ALTERNATIVES TO METHYL BROMIDE FOR NEMATODE CONTROL: A SOUTH FLORIDA SYNOPSIS.

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The breadth and focus of the methyl bromide alternatives research program in Florida is not limited exclusively to evaluation of chemical combination treatment regimes. The Florida program also encompasses an evaluation of a diversity of nonchemical tactics. Some of the nonchemical alternatives evaluated include:

1) Cover crops
2) Organic Amendments
3) Biological Control Agents
4) Crop Rotation (Strip Tillage)
5) Super Heated Water and Steam
6) Paper and Plastic Mulch Technologies and Emissions Reduction
7) Pest Resistant Crop Varieties
8) Solarization
9) Natural Product Pesticides
10) Supplemental Fertilization
11) Fallowing

The objective of this paper is to highlight the results of some of the field trials performed in south Florida during 1997-98.

Large Scale Field Demonstration / Validation Trials:

Large scale field demonstration/validation tests for alternatives to methyl bromide soil fumigation were conducted in cooperation with commercial growers at multiple locations throughout west central and southwest Florida. Each of the trials on strawberry (4) and tomato (4) compared 1, 3 dichloropropene + 17% Chloropicrin (Telone C-17; 35 gal/a) in combination with either Tillam (4 lb a.i./a) or Devrinol (4 lb a.i./a) to methyl bromide (400 lb/a) for crop yield and soil pest control. For strawberry, plot sizes ranged from 0.2 to 5.3 acres. For tomato, plot sizes ranged from 3 to 5 acres. In all studies, both Tillam or Devrinol was sprayed as a broadcast treatment on the soil surface and immediately rotavator incorporated prior to bedding. Each test was monitored for weed, nematode and disease severity and incidence. Differences in plant growth and stand density were periodically monitored over the course of the growing season at each site. Strawberry yields were monitored over a 26 week picking season by grower cooperators. Tomato yields were monitored by grower cooperators, and compared with replicated 20 plant subplots for each of at least 2 harvests per season.

Overall the combination of pre-bed, broadcast application of either Devrinol or Tillam herbicide and soil injection of Telone C-17 into the bed provided similar yields in most cases to that of methyl bromide for both strawberry and tomato. The historical use of methyl bromide at all sites can not be discounted as a factor for obtaining similar yield results. Soilborne disease, weed, and nematode populations were not present in sufficient numbers at most sites to provide meaningful pest control assessments. Some early season reduction in strawberry and tomato plant size was observed along with a corresponding short delay in fruit production. Overall, total tomato fruit production (yield) was similar between fumigant treatments, although some differences among individual harvests were noted between harvests and fruit size categories. At one site, the greater incidence and population level of root-knot nematodes at final harvest after Telone C-17 treatment, again suggests the potential for greater resurgence in root-knot nematodes and increased damage if the field was double cropped.

It should be recognized that even though yields were similar, it is not clear at this time whether this treatment regime will survive the environmental scrutiny of our regulatory agencies or ultimately be adopted by growers due transplant issues associated with Tillam, or to the significantly increased needs for personnel protective equipment required for all workers in the field during Telone C-17 application. Telone C-17 ® presently requires the use of a spray suit, rubber gloves, boots, and a full face respirator by all personnel in the field at the time of application. Although efforts are reputedly underway to address both of these restrictions with the manufacturers and the U.S. E.P.A., the current label restrictions is expected to severely limit their usage in Florida vegetable production.

Plant Resistance Studies:

Four field microplot experiments were performed to test the impact of initial inoculum level (Pi) of *M. incognita* (0, 100, 500, 1000 per 100 cc soil) on fruit yield of susceptible (Agriset 761, Florida 47) and nematode resistant (Sanibel) tomato cultivars in central Florida. In fall studies, tomato yields decreased ($P=0.05$) with *M. incognita* Pi for all cultivars. Sanibel was damaged less ($P=0.05$) and was significantly more tolerant of *M. incognita* than the susceptible cultivars, particularly at the highest Pi. Although root gall severity was high and generally increased with Pi, root galling of Sanibel was generally less ($P=0.05$) than that of susceptible cultivars. No differences ($P=0.05$) in tomato yield or root gall severity were observed between cultivars or *M. incognita* Pi during a spring 1997 study. Final harvest soil population densities were always less ($P=0.05$) on Sanibel than the susceptible cultivars.

In addition to problems of heat instability of the Mi gene for nematode resistance in Sanibel, the continuous or repeated planting of resistant tomato varieties will almost certainly select for virulent races of *Meloidogyne* capable of overcoming the resistance. Therefore the duration and/or utility of the resistance may be time-limited, mandating the rotation of resistant and non-resistant varieties to slow the selection process for new virulent races. These trials have already demonstrated the capacity of some species or races of root-knot to reproduce and inflict damage upon a resistant tomato variety. The results of these preliminary experiments have also demonstrated that even with a resistant variety, which were damaged less than that of the susceptible variety, some consideration of initial soil population levels of the root-knot nematode must be observed to minimize tomato yield losses. Given that significant yield losses can still occur, combined efforts to manage soil populations to low levels prior to planting must still be considered, particularly if tomatoes are planted as a fall crop. Due to the heat instability of the resistant gene and higher yield losses during fall, use of the resistant variety may have to be restricted to spring plantings when cooler soil temperatures prevail.

<u>Soil Amendments</u>: Concurrent field microplot studies, initiated fall 1996, have been conducted to determine the extent to which increasing application rates of a municipal solid composted waste and sludge (0, 15, 30, 60, 90, 120 tons per acre) effect the ability of tomato plants to tolerate root infection by a species of root-knot nematode (*Meloidogyne incognita*). These studies showed that in a sandy soil, poor in organic matter content (less than 2%), tomato yields could be increased significantly (P=0.001) with soil amendments in both nematode free or nematode infested soil. The impact of the root-knot nematode on tomato yield was effectively constant however, suggesting that application of the soil amendment did not enhance the ability of tomato plants to tolerate infection by the root-knot nematode. In these same studies, application of composted municipal wastes at rates up to 120 tons per acre were not been shown to be nematicidal in activity, but actually dramatically increased populations of *M. incognita*. Nematode population increases were directly related to increases (P=0.001) in plant growth and root system size with amendment application rate. This research appears to indicate that the major effects of soil amendments to crop yields appear to be less related to nematode or soil pathogen control than to enhanced plant nutrition and nutrient and water availability.

It is also not clear at this time and preliminary stage of Florida field research whether benefits to crop growth after the initial crop following soil amendment application can be expected. Concurrent studies have shown no response in second crop tomato yields (double crop) following amendment application rates from 15 to 120 tons per acre. Disappearance of nutrients and soil organic matter content appears to be very rapid in the hot, moist soils of Florida. This research suggests that reapplication of the amendments may have to be made on a 12 to 18 month basis to sustain crop growth and yield benefits.

SUMMARY: Recent studies in Florida show that no single, equivalent replacement (chemical or nonchemical) currently exists which exactly matches the broadspectrum efficacy of methyl bromide. For example, yield reductions upwards of 40% were observed in replicate studies with a resistant tomato variety. In other grower demonstration trials, soil solarization proved to be inadequate for nematode, weed, or disease control, or in related research demonstrated potentials for reduced efficacy with soil depth and development of heat tolerant pest populations. Use of composted municipal solid wastes were shown to be non nematicidal, and did not enhance the ability of tomato plants to tolerate root-infection by *Meloidogyne incognita*. A summary of chemical alternatives research suggests that a chemical cocktail of different fumigants (ie, *1,3-dichloropene* with chloropicrin) and a separate, but complementary herbicide treatment will be required to achieve what appears to be satisfactory tomato and strawberry crop yield response. The future success for development of nonchemical alternatives for effective soilborne pest and disease control in Florida will require an integrated approach involving combinations of multiple tactics since none of the nonchemical tactics are considered single, stand alone replacement strategies for methyl bromide soil fumigation at this time. As a result, new field studies evaluating combinations of tactics have been proposed or are in progress to establish cumulative impacts on soilborne pest control and crop yields. However, the lack of sufficient research funding and the proximity of the currently defined phaseout date of January 1, 2001 should be considered major obstacles to evaluation, development, and implementation of many of the proposed nonchemical alternatives.