LARGE SCALE FIELD DEMONSTRATION TRAILING OF FUMIGANT ALTERNATIVES IN FLORIDA STRAWBERRY 2013-14

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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. 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. Alternative chemicals evaluated within these trials include individual and or combined uses of methyl bromide, chloropicrin, dimethyl disulfide (DMDS), 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), Pic Clor 60 (300 lb/ta), Paladin (DMDS 79%) plus Chloropicrin (21%) (60 gpta), TE3 (44% DMDS, 33% Chloropicrin, 23% 1,3-d)(400 lb/ta), TE3 (44% DMDS, 33% Chloropicrin, 23% 1,3-d)(300 lb/ta) in addition to five drip applied fumigants including, metam sodium (as Vapam, 75 gpta), metam potassium (as KPam, 60 gpta), Dazitol (6.25 gpa); Paladin EC (DMDS 79%) plus Chloropicrin EC (21%) (60 gpta); Paladin EC (50 gpta) + Vapam (75 gpta); 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 TE3 and methyl bromide chloropicrin application. 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 all farm locations, 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 or TTape (0.22 gpm/100 ft or 0.45 gpm/ 100 ft row; or 0.40 gpm/100 ft row) 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 December 2013 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. An untreated control was not included as a replicated treatment for comparison at Florida Pacific farms in Dover, FL. All treatments were arranged within their respective experimental areas as a completely randomized block design with 4 replications per treatment. Plot sizes varied from 2 to 12 rows or 0.06 to 0.4 acres among the different grower farm locations.

In addition to the above assessments, the numbers of plants in four plant size categories were also systematically enumerated and recorded at 40 to 50 ft intervals were monitored at FSGA and Florida Pacific Farms experimental sites. (All data not included). Plant size categories, measured as average canopy diameter, were dead (0), small (<20 cm), medium (>20 and < 30 cm) and large (>30 cm). Hyperspectral reflectance field imaging technology was also used to characterize and relate differences in relative strawberry crop yield (based on plant sizing) 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. Cumulative differences in plant numbers and relative yield contribution within each plant size category were then statistically compared with NDVI, and both values used to independently compare differences between various soil fumigant treatments. These data appear as a separate contribution within these proceedings.

Results and Discussion:

At FSGA, weed densities were generally low, 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 Dazitol and low rate of the shank applied TE3 (200 lb/ta) with Vaporsafe TIF (**Figure 1**). The higher nutsedge densities in the TE3 and Vaporsafe treatment indicates apparent limits to rate reductions with TIF mulch films for satisfactory weed control. None of the treatments completely eliminated preplant emergence of nutsedge through the plastic as a pest weed. By the end of the harvest season in March, nutsedge densities had increased to high levels in many of the shank and drip applied fumigant treatments (**Figure 2**).

Compared to the untreated controls and Dazitol treatments, all of the remaining drip and shank fumigation treatments increased ($P \leq 0.05$) strawberry plant growth and yield (**Figure 3**). With the exception of reduced rate treatments, 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, or of DMDS (**Figure 3**). 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. At the end of the harvest season, the numbers of dead plants per 40 linear feet of row was highest ($P \leq 0.05$) in the untreated control and Dazitol treated plants, well correlated with the significant decline in yield observed (**Figure 4**). Sting nematode densities were elevated to high levels in many of shank and drip fumigant treatments at the end of the season (**Figure 5**). 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 Dazitol treatments.

In two additional experiments at the FSGREF farm, metam potassium (KPam HL (62 gpta)) was applied at 2600 parts per million over a 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. 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. A marginal improvement in nutsedge control was observed with distance from the point of drip emission on the center of the bed (**Figure 6**). With KPam, effective nutsedge control was observed in a 16 strip down the middle of the plant bed. Highest emergence occurred on the shoulder s of the plant bed.

In the second experiment, treatments included metam potassium (KPam HL (62 gpta) with and without Integrate 20 surfactant (2 gpa) applied during 1.5 hour (5159 ppm) and 3.0 hour (2590 ppm) injection periods. Integrate 20 surfactant was again applied the day prior to KPam injection in identical format as to Experiment 1. In this experiment and irrespective of Integrate 20 surfactant treatments, both injection regimes provided a weed free strip measuring 14 to 15 inches wide down the middle of the plant bed. For both the 1.5 and 3.0 hour injection periods, Integrate 20 improved lateral spread and numerically reduced nutsedge density with distance from the bed center and point of fumigant delivery. Lowest nutsedge emergence at each 1 inch increment from the drip tape was observed with the longer 3.0 hour KPam injection period in the presence of Integrate 20 surfactant (**Figure 7**).

GENERAL SUMMARY:

The focus of this FSGA funded project for 2013-2014 was to again characterized performance differences between shank applied methyl bromide chloropicrin, Telone C35, Pic Clor 60, DMDS in combination with Chloropicrin, Vapam, and or Telone II fumigant treatments with that of the drip fumigants DMDS EC+ Pic EC, Dazitol, metam sodium (Vapam) and metam potassium (KPam HL). Early season severe stunting from sting nematode was only observed within the untreated controls and Dazitol treatments. 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 85 to 90 percent by the different drip and shank applied fumigants. 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.

- Unlike previous cropping seasons, no meaningful differences in strawberry growth, development, and yield were observed between most fumigant treatments. Dazitol, a drip applied pesticide with active ingredients consisting 0.4% capsaicin and 3.7% allyl Isothiocyanate by weight, failed to provide effective control of the sting nematode or prevent a significant 25 percent loss in strawberry crop yield.

- Integrate 20 surfactant marginally improved lateral spread and numerically reduced nutsedge density with distance from the bed center and point of fumigant delivery. Lowest nutsedge emergence at each 1 inch increment from the drip tape was observed with the longer 3.0 hour KPam injection period in the presence of Integrate 20.

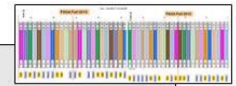
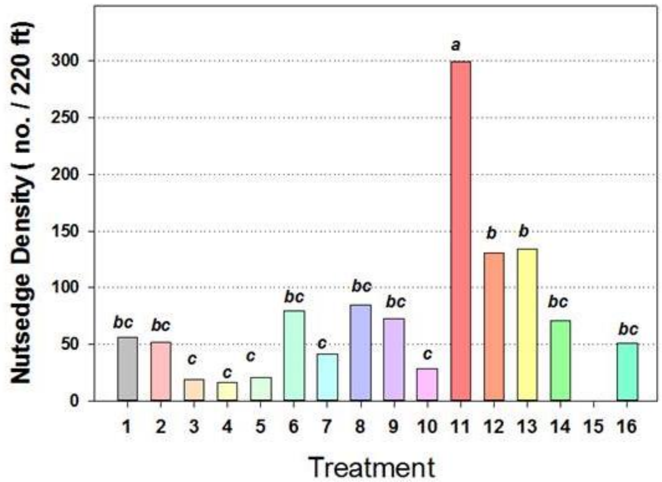


Table 1. Fumigant treatment list for Florida Strawberry Growers Research and Education Foundation Farm, Dover, FL Fall 2013

1. MBr + PIC 67/33 (218 lb/ta)	SHANK	+ Blockade	1 tape	4 reps
2. MBr + PIC 50/50 (320 lb/ta)	SHANK	+ Blockade	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 (60 gpta)	SHANK	+ Blockade	1 tape	4 reps
6. DMDS EC(50gpta)+Vapam(75gpta)	DRIP	+ Blockade	1 tape	4 reps
7. DMDS+PIC+Telone II (TE3)(400 lb/ta)	DRIP	+ Blockade	1 tape	4 reps
8. DMDS EC+PIC (60gpta)	DRIP	+ Blockade	1 tape	4 reps
9. Kpam (60 gpta)	DRIP	+ LDPE	1 tape	4 reps
10. Vapam (75 gpta)	DRIP	+ LDPE	1 tape	4 reps
11. Untreated		+ LDPE	1 tape	4 reps
12. Dazitol(6.3 gpa)+ Integrate 20(2 gpa)	DRIP	+ LDPE	1 tape	4 reps
13. TE3 (19 gpta;12 gpa)	SHANK	+ VaporSafe	1 tape	4 reps
14. TE3 (29 gpta;18 gpa)	SHANK	+ Blockade	1 tape	4 reps
15. Kpam (62 gpta) + Integrate 20	DRIP	+ LDPE	1 tape	4 reps
16. MBr + PIC 67/33 (350 lb/ta)	SHANK	+ Blockade	1 tape	4 reps

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

Figure 1. Preplant densities of yellow nutsedge (Cyperus esculentus) per 220 linear feet of plant row among various shank and drip applied fumigant compounds at the Florida Strawberry Research and Education Foundation Farm, Dover, FL. October 5, 2013). Treatments that are **not** followed by the same letter differ significantly from one another (*P*≤ 0.05).



1. MBr Pic 67/33 (218 lb/TA) +VIF
2. MBr Pic 50/50 (320 lb/Ta) + VIF
3. Telone C35 (35 gal/Ta) + LDPE
4. PicClor 60 (300 lb/Ta) + LDPE
5. DMDS + PIC (60 gpta) + VIF
6. DMDS EC (50 gpta)+Vapam (75 gpta)+VIF
7. DMDS EC + PIC EC + Telone II (400 lb/ta)+VIF
8. DMDS EC + PIC EC (60 gpta) + VIF
9. KPam (60 gal/Ta) + LDPE
10. Vapam (75 gal/Ta) + LDPE
11. Check -Untreated Control + LDPE
12. Dazitol (6gpa) + Integrate 20 (32oz) +LDPE
13. DMDS+PIC+Telone II (TE3) (200 lb/Ta) +TIF
14. DMDS+PIC+Telone II (TE3) 300 lb/Ta) +VIF
16. MBr + PIC 67/33 (350 lb/Ta) + VIF

Figure 2. End of harvest season densities of yellow nutsedge (Cyperus esculentus) per 220 linear feet of plant row among various shank and drip applied fumigant compounds at the Florida Strawberry Research and Education Foundation Farm, Dover, FL. March 21, 2014). Treatments that are **not** followed by the same letter differ significantly from one another (*P*≤ 0.05).

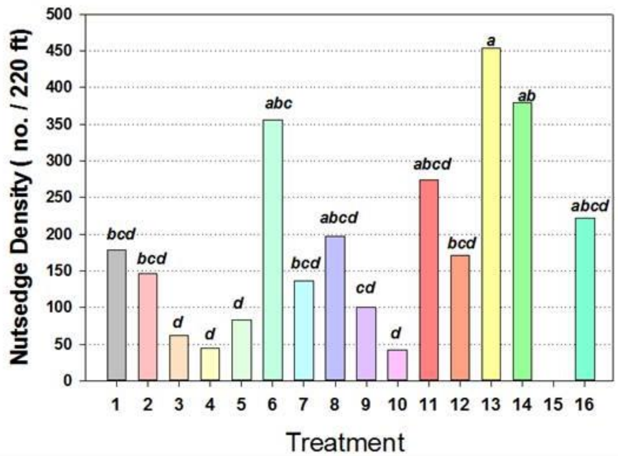


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Figure 3. Strawberry fruit yields (lb/plot) for 16 different fumigants, rates of application, types of plastic mulch applied via shank or drip tape delivery at the Florida Strawberry Growers Research and Education Foundation Farm in Dover, FL during Fall 2013-Spring 2014. Treatments that are not followed by the same letter differ significantly from one another (*P*≤ 0.05).

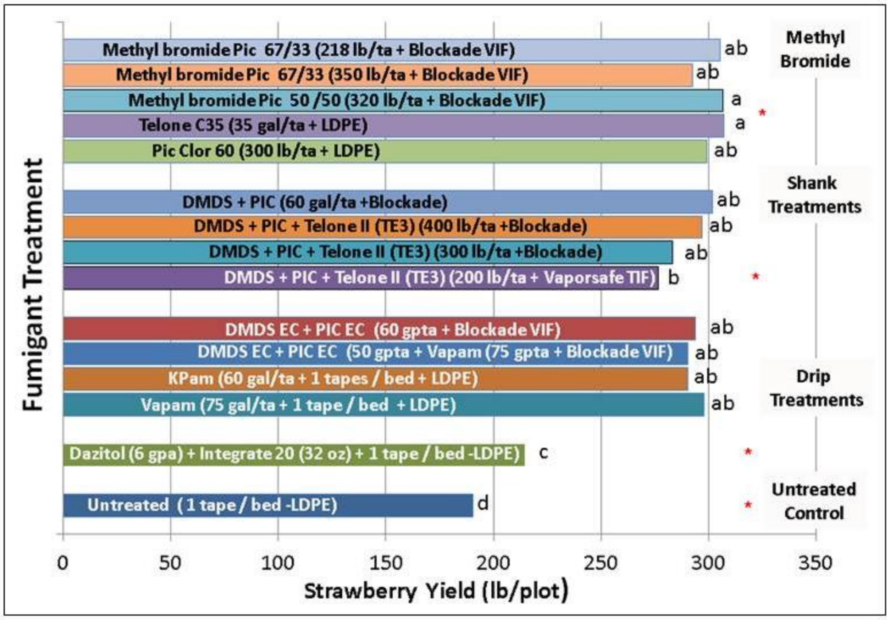

Figure 4. Number of dead plants (per 40 linear feet of row) within treated rows for 16 different fumigants, rates of application, types of plastic mulch applied via shank or drip tape delivery at the Florida Strawberry Growers Research and Education Foundation Farm in Dover, FL during Fall 2013-Spring 2014. Treatments that are not followed by the same letter differ significantly from one another ($P \leq 0.05$).

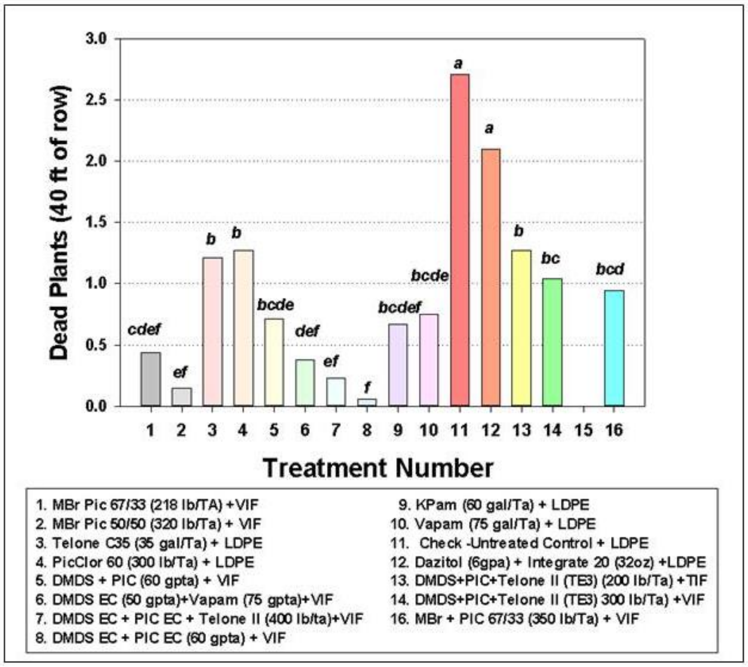

Figure 5. End of harvest season sting nematode population densities among various shank and drip applied fumigant compounds at the Florida Strawberry Research and Education Foundation Farm, Dover, FL. March 15, 2014). Treatments that are **not** followed by the same letter differ significantly from one another ($P \leq 0.05$).

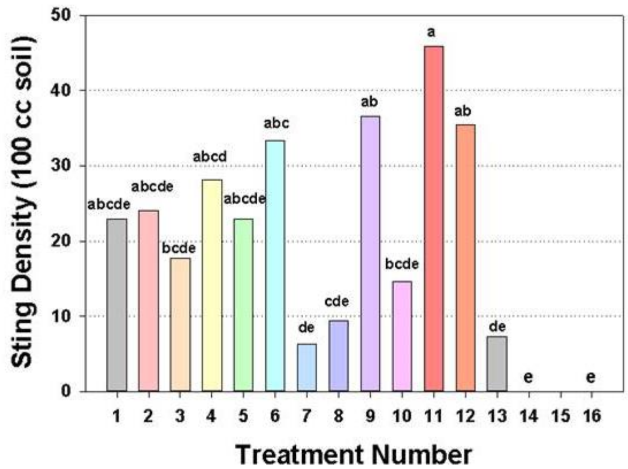

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Figure 6. Mean number of yellow nutsedge (*Cyperus esculentus*) per 210 linear feet of row emerging through plastic mulch at 1 inch increments across a 28 inch bedtop. Treatments include metam potassium KPam HL (62 gpa) applied at 2600 ppm over a 3 hr injection period (1 tape/bed) with and without Integrate 20 surfactant(2gpa). Data are means of 5 beds.

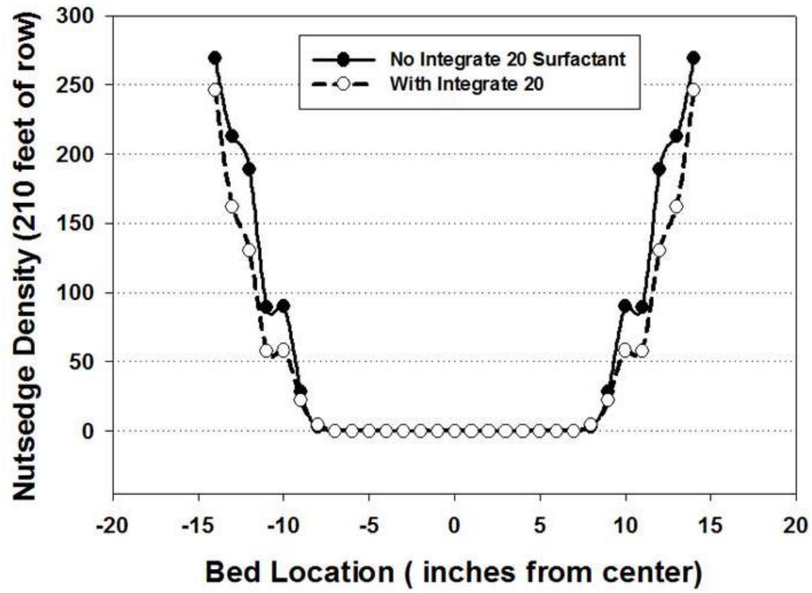

Figure 7. Average yellow nutsedge (*Cyperus esculentus*) emergence per 210 linear feet of bedded row at various distances from the bed center. Treatments include metam potassium (KPam HL (62 gpa) with and without Integrate 20 surfactant(2gpa) applied during 1.5 (5159 ppm) and 3.0 hr (2590 ppm) injection periods. Data are means of 5 beds for each bed location.