolonizing populations of nematodes.

http://www.crec.ifas.ufl.edu/extension/saap/videos/video.zip

Figure 2. Soil population density and depth distribution of the Sting nematode, *Belonolaimus longicaudatus,* observed within 1 foot soil increments at the Florida Strawberry Growers Research and Education Foundation Farm Dover, FL. Soil samples procured from an overall depth of 3 feet, from uncovered fallow, stale beds. Data represent the means and standard error of 8 replicate samples.

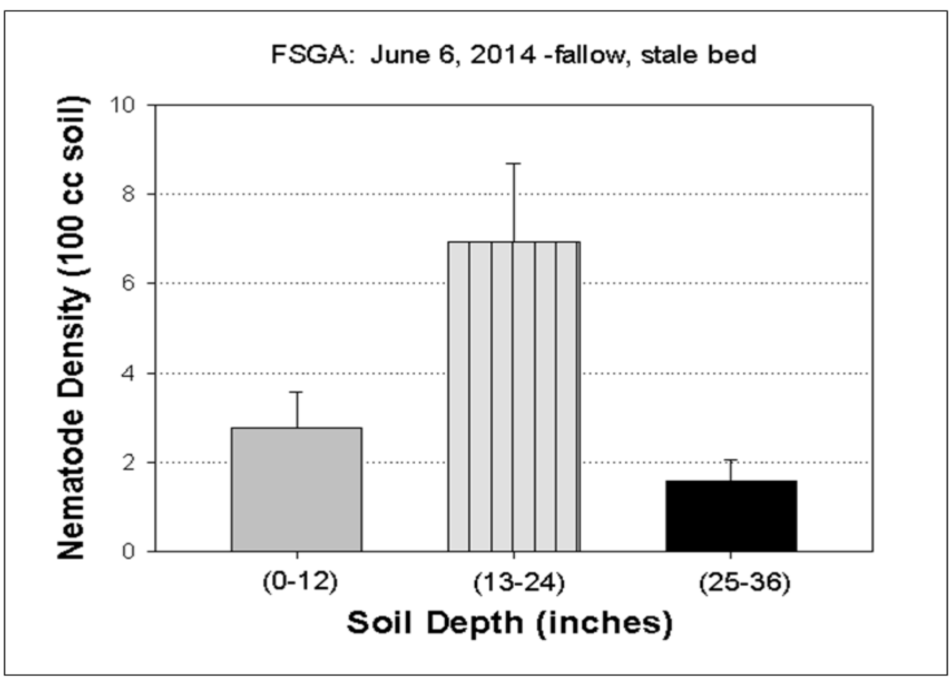

Figure 3. Soil population density and depth distribution of the root-knot nematode, *Meloidogyne hapla,* within 1 foot soil increments at the DB Farm, Plant City, FL. Soil samples procured to an overall soil depth of 3 feet following crop termination-drip fumigation treatment (April) and two month period of bare summer fallow. Data represent the means and standard error of 8 replicate samples.

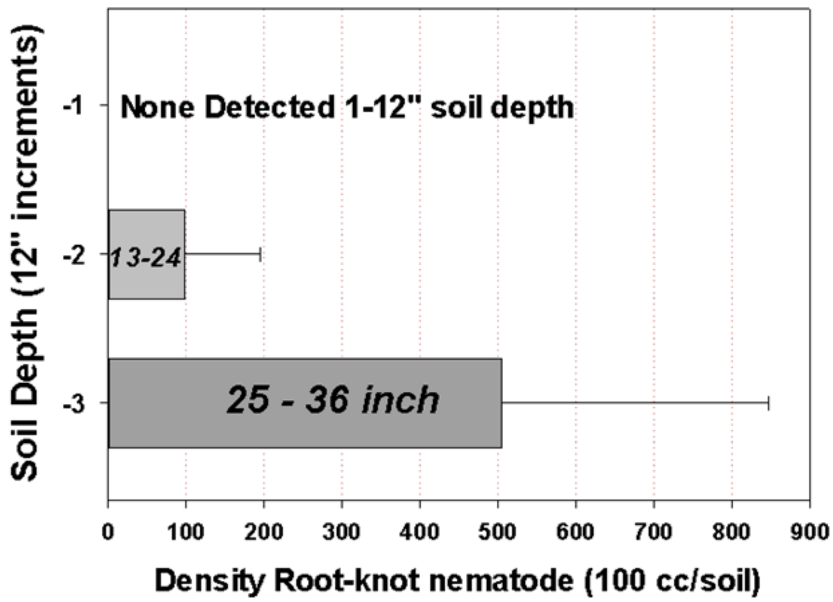

Fig. 4. Concentration Isobutylene in soil strata above and below a 14 inch traffic pan. Soil air measurement obtained thru center of a $12^{1/2}$ " raised, mulch covered bed 3 days post application Telone EC (12 gpa). Data points are means & S.E. 8 reps MB farm, Dover, FL

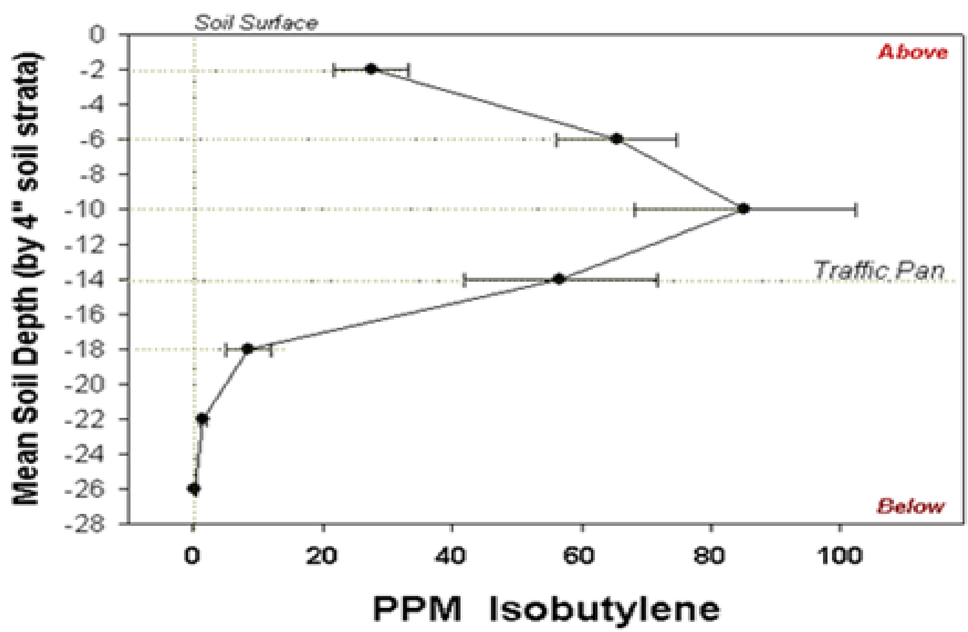

Figure 5. Illustrated example of typical fumigant concentrations in soil air observed above and below a compacted strawberry traffic pan shortly after drip fumigation or shank injection to a soil depth of 8-12 inches. Thecompacted traffic pan acts as a very effective impermeable layer to fumigant gas diffusion into deep soil profile.

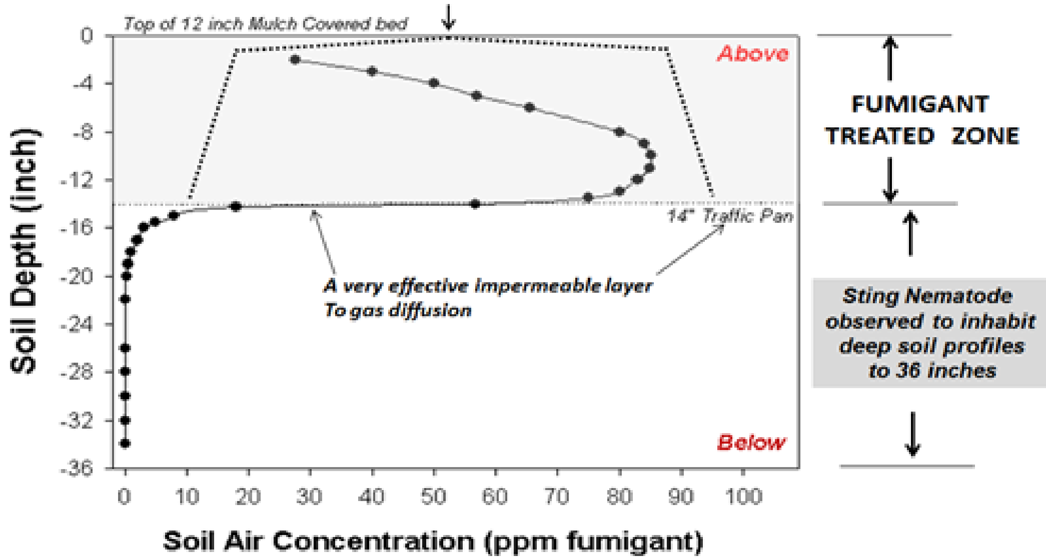

Figure 6. Fumigant Gas Concentration within the Shank Trace and midway between ripper shanks to a soil depth of 36 inches. Telone II fumigant broadcast and deep ripper shank applied (18 gpa) to a 15 inch soil depth. Datapoints are means and standard errors of 4 replicate observations. Plant City, FL. 1 DAA - July 12, 2014