USDA ARS SOUTH ATLANTIC AREAWIDE PROJECT: FIVE YEAR SUMMARY OF LARGE SCALE FIELD DEMONSTRATIONS IN FLORIDA STRAWBERRY 2007-12

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This USDA ARS South Atlantic Areawide project was funded from 2007-2012 ($56-62K/year) to demonstrate and improve the performance and consistency of next-best chemical alternatives to methyl bromide in over 40 field research and grower demonstration site locations within in the Dover – Plant City area of Florida. Each year, strawberry yields and treatment responses were measured at two to three locations including the Florida Strawberry Growers Association (FSGA) research and education foundation farm, and at two commercial farms in Dover and Floral City, FL. Alternative chemicals evaluated within these trials include individual and or combined uses of chloropicrin, methyl iodide, dimethyl disulfide, metam sodium, metam potassium, and 1, 3-dichloropropene with or without use of other additional herbicide(s). A diversity of drip fumigants were also evaluated for pest control efficacy, strawberry yield enhancement, and as a potential risk mitigation tactic to reduce buffer zone distances and overall personal protective equipment requirements which were being proposed by EPA. Secondary objectives were to evaluate the feasibility of using two drip tapes per bed rather than one to enhance efficacy and yield of methyl bromide chloropicrin and of other different drip applied fumigants; and use of a high barrier, semi-impermeable VIF mulch films to reduce emissions and soil fumigant field application rates and to compare crop yield and pest control efficacy of methyl bromide alternatives. A final objective was to evaluate the performance of drip applied fumigants into beds being cropped for the second time to strawberry (double cropping) with as many as 20,000 /acre open planting holes in the plastic mulch from the previous year's strawberry plants. Other experiments examined a combination of a crop termination / drip fumigant treatments made to the stale strawberry bed with or without Telone EC (12-15 gpa) applications prior to the fall planting and fumigant treatment of the subsequent strawberry crop, utilizing the same bed, plastic mulch, and drip irrigation system for the two consecutive crops and drip fumigations. In most cases, field sites were chosen with existing nematode or other soilborne pest and disease problems. Those fields lacking nematode infestation and other pest pressures were grouped and analyzed separately. Some field trial locations were selected and included sites where alternative fumigant products had been used in previous cropping seasons with the objective to evaluate any potential degradation of treatment efficacy after repeated use.

During the 5 years of this reporting, sixty five different treatments were evaluated and compared with a grower standard and or methyl bromide chloropicrin fumigant treatment. In many of these trials, fumigants were applied with commercial grower equipment, in which case the field application was monitored, and observations of flow meter calibration and settings, treatment block locations, and measurements of soil and environmental condition recorded. In addition to grower equipment, other fumigant applications were made using the principal investigators tractors and fumigant application equipment. Clearly there was a benefit to using the principal investigators equipment and fitting into the 'convoy' of farm traffic without forcing the grower cooperator to incur long delay and labor use inefficiency. For the studies reported herein, a variety of fumigants, formulations, and their combinations were evaluated, examining a variety of different rates and methods of application and plastic mulch films.

Differences in actual strawberry yields between the chemical alternatives were ascertained in 20 separate field studies. Weather during the period can be described as two very warm seasons and 3 very cool seasons, with the number of freeze events recorded from 2007 to 2012 as 2, 11, 12, 13, and 6 per season respectively. As a result, annual production levels, harvest frequencies, and overall differences in fruit quality and culling were very different and difficult to meaningfully compare. A changing grower standard of methyl bromide chloropicrin formulation from 98/2 to 67/33 to 50/60 added another level of complexity which challenged meaningful treatment comparison. For summary purposes, relative strawberry yield was used instead of the strawberry yield weight. Relative yield allowed us to avoid using strawberry fruit yield records plagued and influenced by changing environmental and biological conditions and with use of different formulations of methyl bromide. It also accounts for nematode stunting and field level changes in plant sizes, and provides for yield mapping capability and is based upon highly descriptive and established relationships quantifying strawberry fruit yield with plant size. It is also noteworthy to indicate that we had treatment specific – relative yield survey information from over 150 different fields since 2007, many of which were field scale grower demonstrations. As a result, actual strawberry yield data are not reported herein but can be found and compared within the annual proceedings of this conference. In lieu of strawberry yields, relative yields values were determined and averaged across all years and experimental locations to derive an overall, experiment wide, comparison of specific chemical treatments on crop yield relative to maximum canopy coverage and then performance of methyl bromide and other fumigants.

At all field research locations, beds measured 32 inches wide, 10 to 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. At most field research and grower demonstration sites, bare root 'Festival' transplants from Canadian nurseries were planted between 4 to 5 weeks following fumigant treatment. At some Driscoll™ field research sites, a variety of proprietary varieties were evaluated during the course of this project. Assessments of plant growth were made as appropriate during the course of each season to characterize differences in plant size, health, and vigor. At 20 field locations during the period, 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 through April of each year. An untreated control was not included as a replicated treatment for comparison at many field locations. All treatments were typically arranged within their respective experimental areas as a completely randomized block design with at least 4 to over 24 replications per treatment in many grower demonstration trials. Plot sizes varied from 2 to 12 rows or 0.06 to 0.4 acres among the different small plot and grower demonstration site 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 in over 20 monitored fields (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). Using plant sizes, fumigant treatment evaluations based on relative yield were determined in commercial fields with recurring histories of sting nematode problems, and in some cases, fields in which the nematode was not present. Relative yields were computed based on previously reported MBAO research, assuming proportional reductions in yield of 100% for dead, 83% for small, and 52% for medium sized plants relative to large plants. Hyperspectral reflectance field imaging technology were 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 (NTech Industries; Ukiah, 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 and both values used to independently compare differences between various soil fumigant treatments.

GENERAL SUMMARY:

- With regard to formulation of methyl bromide chloropicrin, a changing reference standard for treatment comparison was observed over the course of the 5 year USDA ARS Areawide project period (Figure 1). With increasing cost and decreasing availability of methyl bromide, the chloropicrin content of the formulation increased during the project period with transitions from formulations of 98/2 to 67/33 and to 50/50, which was generally considered inadequate for yield, nematode, or weed control efficacy. The problem with this changing reference standard is that as performance degrades to the level of methyl bromide chloropicrin 50/50, it makes everything else look good in terms of strawberry yield potential. Is it any wonder that that we continue to hear that there are lots of effective methyl bromide alternatives, particularly when studies are conducted in fields without pest pressure.

- Relative strawberry yields were often near equivalent regardless of fumigant treatments when the Sting nematode (*Belonolaimus longicaudatus*) was not present (endemic) within the field (Figure 2). Without pest pressure, all of the different fumigants looks pretty good compared to methyl bromide chloropicrin treatment.

- In the presence of Sting nematode in the field, losses in strawberry yield potential was variable among the different fumigants evaluated (Figure 3). In general, fumigant performance declines on average by 3 to 35 percent from their respective levels observed at sites where the nematode was not present (Figure 2). Performance inconsistency from one production season to another for some of the fumigant treatments evaluated were demonstrated be a truly undesirable trait.

- The top ranking methyl bromide chloropicrin alternative treatment under new plastic mulch in the fall were 3 Way applications involving Telone C35 or Pic Clor 60 shank applications followed by minicoulter applications of Vapam (metam sodium) or KPam (metam potassium) as a separate bed treatment (4 inches deep) to the bed surface prior to mulch installation (Figure 4).

- Among the Telone C35 / Inline and Pic Clor 60 / Pic Clor 60EC treatments, significant differences in relative strawberry yield were observed between shank and drip fumigant treatments (Figure 4). These results clearly suggest the inferiority of drip fumigation treatment, even with two drip tapes per bed into fine sandy soils which typify the Florida strawberry production system.

- These studies demonstrated that improved control of plant parasitic nematodes and relative strawberry crop yields are dependent upon the adoption of early crop destruction as an IPM practice (Figure 5). Temperature probes installed into stale-beds into east and west bed shoulders and bed center locations demonstrated that soil temperature at 6 to 12 inches (15-30 cm) depth could attain temperatures of 100 to 120 F on a daily basis. These results suggested that crop termination treatments with a drip fumigant, followed by stale bed summer solarization treatment did not necessarily have to be 100% effective to provide nematode control within strawberry plant beds. The crop termination treatment was observed to eliminate food and incrementally reduce spring populations of Sting nematode, followed by summer solarization, and fall drip fumigation treatment translated to higher yields within the subsequent planted fall double crop. The harder, more compact stale beds also appear to laterally transport fumigants easier, resulting in increased yield response in the subsequent strawberry crop.

Figure 1. Results from multiyear USDA ARS Areawide Project studies(2007-2012) evaluating the benefits of 3 shank applied methyl bromide chloropicrin formulations, including 98/2 (400 lb/ta);67/33 (350 lb/ta);50/50 (350 lb/ta). Numbers of experiments (in parentheses below) averaged to form grand mean +/- standard error.Relative yield computed from end of season assessment and distribution of plant sizes within field in which Sting nematode (*Belonolaimus longicaudatus*) is present.

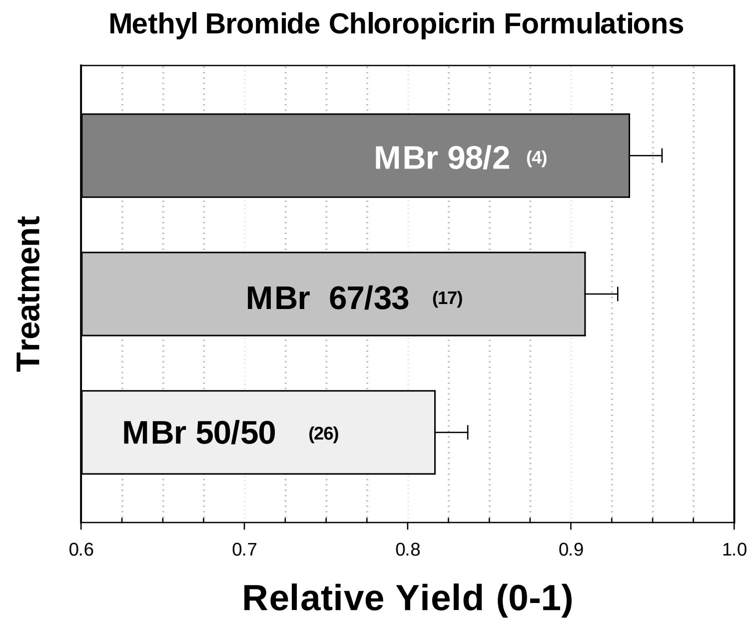

Figure 2. Results from multiyear USDA ARS Areawide Project studies (2007-2012) testing the benefits of drip applied Vapam (75 gpta), KPam (60 gpta) or shank applied Pic Clor 60 (250-300 lb/ta), Telone 35 (35 gpta), Dimethyl Disulfide (60 gpta), Midas 98/2 (100 lb/ta) or three formulations of methyl bromide chloropcrin including 98/2 (400 lb/ta);67/33 (350 lb/ta); 50/50 (350 lb/ta). The 3 Way includes minicoulter application of Vapam (75 gpta). Numbers of experiments (In parentheses below) averaged to form grand mean +/- standard error.Relative yield computed from end of season assessment and distribution of plant sizes within fields in which the Sting nematode (*Belonolaimus longicaudatus*) is NOT present.

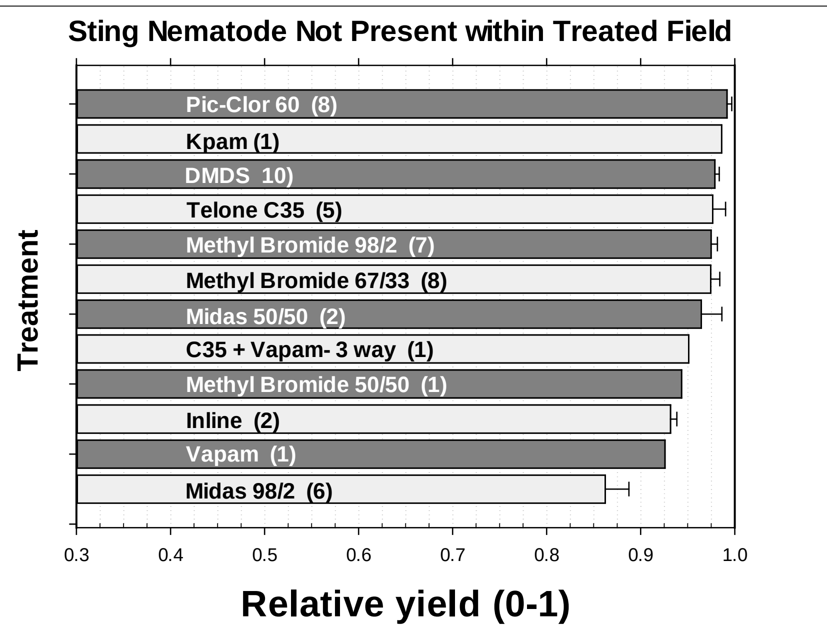

Figure 3. Results from multiyear USDA ARS Areawide Project studies(2007-2012) evaluating the benefits of a variety of shank or drip applied fumigant compounds with or without 3-way minicoulter applicationsof Vapam or KPam or to double cropped strawberries or under new plastic. Numbers of experiments (in parentheses below) averaged to form grand mean +/- standard error. Relative yields computed from end of season assessment and distribution of plant sizes within fields in which the Sting nematode (*Belonolaimus longicaudatus*) **is** present in all fields.

All Sites Where Sting Nematode is Present within Treated fields

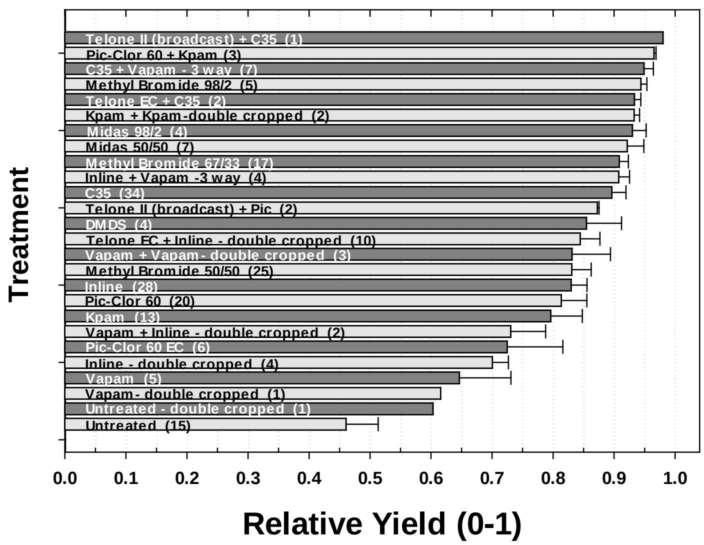

Figure 4 . Results from multiyear USDA ARS Areawide Project studies (2007-2012) evaluating the benefits of drip applied Telone Inline (35 gpta) or Pic Clor 60 EC (250-300 lb/ta) compared with shank applied Telone C35 (35 gpta) or Pic Clor 60 (250-300 lb/ta) with or without minicoulter application (3-way) of Vapam (75 gpta) or Kpam (60 gpta). Numbers of experiments (in parentheses below) averaged to form grand mean +/- standard error. Relative yield computed from end of season assessment of plant sizes.

All Sites Sting Nematode is Present within Treated Field
3 Way > Shank > Drip Fumigation

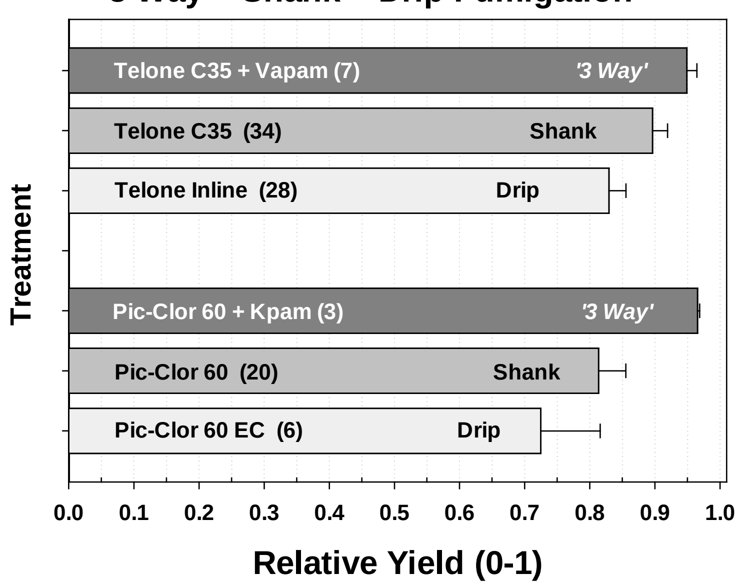

Figure 5. Results from multiyear USDA ARS Areawide Project studies (2007-2012) evaluating the benefits of drip applied Vapam (75 gpta) or KPam (60 gpta) appied as either a spring crop termination treatment or fall preplant application under new or double cropped plastic mulch compared with 2 formulations of methyl bromide chloropicrin. Numbers of experiments at the FSGA research farm Dover, FL (in parentheses) averaged to form grand mean +/- standard error. Relative yield computed from end of season assessment and distribution of plant sizes within fields in which the Sting nematode (*Belonolaimus longicaudatus*) is present within the field.