LARGE SCALE FIELD DEMONSTRATION TRAILING OF FUMIGANT ALTERNATIVES IN FLORIDA STRAWBERRY 2014-15

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

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 shank and drip applied fumigants. Field trials were conducted at the Florida Strawberry Growers Research and Education Foundation Farm in Dover, FL. Alternative chemicals evaluated within these trials include individual and or combined uses of methyl bromide, chloropicrin, allyl isothiocyanate (AITC) (Dominus™) dimethyl disulfide (DMDS) (Paladin™), and 1, 3-dichloropropene (Telone II™) with use of appropriate herbicide(s). A diversity of drip fumigants were also evaluated for pest control efficacy and strawberry yield enhancement. Secondary objectives were to evaluate the use of high barrier, semi-impermeable mulch film (Pliant Blockade® VIF) and Raven Industries Vaporsafe® TIF film to reduce emissions and soil fumigant field application rates and to compare crop yield and pest control efficacy of soil and drip applied fumigant alternatives.

Methods: Two grower field studies focused on a co-application approach of different fumigants, herbicides, and other alternative tactics to achieve pest control efficacy and crop growth response similar to that of methyl bromide. Among the sites, chisel applied soil treatments included broadcast equivalent methyl bromide (67%) chloropicrin (33%) (350 lb/ta), methyl bromide (50%) chloropicrin (50%) (350 lb/ta), Telone C35 (35 gpta), Telone C35 (35 gpta) plus a deep shank (15 inches) Telone II (18 gpta), Pic Clor 60 (300 lb/ta), Paladin (DMDS 79%) plus Chloropicrin (21%) (40 gpta), Paladin (DMDS 79%) plus Chloropicrin (21%) (25 gpta), Trifecta (44% DMDS, 33% Chloropicrin, 23% 1,3-d)(300 lb/ta) in addition to five drip applied fumigants including metam potassium (as KPam, 60 gpta), allyl isothiocyanate (AITC)(Dominus 25 gpta); Paladin EC (DMDS 79%) plus Chloropicrin EC (21%) (40 gpta); Dominus (67%) plus 33% Chloropicrin (325 and 400 lb/ta), propylene oxide (67%) plus Chloropicrin (33%) (400 lb/ta) and propylene oxide (40%) plus Chloropicrin (40%) plus Telone II (20%) (400 lb/ta); at the Florida Strawberry Growers Association (FSGA) Research and Education farm in Dover, FL (**Table 1**). At all field locations, the highly gas retentive Pliant VIF Blockade or Raven Industries Vaporsafe® TIF was installed immediately after Paladin, Dominus, methyl bromide chloropicrin or propylene oxide. All fumigants were applied with commercial grower equipment. Calibration procedures were followed at each experimental location. 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 represent 62.5% of the broadcast or reported per treated acre (ta) rates expressed above. At FSGA, bare root 'Festival' transplants from Canadian nurseries were planted between 4 to 5 weeks following fumigant treatment. Water and nutrients were supplied to each plant row with Netafim (0.36 gph/ emitter 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 harvested (lb/plot or lb/row) and numbers of individual flats (8 lb/flat and 10,890 ft/a) were determined on a 2 to 3 day basis from early January 2014 through March 2014. Following chemical treatment, weed densities were monitored and recorded on a periodic basis to determine any differences in weed control between fumigant treatments. To characterize fumigant efficacy and cross bed mobility in water and gases phases across the strawberry plant bed, yellow nutsedge emergence through the plastic mulch were enumerated within each of 14, one inch, increments measured from the bed center. 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 in length or 0.06 acres among the different fumigant treatments.

In addition to the above assessments, hyperspectral reflectance field imaging technology was used to characterize and relate differences in strawberry crop yield to within row, green vegetative cover. A tractor mounted GreenSeeker optical sensor (Trimble Navigation, Sunnyvale, CA) was used to scan strawberry rows to provide estimates of green canopy cover (NDVI) against a backdrop of black plastic mulch covering the raised bed. Differences between NDVI and strawberry yield were then compared between various soil fumigant treatments. These data appear as a separate contribution within these proceedings.

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 rot etc.) and severity was also visually determined and recorded at periodic intervals within each of replicate blocks by row and sprinkler section within each the different, chemically treated areas (data not reported). Statistical analyses and treatment comparisons will be determined statistically using SAS ANOVA (t-Test comparisons) ($P<0.05$).

Results and Discussion:

At FSGA, weed densities were relatively high, with yellow nutsedge (*Cyperus esculentus*) observed as the predominant weed species. Highest post fumigation densities of yellow nutsedge were observed in the untreated controls, followed by the either of the propylene oxide treatments and high rate of the drip applied Dominus Chloropicrin (400 lb/ta) with Berry VIF (**Figure 1**). No differences ($P\leq0.05$) were observed in the numbers of nutsedge emerging at any specified distance from the bed middle between either of the propylene oxide treatments and untreated control. The higher nutsedge densities outward towards the bed shoulders for all of the drip applied fumigant treatments, particularly Dominus plus Pic (400 lb/ta) illustrates the limitations to which fumigant chemicals can be laterally dispersed in a Florida fine sand from a bed center drip source for satisfactory weed control. None of the treatments, with the exception of methyl bromide chloropicrin 67/33 and DMDS+PIC (40gpta), completely eliminated preplant emergence of nutsedge through the plastic as a pest weed (**Figure 4**). By the end of the harvest season in March, nutsedge densities had increased to higher levels in many of the shank and drip applied fumigant treatments, particularly the propylene oxide treatments (data not shown).

Compared to the untreated controls, all of the drip and shank fumigation treatments increased ($P\leq 0.05$) strawberry plant growth and yield (**Figure 2**). No meaningful differences ($P=0.05$) in strawberry yield were observed between the different drip and shank applied fumigants including different formulations, application rates, and types of plastic mulch films used with methyl bromide chloropicrin, Telone C35, Pic Clor 60, DMDS, Dominus, or propylene oxide treatments (**Figure 2**). Of the drip fumigation treatments, it is noteworthy to indicate that parity with the shank treatments occurred even when these drip formulations were delivered via a single drip tape per bed. Sting nematode densities were elevated to high levels in the propylene oxide plus Pic, low rate of Dominus plus Pic (25 gpta) and untreated control treatments at the end of the season (**Figure 3**). Populations rebounded late in the season on abundant strawberry plant growth and only appeared to reduce overall plant size and strawberry yields within the untreated controls and propylene oxide treatments.

In an additional experiment at the FSGREF farm, metam potassium (KPam HL (62 gpta)) was applied over a 1.5 hour and 3 hour injection period using a single drip tape per bed with and without Integrate 20 surfactant (2 gpa). The Integrate 20 surfactant is labelled as a product to improve bed distribution, lateral spreading and effectiveness of soil applied pesticides, including drip fumigants. Integrate 20 surfactant was injected into the irrigation stream at a rate of 2 quarts in a 30 minute injection period in the first 180 gallons of water the day prior to KPam HL application. An additional treatment evaluating a split application approach in which the KPam HL was applied at 31 gpta over a 1.5 hour injection period on each of two consecutive days. Yellow nutsedge densities which had emerged through the plastic mulch were then enumerated at 1 inch increments from the bed middle across the 28 in bed top. No meaningful improvement in nutsedge control was observed with distance from the point of drip emission on the center of the bed with use Integrate 20 (Data not shown). With KPam, effective nutsedge control was observed in a 16 to 18 inch strip down the middle of the plant bed. Irrespective of treatment, highest emergence occurred on the shoulders of the plant bed. Higher densities overall were observed with the shorter 1.5 hour injection period and with the split application. Management of the Charcoal rot fungus *Macrophomina phaseolina* using inoculum buried at different locations on the plant bed were also reduced with all of the drip applied fumigants (data not shown). The higher survivorship of the fungus at the bed shoulders for all of the drip applied fumigant treatments, particularly the Dominus treatments illustrates the limitations to which fumigant chemicals can be laterally dispersed in a Florida fine sand from a bed center drip source for satisfactory disease control.

GENERAL SUMMARY:

The focus of this FSGA funded project for 2014-2015 was to again characterized performance differences between shank applied methyl bromide chloropicrin, Telone C35, Pic Clor 60, Propylene oxide, DMDS in combination with Chloropicrin, and or Telone II fumigant treatments with that of the drip fumigants DMDS EC+ Pic EC, Dominus with and without chloropicrin, and metam potassium (KPam HL). Early season severe stunting from sting nematode was only observed within the untreated controls with stunting increasing in severity within propylene oxide treatments late season. Sting nematode population densities increased to high levels in many of the drip and shank applied fumigant treatments, although not to the apparent detriment to the growth and yield of strawberry plants.

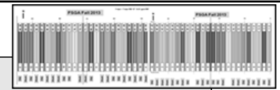
Key Points:

- Compared to the untreated control, yellow nutsedge densities were significantly ($P \leq 0.05$) reduced by 90 percent or more by many of the different shank and or drip applied fumigants. Notable exceptions included propylene oxide, KPam, and some Dominus treatments. By the end of the production season, nutsedge densities had increased to significantly higher levels, levels which demanded consideration of other weed management considerations at crop termination and other postharvest and summer broadcast tillage and herbicide treatments.

- Although strawberry yields were improved by 33 to 50% by fumigant treatment, no meaningful differences in strawberry growth, development, and yield were observed between most fumigant treatments.

- No meaningful improvement in nutsedge control was observed with distance from the point of drip emission on the center of the bed with use Integrate 20 surfactant.

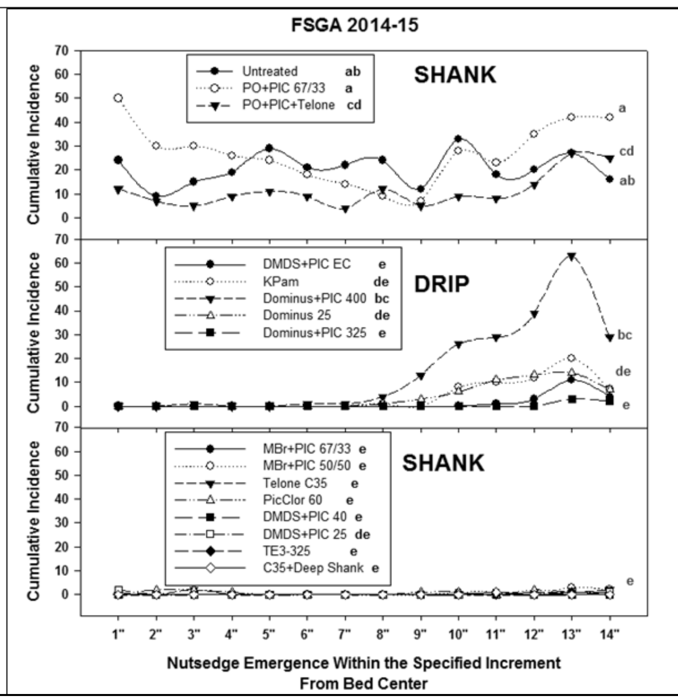
Table 1. Fumigant treatment list for Florida Strawberry Growers Research and Education Foundation Farm, Dover, FL 2014-15



1.	MBr + PIC 67/33 (350 lb/ta)	SHANK	+ TIF VaporSafe	1 tape	4 reps
2.	MBr + PIC 50/50 (320 lb/ta)	SHANK	+ TIF VaporSafe	1 tape	4 reps
3.	Telone C35 (35 gpta)	SHANK	+ LDPE	1 tape	4 reps
4.	Pic-Clor 60 (300 lb/ta)	SHANK	+ LDPE	1 tape	4 reps
5.	DMDS + PIC (40 gpta)	SHANK	+ TIF Vaporsafe	1 tape	4 reps
6.	DMDS + PIC (25 gpta)	SHANK	+ TIF Vaporsafe	1 tape	4 reps
7.	DMDS+PIC+Telone II (TE3)(300 lbs/ta)		+ TIF Vaporsafe	1 tape	4 reps
8.	DMDS EC+PIC (40gpta)	DRIP	+ TIF Vaporsafe	1 tape	4 reps
9.	Kpam (62 gpta)	DRIP	+ LDPE	1 tape	4 reps
10.	Dominus + PIC (400 lb/ta)	DRIP	+ LDPE	1 tape	4 reps
11.	Untreated	--	+ LDPE	1 tape	4 reps
12.	Telone C35 (35gpta) +deep Drip Telone II (18gpta)	Shank	+ LDPE	1 tape	4 reps
13.	Dominus (25 gpta)	Drip	+ Blockade	1 tape	4 reps
14.	Dominus+PIC 67/33 (325 lb/ta)	Drip	+ Blockade	1 tape	4 reps
15.	PO + PIC (67/33) (400 lb/Ta)	SHANK	+ Blockade	1 tape	4 reps
16.	PO+Telone+PIC (40/40/20)(400lb)	SHANK	+ Blockade	1 tape	4 reps

16 treatments x 4 reps x 2 row plots = 128 rows x 240 ft /row

Figure 1. Mean number of yellow nutsedge (*Cyperus esculentus*) per 240 linear feet of row emerging through plastic mulch at 1 inch increments across a 28 inch bedtop. Fifteen fumigant treatments were evaluated and applied either via 2 shanks per bed (10 inches deep) or via the drip irrigation system (1 tape /bed; emitting 0.4 gpm/100 ft). All fumigants were injected over a 3 hr injection period. Data are means of 8 beds 240 feet in length.



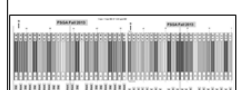


Figure 2. Strawberry fruit yields (lb/plot) for 16 different fumigants, rates of application, types of plastic mulch applied via shank or drip tape delivery at the Florida Strawberry Growers Association Research & Education Farm in Dover, FL during Fall 2014-Spring 2015.

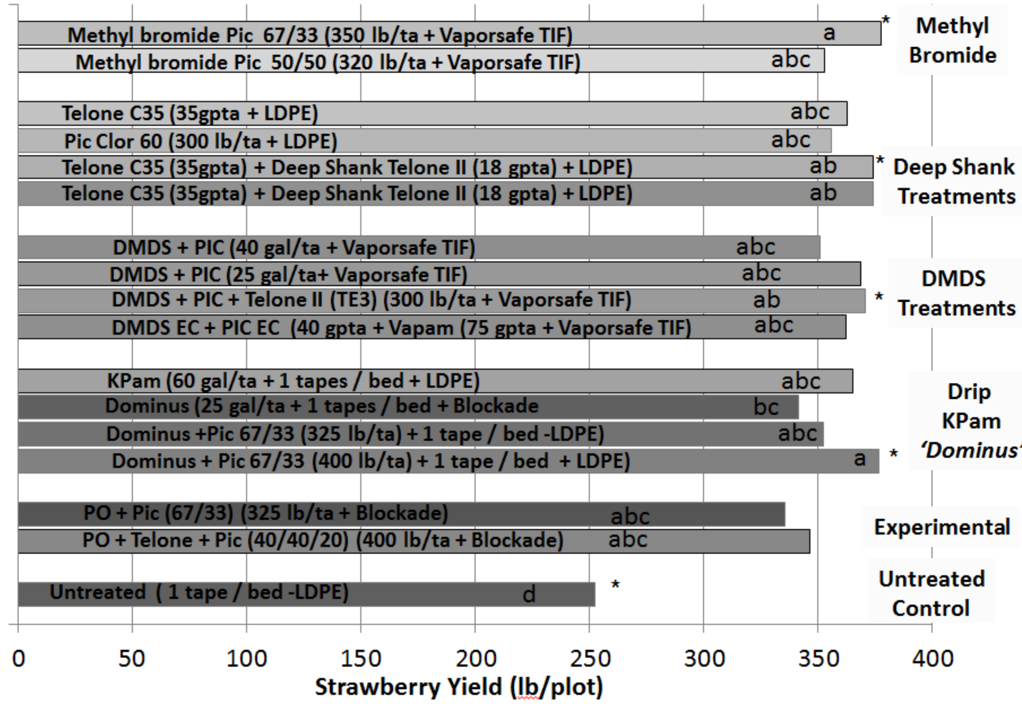


Figure 3. End of harvest season sting nematode population densities among various shank and drip applied fumigant compounds at the Florida Strawberry Research and Education Foundation Farm, Dover, FL. March 21, 2015). Treatments that are **not** followed by the same letter differ significantly from one another ($P \leq 0.05$).

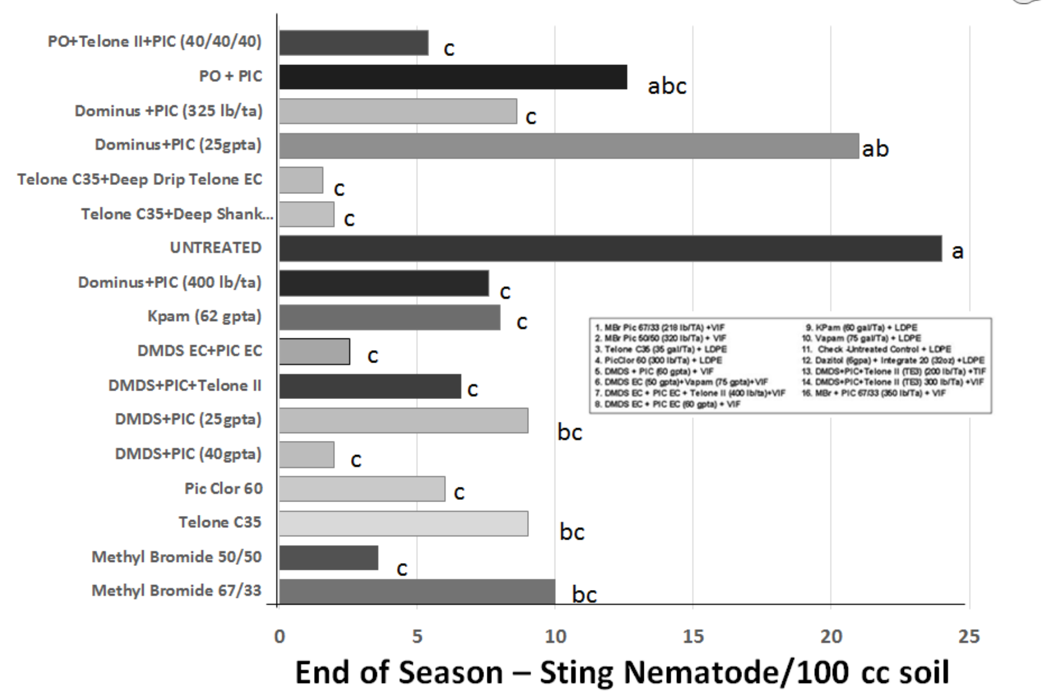


Figure 4. Relative to the untreated control, percent nutsedge control of yellow nutsedge (*Cyperus esculentus*) per 240 linear feet of row of 16 fumigant treatments applied as either 2 shanks per bed or via the drip irrigation system (1 tape /bed). Treatments that are **not** followed by the same letter differ significantly from one another ($P \leq 0.05$).