LARGE SCALE FIELD DEMONSTRATION TRAILING OF FUMIGANT ALTERNATIVES IN FLORIDA STRAWBERRY 2012-13

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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 FSGA research farm and at other grower field demonstration sites. 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 feasibility of using two drip tapes per bed rather than one to enhance efficacy of metam sodium and metam potassium as different drip applied fumigants; and use of a high barrier, semi-impermeable mulch film (Pliant Blockade VIF) 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; 30 gpta plus Blockade VIF), Pic Clor 60 (300 lb/ta; 250 lb/ta plus Blockade VIF), Paladin (DMDS 79%) plus Chloropicrin (21%) (45 and 60 gpta), TE3 (44% DMDS, 33% Chloropicrin, 23% 1,3-d)(400 lb/ta), in addition to five drip applied fumigants including, metam sodium (as Vapam, 75 gpta), metam potassium (as Kpam, 60 gpta) both evaluated with either one or two drip tapes per bed and Paladin EC (DMDS 79%) plus Chloropicrin EC (21%) (60 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 Blockade 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 32 inches wide, 10 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 and Ferris, 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 2012 through April 2013. 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 Ferris Farms, Floral City. 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 Ferris 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, Vapam and KPam drip fumigant treatments. With Vapam and KPam, effective nutsedge control was best fit to exponential growth functions illustrating the increased survival of nutsedge plants emerging through the plastic mulch with distance from the bed center and emission points of the fumigant from the drip tape (Figure 2). The highest level of nutsedge control, typically involving a 24 to 26 inch nutsedge free strip down the middle of the plant bed, was achieved with 2 drip tapes per bed with Vapam and particularly KPam.

Compared to the untreated controls and many of the drip fumigation treatments, strawberry plant growth and yield were significantly improved (P=0.05) by shank applications of the soil fumigants. No differences (P=0.05) in strawberry yield were observed between the different 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 1). Of the drip fumigation treatments, DMDS EC plus Chloropicrin EC plus Telone EC (TE3) produced strawberry yields equivalent to that of shank application, even when delivered via a single drip tape per bed. Unlike previous years, there was no apparent benefit associated with delivery of Vapam or KPam through 2 (twin) drip tapes per bed compared to one for these drip fumigants (Figure 1). With regard to yield and end of season nematode population densities at FSGA, improved fumigant efficiency was not observed with two tapes per plant bed. Although higher, a significant horticultural benefit that was expected from a second drip tape per bed was not observed within the untreated control even when damaging populations of sting nematode were present. Similar results were observed with estimates of relative yield derived from analysis of the numbers of small, medium, large, and dead plants per 40 linear feet of row.

In an attempt to determine if microbial degradation was the cause for such poor yield and nematode control where Vapam and KPam was applied and had been used in the 3 previous cropping seasons, an end-of-season crop termination treatment with Vapam (75 gpta) was used to evaluate difference in the rates of soil dissipation at sites where it had never been used and in those after long term, repeated use. Soil air concentrations of Vapam (MITC expressed as PPM isobutylene) were monitored following Vapam application through either 1 or 2 drip tapes per bed using a MiniRae 2000 PID-VOC meter (RAE Systems, Inc., Sunnyvale, CA). To confirm the presence of

enhanced Vapam biodegradation, comparisons were made of Vapam treatments where Vapam had been repeatedly applied to the same plots over the previous 3 years were compared with areas which had never received Vapam treatments. In this trial, no differences (P=0.05) in soil air concentrations and dissipation rate were observed between no prior and repeated Vapam use treatments (Figure 3). These results, coupled with measures of nutsedge control (Figure 2), would suggest that causes other than enhanced biodegradation were responsible for the poor yield and loss of nematode control within Vapam and KPam treated plots at FSGA during 2012-2013. Since both KPam and Vapam proved to be very effective treatments for control of Charcoal rot caused by *M. phaseolina*, it is now believed that upward migration and nematode recolonization from outside and below that of the treated zone was the cause for such poor nematode control and strawberry yield.

At Ferris Farms, strawberry yields expressed as pounds per acre, were significantly (P=0.05) enhanced when shank applications of Telone C35 (35 gpta) were complemented with supplemental herbicide applications of Devrinol 50-DF (Napropamide; 4 lb a.i. /a preplant incorporated) plus Goal 2XL (Oxyfluorefen; 2 pts/a as a directed spray to bed top) and compared to Telone C35 treatment without herbicide treatment (Figure 4).

GENERAL SUMMARY:

The focus of this FSGA funded project for 2012-2013 was to characterized performance differences between shank applied methyl bromide chloropicrin, Telone C35, Pic Clor 60, DMDS and PIC fumigant treatments with that of the drip fumigants DMDS EC+ Pic EC, metam sodium and metam potassium. Early season severe stunting from sting nematode was observed within the untreated controls and all metam sodium and metam potassium treatments. For either metam treatments, plant stunting was significant irrespective of whether 1 or 2 drip tapes per bed were used to supply water and the drip fumigants. No differences in soil dissipation and relative soil air concentration of metam sodium (Vapam) were observed between plant beds where either Vapam or KPam had been repeatedly applied on a semiannual basis when compared with plant beds which had received no such prior treatment. These results suggest that upward migration and nematode recolonization from outside and below that of the metam treated zones were the cause for such poor nematode control and strawberry yield. The FSGA data also strongly supports the need for specific fumigants to provide season long protection from a newly emerging fungal disease problem, Charcoal rot caused by *Macrophomina phaseolina*.

Key Points:

- Yellow nutsedge control was significantly enhanced when two drip tapes centered on the plant bed were used rather than one for drip irrigation delivery of the fumigant.
- For yield and nematode control, significant performance inconsistency from one production season to next was observed for metam sodium and metam potassium.

- No differences in soil dissipation and relative soil air concentration of metam sodium (Vapam) were observed between plant beds where either Vapam or KPam had been repeatedly applied on a semiannual basis when compared with plant beds which had received no such prior treatment. These results suggest that upward migration and nematode recolonization from outside and below that of the metam treated zones were the cause for such poor nematode control and strawberry yield. These results suggest that upward migration and nematode recolonization from outside and below that of the metam treated zones were the cause for such poor nematode control and strawberry yield.

Table 1. Fumigant treatment list for Florida Strawberry Growers Research and Education Foundation Farm, Dover, Fl Fall 2012

1.	Methyl bromide + PIC 67/33 (350 lb/ta)		+ Blockade	1 tape	4 reps
2.	Methyl bromide + PIC 50/50 (320 lb/ta)		+ Blockade	1 tape	4 reps
3.	Telone C35 (35 gpta)	Shank	+ LDPE	1 tape	4 reps
4.	Telone C35 (30 gpta)	Shank	+ Blockade	1 tape	4 reps
5.	DMDS + PIC (45 gpta)	Shank	+ Blockade	1 tape	4 reps
6.	DMDS + PIC (60 gpta)	Shank	+ Blockade	1 tape	4 reps
7.	DMDS + PIC + Telone II (TE3)(400 lb/ta)		+ Blockade	1 tape	4 reps
8.	DMDS EC + PIC EC + (60 gpta)	DRIP	+ Blockade	1 tape	4 reps
9.	Pic-Clor 60 (300 lb/ta)	Shank	+ LDPE	1 tape	4 reps
10.	Pic-Clor 60 (250 lb/ta)	SHANK	+ Blockade	1 tape	4 reps
11.	Kpam (60 gpta)	Drip	+ LDPE	1 tape	4 reps
12.	Kpam (60 gpta)	Drip	+ LDPE	2 tapes	4 reps
13.	Vapam (75 gpta)	Drip	+ LDPE	1 tape	4 reps
14.	Vapam (75 gpta)	Drip	+ LDPE	2 tapes	4 reps
15.	Untreated	-	+ LDPE	1 tape	4 reps
16.	Untreated	-	+ LDPE	2 tapes	4 reps

LDPE (Low density polyethylene mulch film; Berry Plastics Corporation Blockade ® VIF , 1.25 mil
1 or 2 drip tapes per plant bed; 16 treatments x 4 reps x 2 row plots = 128 rows x 240 ft /row

Figure 1. Strawberry fruit yields (lb/plot) for 16 different fumigants, rates of application, types of plastic mulch, and numbers of drip tapes per bed applied via shank or drip tape delivery at the Florida Strawberry Growers Association Farm in Dover, FL during Fall 2012-Spring 2013.

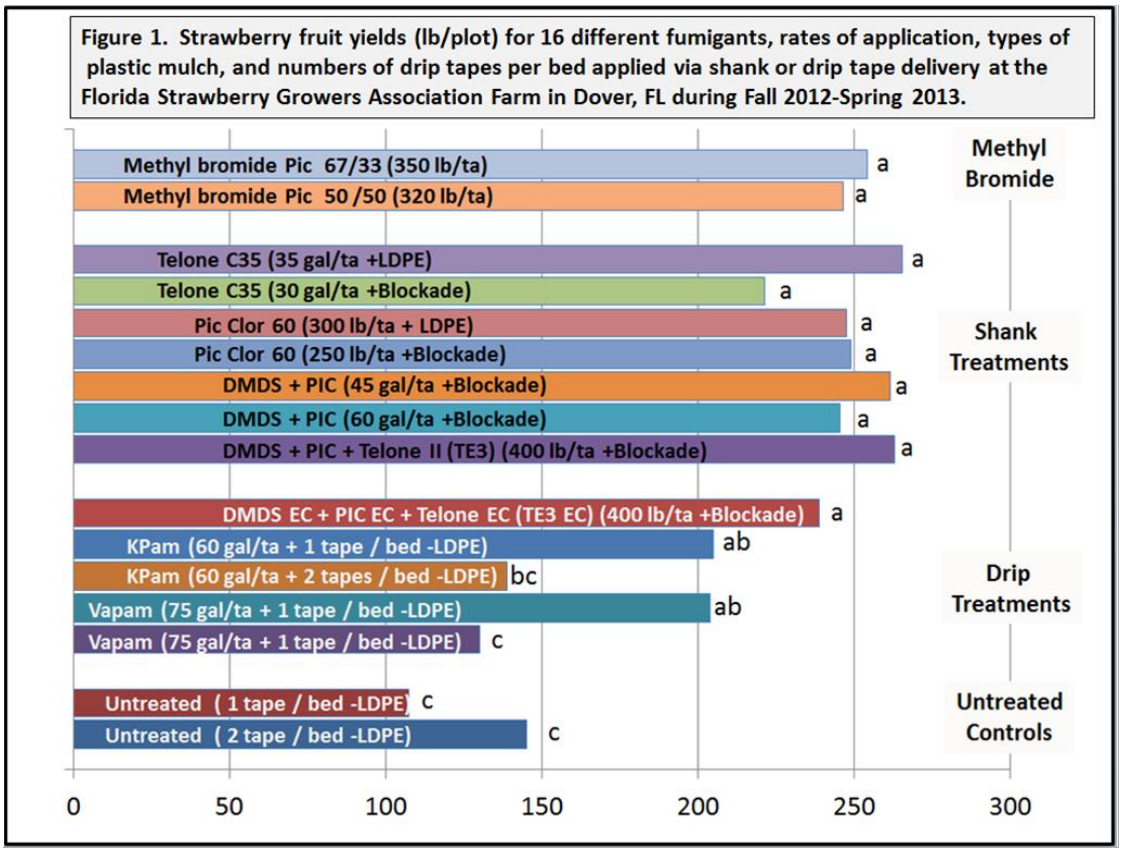

Figure 2. Distance from bed center location of surviving nutsedge plants emerging through the plastic mulch bed covering following a 200 minute drip fumigation treatment with Vapam (75 gpa) and Kpam (60 gpa) using 1 or 2 drip tapes bed plant bed. Data fit to parameter exponential growth functions.

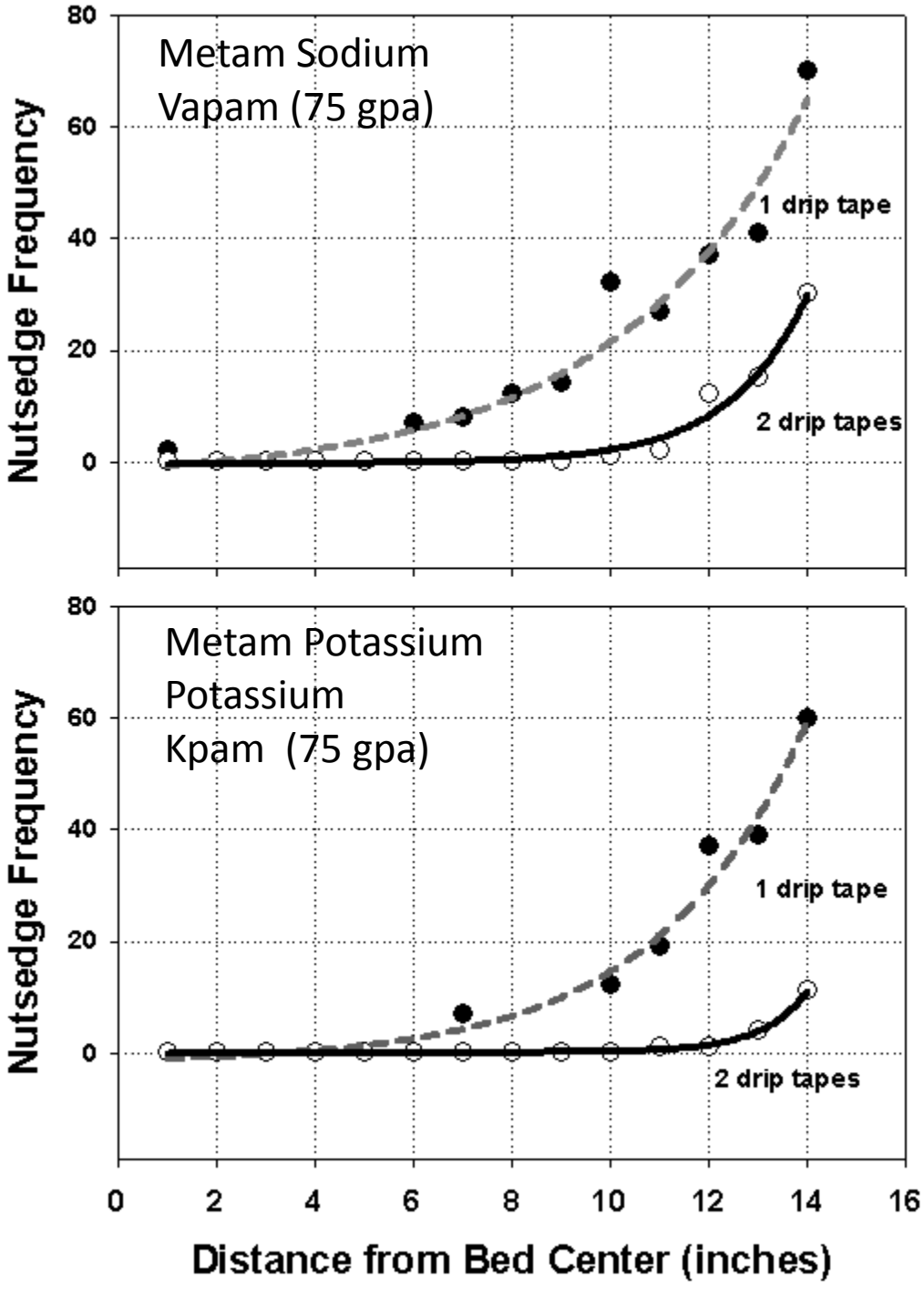

Figure 3. Soil air concentrations of Vapam (MITC expressed as PPM isobutylene) drip applied at 75 gallons per treated acre through either 1 or 2 drip tapes per bed as an end of season crop termination treatment. To confirm the absence of Vapam biodegradation, comparisons of Vapam treatments where Vapam had been repeatedly applied to The same plots over the precious 3 years were compared with areas which had never received Vapam treatments. No Differences between treatments (Vapam vs CK) suggests that causes other than biodegradation were responsible for Loss of nematode control within Vapam and Kpam plots at FSGA during 2912-2013.

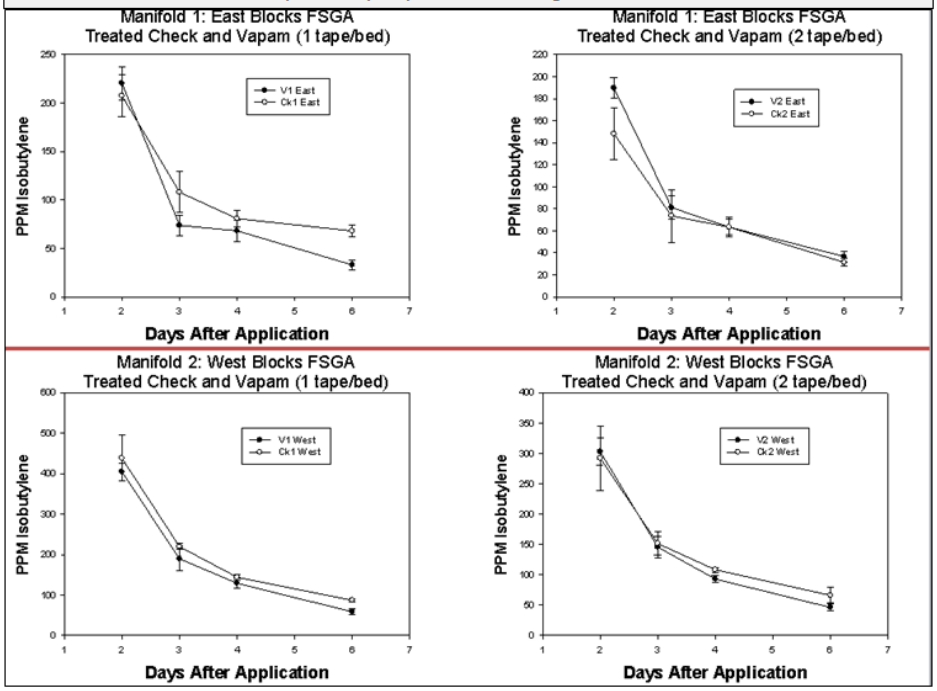

Figure 4. Differences in strawberry yield (pounds per acre) between fumigant and weed managment options at Ferris Farms, Floral City, Fl. Devrinol (8lb/a) and Goal (2 pts/a) applied as a surface directed spray to the bed top was compared with mini-coulter application of KPam (60 gpta) and an untreated control for weed control.