LARGE SCALE FIELD EVALUATIONS OF FUMIGANT ALTERNATIVES AND VERTICAL MANAGEMENT ZONES IN FLORIDA STRAWBERRY 2016-17

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This large scale field demonstration project was funded by a Florida Strawberry Growers Research and Education Foundation grant to demonstrate and improve the performance and consistency of soil and drip applied fumigants. More specifically, these studies were conducted to demonstrate the importance of deep fumigant placement and management of Sting nematode, *Belonolaimus longicaudatus*, as a composite of vertical management zones located above and below a gas impermeable traffic pan. To target deep soil profiles, new fumigant application systems were developed to shank inject fumigants 40 cm deep. Field trials were conducted at the Florida Strawberry Growers Research and Education Foundation Farm in Dover, FL and at other grower field demonstration sites in Plant City, Florida.

Methods: The fumigant treatments included deep shank applications of 1, 3-dichloropropene (Telone II™; 18.4 L/ha) with or without Telone C35 (46 L/ha), PicClor60 (38 L/ha), PicClor80 (35.2 L/ha), and Pic100 (33 L/ha) applied in-the-bed. The differing formulations allowed evaluation of increasing chloropicrin use rates from 21.4 to 45.9 kg/ha to effectively manage Sting nematode and Charcoal Rot, caused by *Macrophomina phaseolina*. Other fumigant treatments evaluated included bed shank and drip treatments of Paladin® Pic (79/21%) (46 L/ha), drip applied metam potassium (KPAM®; 95 L/ha) and allyl isothiocyanate (Dominus® 46 L/ha). An untreated control with and without the deep shank Telone II ™ (18.4 L/ha) treatment was included for comparison (**Table 1**). Drip fumigants were applied via specifically designed and constructed manifolds that the Principal Investigator built to ensure appropriate concentration and product distribution among replicated plots within the field. In general all drip fumigants were preceded by a 30 charge period, followed by a 3 hour injection period, and finished with a 30 flush period. The deep drip lines which were installed during the previous season and were to be used again these season were found to be defective midway through the fumigant injection period for the Telone EC application. Laser land leveling procedures which were conducted

in the field during the summer moved soil to and from different areas of the field which exposed deeply installed drip tubes to damage from disking operations during land preparation. The results from the two affected treatments were excluded from analysis.

At FSGA, the highly gas retentive Berry Plastics Total Blockade TIF, 1.25 mil was installed immediately after DMDS applications. All other fumigant applications were applied under Berry Plastics Blockade VIF mulch. All fumigants were applied with commercial grower equipment. Calibration procedures were followed certified applicators and pesticide label requirements for buffers, posting, rates of use, and personal protective equipment requirements were closely followed.

At FSGA, beds measured 30 inches wide, 12 inches in height, with rows spaced on 4 foot centers. Actual per acre fumigant use rates for represent 62.5% of the broadcast or reported per treated acre (ta) rates. At Favorite, bare root 'Sweet Sensation' transplants from Canadian nurseries were planted between 4 to 5 weeks following Telone EC treatment. Water and nutrients were supplied to each plant row with Netafim (0.26 gpm/100 ft on at least a daily/ twice daily basis (unless sufficient rainfall occurs) for much of the season. Fertigation rates were seasonally defined based on crop growth stage. Fertilization rates were generally based on a near field equivalent of 225 lbs NPK per acre per season. Other pest and disease control measures were maintained primarily on both a prophylactic and as needed basis.

Assessments of plant growth were made as appropriate during the course of the season to characterize differences in plant size, health, and vigor. Strawberry fruit were commercially harvested on a 2 to 3 day basis from early December 2016 through March 2017. Following chemical treatment, weed densities were monitored and recorded on a periodic basis to determine any differences in weed control between treatments. Counts were always low and are not reported. All treatments were arranged within their respective experimental areas as a completely randomized block design with 4 replications per treatment. Plot sizes were 2 rows 240 feet long or 0.03 acres for each treatment replication. Impact of each chemical treatment on nematode population densities within treated blocks were determined at final harvest by collecting twelve soil cores 1 inch in diameter by 12 inches deep from the root zone of each replicate block, extracting the nematodes from them and counting them by genera. Disease incidence (i.e., Anthracnose, Charcoal root rot, etc.) and severity also were visually determined and recorded at periodic intervals within each of replicate blocks by row and sprinkler section within each the different, chemically treated areas. Statistical analyses and treatment comparisons were determined statistically using SAS ANOVA PROC GLM ($P<0.05$).

Results and Discussion:

Strawberry yields were significantly (P<0.001) increased for each Telone Chloropicrin formulation applied to the plant bed when Telone II was deep shank applied below the traffic pan within vertical management zone 2 (**Figure 1**). A reduced level of response for Telone C35 with deep shank Telone II was observed and is thought to be attributed to repeated treatments to the same beds for two consecutive years of strawberry production. In other grower trials where deep shank treatments have been repeatedly applied for nematode control, yields were less responsive with each annual application suggesting an every other year application may only be required to manage nematodes in deep soil profiles to minimize strawberry crop losses. Strawberry yields increased 34% above that of the untreated control following only the deep shank Telone II treatment (18.4 L/ha).). Strawberry yields increased 34% above that of the untreated control following only the deep shank Telone II treatment (18 gpta) (18.4 L/ha). Additional yield increases of 36 to 54 percent were observed when the deep shank treatment was supplemented with an in-the-bed fumigant treatment using the different formulations of Telone and Chloropicrin (**Figure 2**). Additional yield increases of 10 to 34 percent were observed when the deep shank alone treatment was supplemented with an in-the-bed fumigant treatment of either Telone C35, Pic Clor 60, Pic Clor 80 or TriPic 100 (**Figure 3**).

Strawberry yields were unresponsive to application rates of chloropicrin greater than 21.4 kg/ha (**Figure 4**). This was partially attributed to the reduced level of Sting nematode control with increasing rates of chloropicrin application to the plant bed (vertical management zone 1) (**Figure 5**). Additional chloropicrin in itself did not reduce disease induced plant mortality at season's end, but deep shanking Telone II significantly reduced final harvest Sting nematode populations compared to the untreated controls or in-the-bed only fumigant treatments (**Figure 5**). KPAM® and Dominus® produced strawberry yields equivalent to that of the untreated control (**Figure 1**).

Summary: Use of deep shank Telone II (18.4 L/ha) has largely resolved Sting Nematode induced yield losses in FL strawberry. We believe a primary cause of inconsistent nematode control using methyl bromide 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.

KEY POINTS:

- Strawberry yields were significantly increased for each Telone Chloropicrin formulation applied to the plant bed (Vertical Management Zone 1) when Telone II was deep shank applied below the bed and traffic pan within vertical management zone 2.

- The Value Added (20 - 34%) is clearly demonstrated with comparison of each formulation and Untreated Control With and Without Deep Shank Telone

- Strawberry yields were unresponsive to application rates of chloropicrin greater than 21.4 kg/ha.

- We believe primary cause of inconsistent yields and nematode control with alternatives has been identified and resolved with adoption of Vertical Management Zones!

Table 1. Treatment List for Florida Strawberry Growers Association Research and Educational Foundation Farm trial in Dover, FL conducted Fall 2016 through Spring 2017.

1. Telone C35 + Deep Drip	DRIP	+ TIF	350 lb/ta
2. Telone C35 (30 gpta)	SHANK	+ VIF	30 gpta
3. Telone C35 + Deep Telone II	SHANK	+ VIF	30 gpta +12 gpta
4. Pic Clor 60	SHANK	+ VIF	300 lb/ta
5. Pic Clor 60 + Deep Telone II	SHANK	+ VIF	300 lb/ta +12gpta
6. Pic 80	SHANK	+ VIF	23 gpta
7. Pic 80 + Deep Telone II	SHANK	+ VIF	23 gpta+12 gpta
8. Pic 100	SHANK	+ VIF	21.6 gpta
9. PIC 100 + Deep Shank Telone II	SHANK	+ VIF	21.6 gpta+12 gpta
10. Kpam	DRIP	+ VIF	62 gpta
11. DMDS+PIC (30 gpta)	SHANK	+ TIF	30 gpta
12. DMDS EC + PIC EC	DRIP	+ TIF	30 gpta
13. Dominus	DRIP	+ VIF	30 gpta
14. Untreated Control	-----	+ VIF	----
15. Check + Deep Shank Telone	SHANK	+ VIF	12 gpta
16. Check + Deep Drip Telone	DRIP	+ VIF	12 gpta

Figure 1. Average strawberry yield cv. Sweet Sensation (8 lb flats/a) at seasons end among shank and drip applied fumigant treatments with and without deep shank Telone II at the Florida Strawberry Growers Research and Education Foundation Farm Dover, Florida. 2016-2017. Refer to Table 1 this document for treatment description.

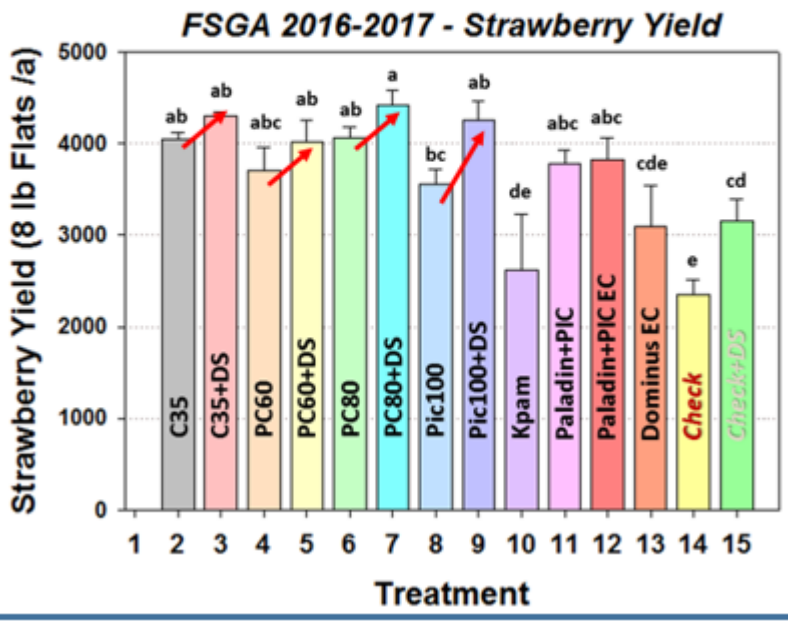

Figure 2. Average strawberry yield cv. Sweet Sensation (8 lb flats/a) at seasons end among 4 Telone Chloropicrin fumigant formulation treatments with and without deep shank Telone II at the Florida Strawberry Growers Research and Education Foundation Farm Dover, Florida. 2016-2017. Percentage increase in strawberry yield relative to the untreated check for each formulation is identified above each yield bar. Refer to Table 1 this document for treatment description.

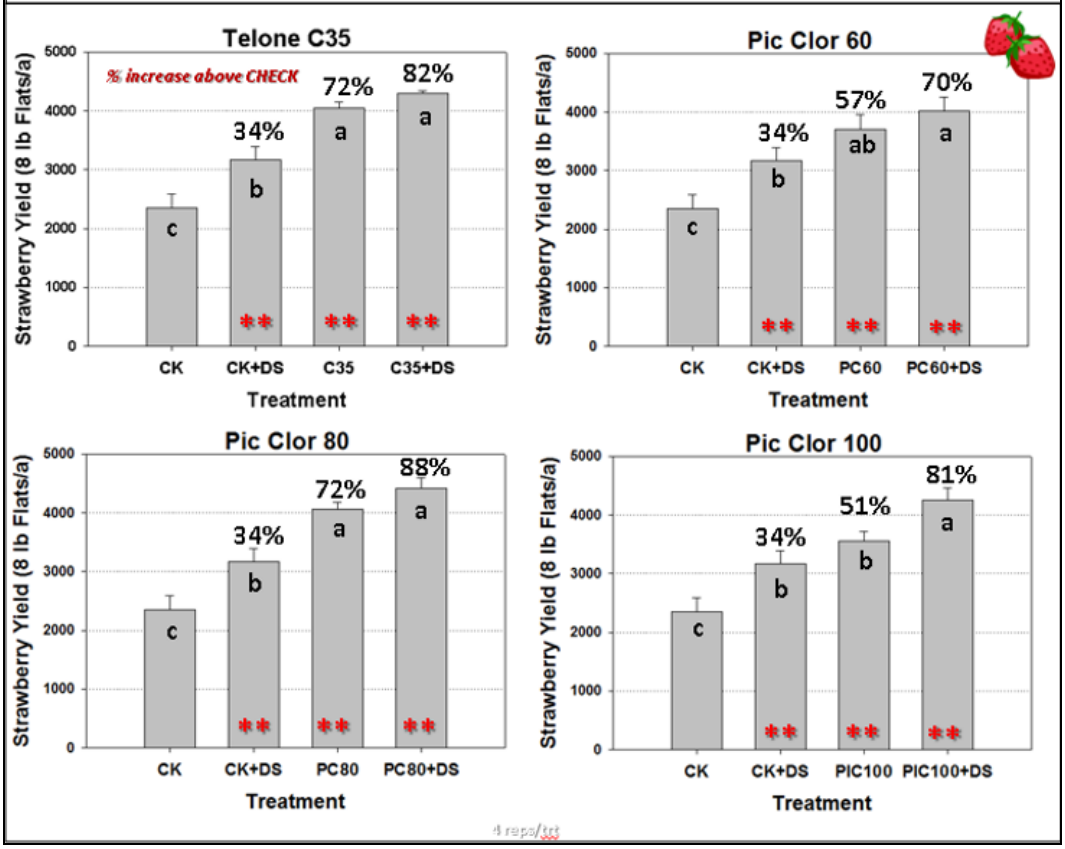

Figure 3. Percent strawberry yield cv. Sweet Sensation increase among 4 Telone-Chloropicrin fumigant formulation treatments and for the untreated raised bed when a deep shank Telone II (18 gpta) treatment is applied 16 inches below the plant bed and traffic pan at the Florida Strawberry Growers Research and Education Foundation Farm Dover, Florida. 2016-2017. Refer to Table 1 this document for treatment descriptions.

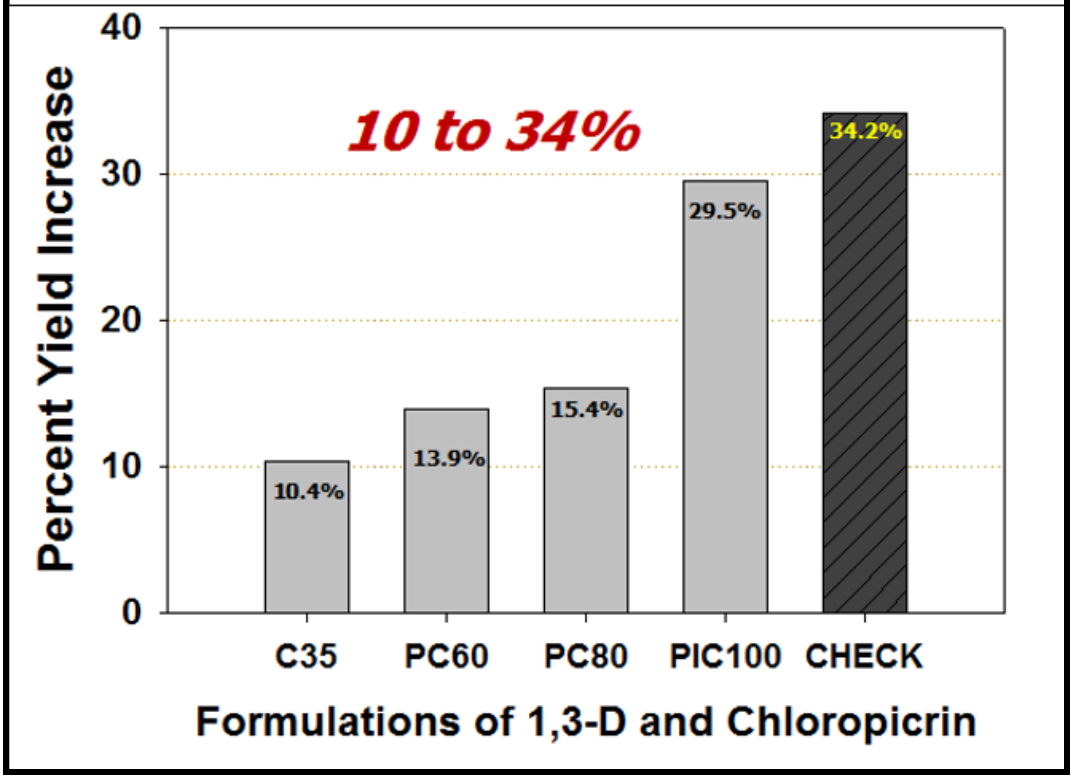

Figure 4. Average strawberry yield cv. Sweet Sensation (8 lb flats/a) at seasons end among 4 Telone Chloropicrin fumigant formulation treatments with and without deep shank applied Telone II to a depth of 16 inches at the Florida Strawberry Growers Research and Education Foundation Farm Dover, Florida. 2016-2017. Numbers embedded within treatment bars quantify pounds (lb) of chloropicrin applied on a per acre basis. No yield benefit is observed above a level of 73 lb chloropicrin per acre with or without deep shank Telone II. Refer to Table 1 this document for treatment descriptions.

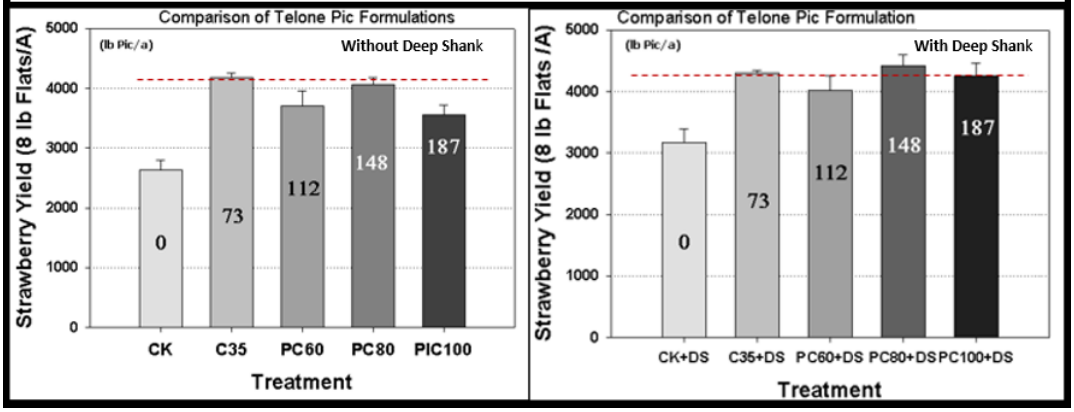

Figure 5. End of harvest season Sting Nematode soil population densities among shank and drip applied fumigant treatments with and without deep shank Telone II to a depth of 16 inches at the Florida Strawberry Growers Research and Education Foundation Farm Dover, Florida. 2016-2017. Note diminished control with higher chloropicrin application rates per acres. Refer to Table 1 this document for treatment descriptions.