Title: Examination of an integrated approach of using composts, summer cover crops, beneficial mycorrhizal fungi and vermicompost for organic and conventional strawberry production in the Southeast.

Progress Report

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Research Proposal

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Objectives:

1. To evaluate the integrated treatments of compost applications with selected summer cover crops and beneficial mycorrhizal fungi and vermicompost applications for their effects on strawberry field production in North Carolina.
2. To evaluate the impact of vermicompost and beneficial mycorrhizal fungi inoculants on strawberry plug production

Justification and Description:

Strawberry growers in the Southeastern (SE) U.S. face unique production challenges due to the warmer climate, poorer soil fertility, and higher pest pressures compared to other regions of the country. Soil borne pathogens, especially root rot diseases, weeds, and nematodes frequently cause considerable yield reductions in strawberries (Wing et al., 1995). Pest problems can become chronic when strawberries are replanted in the same location each year, a common practice for roadside stands or pick your own production in the SE. Methyl bromide fumigation has the been the main approach to control soil borne pests in strawberries in the SE; however it is currently being phased out for its negative contribution to ozone depletion. Although there are a number of fumigation and pesticides alternatives being examined, there are significant health and environmental concerns associated with some of these and none are as effective as methyl

bromide (Duniway, 2002). As restrictions on methyl bromide tighten, it is critically important to investigate *sustainable* approaches to pest and soil management for both organic and conventional strawberry producers in this region that are effective, economically viable and also enhance overall soil quality.

Cover crops can be important components to improving soil quality, soil fertility and pest management in strawberry systems. Using cover crops in rotation with strawberries has been demonstrated to increase soil organic matter and fertility, enhance biological activity and break up pest cycles (Seigies and Pritts 2006), although most of this research has concentrated on the NE or Western U.S. Investigators on this proposal (Drs. Michelle Schroeder-Moreno and Gina Fernandez) have preliminary research from a previous two year study funded from a SARE grant (No. LS07-200) demonstrating an array of potential summer cover crop species that can be utilized in strawberry systems in NC and the SE. We additionally have worked with three strawberry producers in NC (Indigo Farms in Calabash, Iseley Farms in Burlington and Buckwheat farms in Apex) to examine producer identified potential challenges and perceived benefits of selected cover crops in on-farm research. All farmers noted that managing summer cover crops in strawberries are challenged by a short growth period (mid June thru end of August) and recommended seedling rates for these species may be less than what is needed to maximize growth for this restricted time frame. More research is necessary to determine specific cover crop combinations, enhanced seeding rates and integrated applications of composts to maximize cover crop biomass and their benefits on soil quality, fertility and pest management for strawberry production in North Carolina and the SE.

Plug production practices also provide an opportunity to pre-inoculate strawberries with beneficial soil organisms, often eliminated or reduced through chemical fumigation and even biofumigation practices with brassicaceous cover crops. Inoculation with arbuscular mycorrhizal fungi (AMF) can benefit strawberry plants by improving plant growth and nutrition (Khanizadeh et al., 1995) and reducing damage caused by *Phytophthora* root rot (Norman and Hooker, 2000). Plug systems also provide an opportunity to pre-inoculate strawberries with an array of beneficial organisms through vermicompost inputs. Vermicompost applications have been shown to reduce physiological disorders and increasing pest resistance in strawberries (Singh et al., 2008), although very little is understood about the potential synergistic effects of inoculations with mycorrhizal and vermicomposts in strawberries.

Well-designed cover crop rotations and compost applications that add soil organic matter may also improve the environment for enhanced functioning of AMF and the soil microbial community in vermicomposts. Diverse rotations with species that support AMF are thought to play a key role in enhancing the indigenous AMF community and subsequent crop benefit, although this is relatively unexplored in practice. **The purpose of this project is to evaluate an *integrated* approach of summer cover crop rotations and compost applications with pre-inoculation with beneficial mycorrhizal fungi and vermicompost as systems-level strategies to enhance soil quality, soil fertility and pest management for strawberry production in**

North Carolina. Evaluation of cover crops for diverse functions, including enhancing AMF and vermicompost applications, as proposed in this study, are major advancements towards developing integrated approaches for sustainable soil and pest management for both organic and conventional strawberry production in North Carolina and the SE.

Methods:

Methods for Objective 1: Field study at the Center for Environmental Farming Systems

We have established the field part of this study in June 2009 at the Center for Environmental Farming Systems (CEFS; www.cefs.ncsu.edu) in Goldsboro, NC, capitalizing on our experience from our previous two year strawberry cover crop project and knowledge about the background mycorrhizal fungi populations there. Our field study was set up as a randomized split block design with the main treatments being five compost and cover crop treatments and each plot was replicated 6 times. Composted manure was additionally added in the rate of 11 tons/ac to each cover crop plot in mid June 2009 (and same time in June 2010) prior to strawberry planting in 2009 and after strawberry plants were pulled up in 2010. Composted manure was incorporated and cover crop treatments were planted in each plot shortly thereafter (usually no more than a 1 week following compost additions). The five compost/cover crop treatments will consist of: 1) Pearl millet (*Pennisetum glaucum* var. "Piper"), 2) Pearl millet in combination with Cowpea (*Vigna unguiculata* var. "Iron clay"), 3) Pearl millet in combination with Soybean (*Glycine max* var. "Laredo"), and 4) Control (no compost and no cover crops). Cover crops were flail mowed early Sept each year and following 1-2 weeks for drying out on the field were incorporated fully in the soil. Each plot contained two strawberry beds (split plot) representing the two beneficial soil treatments- native mycorrhizal fungi and native mycorrhizal fungi and vermicompost applications (split plot factor). Bare root "Chandler" strawberry organically certified tips (roots that have not been exposed to soil or other AM fungi) were pre-inoculated with AMF or AMF + vermicompost and grown in misting benches in a greenhouse at NCSU four weeks prior to planting strawberries during the first week of October. Strawberries were planted using drip irrigation under plastic on raised beds and following guidelines according to national organic standards, including approved organic pre-plant fertilizers and soluble fertilizers for fertigation, and organic disease and insect controls. These treatments and field experiment will be replicated for two seasons of strawberry growth and harvest.

To examine the effects of the cover crop treatments and beneficial pre-inoculation treatments, we measured marketable (and total) strawberry yields, strawberry shoot and root biomass and leaf tissue nutrients (at least five times during strawberry growth per season). We additionally measured soil extractable N at each of the five periods of strawberry growth to understand how N was released from organic sources over time which is a critical component of organic soil fertility that is poorly understood for strawberries. We made observations of any disease incidence (e.g., *Phytophthora*, *Botrytis* and *Anthracnose*).

Methods to Satisfy Objective 2: Phytotron study

We just finished setting up a study a study to assess the separate and combined effects of native AMF species and vermicompost applications compared to controls (without mycorrhizas or vermicompost) on strawberry plug growth and nutrient responses when infected with *Pythium irregulare*. We planted Chandler strawberry tips obtained from the Micropropagation Unit (MPU) into flats under misting benches with either live native mycorrhizas, vermicompost treatments or their appropriate controls on Nov 17th 2010. We will inoculate all treatments with either live *P. irregulare* (obtained from Dr. Frank Louws) or a sterilized *P. irregulare* control and transplant into 6 in pots after 4 weeks under the misting bench. We will monitor strawberry growth, dry weight at harvest and mycorrhizal and *P. irregulare* colonization for an additional 10 weeks in the phytotron growth chambers.

Results:

While we are still working on analyzing data from the recent strawberry harvest in June 2010 from the field experiment , all data (strawberry yields, strawberry shoot and root dry weights, and leaf area at five strawberry growth stages) have been entered in excel and we are preparing for data analyses in the next 2 weeks. The mycorrhizal colonization, strawberry leaf/petiole nutrient analyses, weed abundance and extractable soil N at the five growth periods are in different stages of analyses in the laboratory and we anticipate these will be completed by Jan 2010. Although through very preliminary analyses, we found no difference among cover crop treatments (grouping split plots) in total seasonal marketable yield per plant (Table 1). There was a trend for the Pearl Millet/Soybean treatment to have higher marketable yields per plant and overall yields seem to correspond to average strawberry yields during last year's season for this area. No disease incidence was observed for any of the treatments in the field experiment. Effects of cover crop and compost treatments may not be apparent only after one season's growth, which is why at least one more season of strawberry growth is warranted before any big conclusions are made.

Table 1. Mean Marketable total season yields per plant for each cover crop treatment (lbs/plant) for 6 replicate plots in the field experiment at CEFS. Each cover crop treatment additionally included the compost addition.

	Control	**Pearl Millet**	**Soybean**	**Cowpea**	**Pearl Millet +Cowpea**	**Pearl Millet + Soybean**
Marketable total per plant (lbs/plant)	0.79	0.79	0.77	0.82	0.78	0.86
Standard error	0.06	0.05	0.04	0.03	0.04	0.04

Conclusions

Research is ongoing and we will need another season (2010-2011) of strawberry growth in the field experiment and another experimental trial in the phytotron before we can draw any major conclusions. Formal results are expected by late 2011 as field and laboratory research is wrapped up and analysis begins.

Impact Statement

We are making steady progress in understanding how different integrated sustainable soil management practices can be utilized as sustainable alternatives for methyl bromide use in North Carolina. Results from these field and phytotron experiments will help us to understand how the integration of summer cover crops, composts and pre-inoculation of plugs with native mycorrhizal fungi and vermicompost may benefit strawberry plug growth and nutrient uptake and possibly reduce damage caused by *Pythium* and the Black Root rot pathogen complex, one of the major pathogens in non-fumigated and organic production.

Citation(s) for any publications arising from project

Garland B, MS Schroeder-Moreno, G Fernandez, N Creamer. Influence of Summer Cover Crops and Mycorrhizal Fungi on Strawberry Production in the Southeastern United States. Hort Science. *In review.*

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