Enhancing Strawberry Yields Using Vertical Management Zones for Nematode Control

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Since the phase-out of methyl bromide (MBr) in 2015, a reliable and consistent soilborne pest and disease control program has not been fully established, with incidence and severity of nematode problem fields increasing in Florida. Unlike MBr, the alternative fumigants, with current application methods, are unable to distribute vertically below a traffic pan, located just below the level of the raised bed. The presence of the subsurface traffic pan (a dense, highly compacted soil layer), has been shown to restrict hydraulic conductivity, permeability to fumigant gases, and crop root penetration into deeper soil. We believe that treating these different vertical zones, those above and below the traffic pan, is critical for nematode control and for sustaining crop production.

Methods: During 2015, field studies were initiated to demonstrate the importance of deep fumigant placement and need for considering sting nematode control as a composite of vertical management zones (**Figure 1**). Two different tractor mounted hydraulic soil sampling probes, extracting either 3.8 or 10 cm soil cores 122 cm deep were used to characterize the spatial distribution of plant pathogenic nematodes in commercial strawberry fields employing a variety of crop and nematode management practices. The results from these field samplings have repeatedly shown that sting and or root-knot nematode can inhabit very deep soil profiles, below the traffic pan and well below the depths to which any of the current shank or drip applied fumigants diffuse. The depths to which nematodes reside are also below depths where plant roots are found and well below depths that are typically ever sampled for nematodes. To target deep soil profiles, new fumigant application systems were developed to make deep shank or deep drip fumigant applications to a depth of 40 cm (16"). Three nematicide treatments including deep shank and or drip applications of 1,3-dichloropropene (Telone™; 140-168 L/ha), with or without a grower standard treatment to the plant bed, were evaluated in 10 commercial strawberry fields in Dover, FL. Each treatment was replicated, systematically in alternating 2 row plots, at least 6 times. Broadcast and in-row (strip) deep shank 1,3-D were evaluated in separate trials.

Fumigants were generally applied in a 2 step, sequential process consisting of targeted delivery of fumigants to the two different soil depths or vertical management zones. As a prebed treatment, the deep shank unit injected Telone II (15-18 gpta) to a depth of 15 inches to the flat which was then immediately followed by a grower application of their separately applied fumigant to the raised plant bed during the bedding operation. The bed was firmly pressed (sometimes twice) and the drip tape and mulch (usually an impermeable film) installed as a covering over the bed. The covering of the deep shank trace by the formation of the raised plant bed serves to impede rapid escape of deeply placed fumigant gases out of the bed. At the same time, the injection of the grower standard applied fumigant fills the raised bed with fumigant occupied airspace with their soil treatment. The covering of the bed with an impermeable mulch film not only serves to impede fumigant outgassing from the bed but we believe when coupled with the other factors, serves to encourage radial expansion of the deep shank applied fumigant into the deeper soil profiles where nematodes reside.

During fall 2015, five different experiments within nematode infested fields were deep drip fumigated using a subsurface drip line buried approximately 21 inches below the top of the mulch covered bed. The buried drip tape (Netafim 12", 10 mil, 0.36 gph@10 psi) was installed 15 inches deep to the flat prior to bedding during fall 2014. For all experiments, Telone EC (15 gpta) was injected over a 3 to 3.5 hour injection period followed by a 30 minute flush.

Results and Discussion: Soil population densities of sting and or root-knot nematode were significantly lower at seasons end with either deep drip or deep shank 1,3-D applications compared to the grower standard (data not shown). When the grower standard was applied to the raised plant bed, supplemental deep shank treatments of 1,3-D increased strawberry yields by as much as 9 to 29% in many of the fields **(Figure 2)**. Even without significant nematode pressure in the field, crop health, vigor, and appearance were always enhanced, and yields, though not significant in these instances, were always numerically higher in the supplemental deep shank or deep drip 1,3-D treatments compared to the grower standard. We believe a primary cause of inconsistent nematode control using MBr alternatives has been identified, and that supplement fumigant applications, which consider the importance of vertical management zones, will be required to manage nematode pests in Florida strawberry.

The presence of a traffic pan observed to occur just below the base of the raised, plastic mulch covered bed is another formidable barrier to diffusion of the alternative fumigants into deeper soil. In practical terms, the compacted traffic pan occurs just below the depth of the deepest tillage implement used in the field and has been shown to unavoidably cause changes in soil hydraulic conductivity, diffusion of fumigant gases, and thus soil fumigation efficacy and field distribution of nematodes and crop damage. We believe it is the presence of the traffic pan coupled with the differences in vapor pressure and boiling point which so limit soil movement and spatial distribution of the fumigant in soil which has resulted in the increase in root-knot nematode problems being reported in tomatoes and for the severe and reoccurring problems associated with sting nematode in Florida strawberry to specifically name but a few. The focus of today's presentation and proceedings paper is therefore to discuss new research tools being used that quantify the spatial distribution of nematodes and soil fumigants concentrations in soil air and how each of these factors are interrelated and contribute to what we believe are the inconsistencies in crop yield response to the alternative fumigants in Florida agriculture. It will conclude with the justification and need for developing new fumigant placement strategies that view nematode management as a composite and integration of vertical management zones.

Summary

Our research conceives soil fumigation as a 2 step process and as composite of vertical management zones for nematode control and for sustaining optimum crop production (**Figure 1**). The new approach separately targets fumigant treatments to areas above (Zone 1) and below the traffic pan (Zone 2). It differs from previous 2 way approaches in that prebed applications do not rely on coulter based systems which do not place the fumigant deep enough into the soil, beneath the traffic pan to address more deeply situated nematode populations. The potential importance of the deeply distributed reservoir of nematodes and their effects on subsequent plant growth are now being considered within the testing phases of new deep shank and subsurface drip application technologies for soil fumigants. These new systems are expected to improve fumigant penetration, overall nematode control and crop yield response consistency. Our strawberry results suggests that nematode damage potential to the crop occurs from migrating individuals from soil depths below which fumigants distribute. We would contend that the strawberry work provides a barometer for what we might expect to see in tomato and other Florida vegetable crops. Based on these findings, we believe we have identified the root causes of yield and nematode control inconsistencies associated with the alternative fumigants, and have the new technologies under evaluation which can help resolve these problems.

Figure 1.

Structuring Soil Pest & Disease Control

As a Composite of Vertical Management Zones

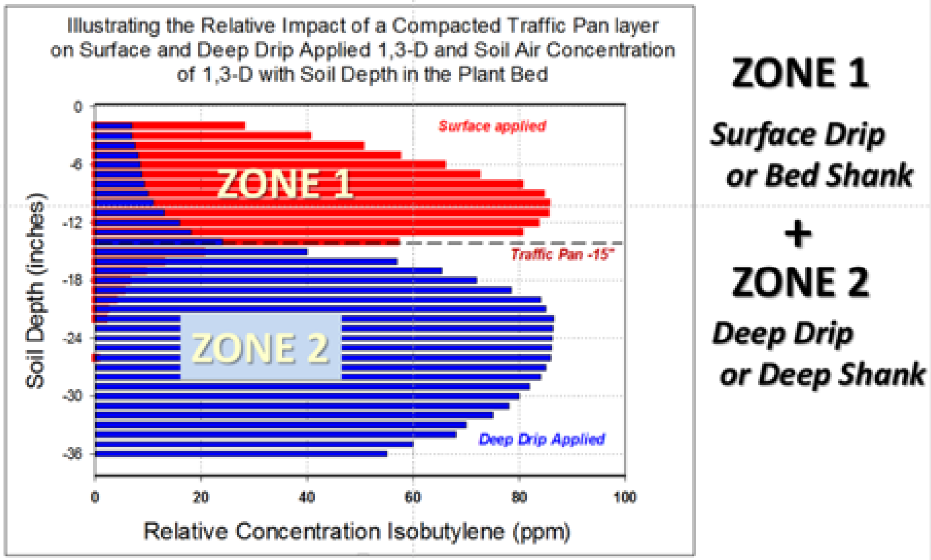

Figure 2. Strawberry relative yield responses to summer broadcast untarped deep shank (16"soil depth) applications of Telone II (18 gpta) or to tarped in-row deep shank (16") or deep subsurface drip (16") fumigation treatments at six, Sting nematode commercial strawberry fields in Dover FL during spring 2016. Relative strawberry yields based on complete enumeration and yield contribution of 4 plant canopy size categories dead (0), small (<20 cm canopy diameter), medium (>20 and < 30 cm) and large (>30 cm).