# PROGRESS REPORT

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PROJECT TITLE: IMPROVING SOIL HEALTH FOR STRAWBERRY PRODUCTION IN THE SOUTHEAST: PROVIDING TOOLS FOR GROWERS

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PUBLIC ABSTRACT

In the Southeast United States (SEUSA), strawberries are grown as an annual crop. Several on-farm research studies have been conducted over the last 15 years to develop economically viable non-fumigant soil-borne disease management programs. Management systems that have been evaluated were to utilize compost, cover crops, crop rotations, organic amendments, and bio-fumigation of soil with a mustard meal, and the use of anaerobic soil disinfestation (ASD) methods. We also have advanced novel biological control agents (BCAs) as potential products for use in the strawberry production system and the long term, these will be integrated into biologically-based production systems. Our main objective of this project was to advance strawberry production systems and garner a greater capacity of farming system approach that contributes to soil health, disease suppression, and yield. We have established an experiment at Horticultural Crops Research Station, NC during the 2020-2021 strawberry growing season. We evaluated and compared the ASD, cover crops, composts, and chemical soil fumigation performances on plant biomass and fruit yield. The experiment was randomized and replicated four times with 10 treatments. After ASD, cv 'Camarosa' was planted and strawberry plant health, nematode counts, weed density, plant biomass were collected at pre-fumigation, planting, and final harvesting. Total yield was assessed weekly and cumulative yields were calculated in lbs/A. The results of the use of all ASD treatments and fumigant PicClor-60 significantly increased marketable and total yield compared to non-treated control (TIF or clear plastic without a fumigant or amendments). The compost/cover crop (CC + Comp) and plots covered with clear plastic, supplemented with Mustard meal full rate (Must Full CLR) or not amended (UTC CLR) had the lowest yields. The yield waspresumably fostered by higher plant biomass as measured by crown and root growth. The findings of this study indicated that the use of ASD treatments (full and half rates) with molasses and mustard meal can provide comparable yields as fumigation and could reduce the cost of synthetic nitrogen fertilizer.

## INTRODUCTION

Soil-borne fungal pathogens, nematodes, and weeds are considered major biotic factors limiting strawberry productions in the SEUSA. Among them, black root rot (Coons, 1924) is a major disease complex of strawberry (*Fragaria* × *ananassa*), caused by pathogenic fungi (*Pythium irregulare,* and *Rhizoctonia fragariae*) and the plant-parasitic nematode (*Pratylenchus* spp.) in North Carolina and surrounding states (Abad et al., 1999; LaMondia, 2003). Black root rot complex causes the death of feeder roots and the degradation of structural roots resulting in an overall decrease in productivity (Maas, 1998) and can cause up to 40% yield losses (https://content.ces.ncsu.edu/black-root-rot-of-strawberry).

Methyl bromide (MeBr), a soil fumigant has been used in strawberry production that relied on the single application of a broad-spectrum biocide to disinfest soils before planting. Due to health and environmental concerns, this soil fumigant was phased out for commercial use. Recently, major research has been focused on soil management practices to promote sustainable soil quality, productivity, and soil health (Pankhurst et al. 1997). These included management practices were cover crops, reduced tillage, composts, mulches, and organic amendments (Abawi and Widmer, 2000; Louws et al. 2000). Cover crops (e. g., ryegrass, pearl millet, oat, white clover, hairy vetch) have been incorporated as green manure before planting cash crops (Creamer et al., 1997). The use of cover crops not only enhances soil health and crop yield but also, can prevent erosion, reduce soil-borne pathogen and plant-parasitic nematode populations, and add organic matter or nitrogen (e. g., legumes) to the subsequent cash crop (Fageria et al. 2005). Likewise, the application of organic amendments (e. g., mustard meals, molasses, rice barn) and composts increased organic matters and microbial populations, suppressed the soil-borne pathogens, and led to improving the soil quality (Pera et al. 1983). Several non-chemical cultural practices such as soil amendments, composts or crop residues, cover crops other than host resistance, have been utilized and significantly enhanced C: N ratios and favorable soil chemical properties to improve soil health indicators, increase yield, and reduce soil-borne pathogens in vegetables and strawberry (Bernard et al. 2012; Cohen and Mazzola, 2006; Fang et al., 2012; Larkin et al. 2011; Litterick et al. 2004; Watanabe et al. 2011). The main objective will be to evaluate the performances of molasses (as a model carbon source), mustard meal, cover crops + compost, and compare with soil fumigant (PicClor 60), and untreated control (UTC) as biologically sustainable disease control options in strawberry production systems.

## MATERIALS AND METHODS

During the 2020-2021 growing season, we established a randomized, replicated (four times) with 10 treatments experiment in an open field at Horticultural Crops Research Station, Castle Hayne, NC. Each plot consisted of 3 beds 30 feet long planted to strawberries in twin rows and offset in the twin rows. In 2020, legume/grass (Cowpea: Pearl Millet, 100:10 lb/A) was field sown in late June. The summer cover was managed for optimum growth and then flail mowed to allow cut residue distribution evenly on the cover crop plots. Compost (12 Tons/A), produced using the Controlled Microbial Compost (CMC) system, was amended to these plots just before seeding. The cover crop and compost were soil incorporated 8 to12 inches deep using a PTO-driven rototiller. Beds were pulled and covered with totally impermeable film (TIF) with two drip tapes buried 2 to 4 in deep and spatially distributed in the bed. Cover crop residues were left under these conditions until strawberry plants were transplanted (3 weeks later). The cover crop was highly labile upon incorporation and plastic beds pulled well. In this study, the cover crop + compost plots were also flooded with water. ASD beds were established, and drip irrigation was applied (via the two buried lines) within 16-24 hours to saturate the beds and induce anaerobic conditions in the topsoil. To collect temperature and redox potential data, sensors were programmed to collect data during the treatment period. Redox electrodes hooked up to Campbell Scientific dataloggers to calculate real-time changes in the redox potential (anaerobic state) of the soil. Carbon treatments included molasses (5000 lbs/A; full rate) or half rate (2500 lbs/A) and Mustard Meal (Biofence) applied in 2000 lbs/A (full rate) or half rate (1000 lbs/A). An additional treatment consisted of half rate of each. In addition, molasses at the full rate was covered with clear plastic. The most common commercial fumigant, Pic-Clor60 was used as a control and injected into the beds during the bed formation process at 300lbs/treated A (positive control). Untreated controls included beds overlain with TIF or clear plastic but without a fumigant or amendments. Strawberry cv 'Camarosa' was planted in Oct; managed over the winter and harvested from mid-April to Mid-June 2021 at weekly intervals. Whole plant samples were collected at peak harvest to assess plant dry weights of the crowns and leaves. Field soil samples were collected as a baseline at cover crop seeding (from each rep), at planting from each plot, and again at peak harvest and 12 months later. Soils were analyzed for nutrient, pH, carbon, microbial activity, and soil health parameters. Nematode counts were done at NCDA, Nematology Lab, Raleigh, NC. All experimental data were collected from the 40 plants of the harvesting area in the inner bed to limit inter-plot interference. Yield data were analyzed using a two-way repeated-measures analysis. Spearman's correlation coefficient between the 2020 and 2021 yield data.

RESULTS

All ASD and Pic-Clor60 treatments provided significantly higher cumulative marketable yield and total yield compared to nontreated control (Figure 1). ASD with molasses + mustard combined at half rates (Mol + Must ½), and molasses applied at full rates (Mol Full) had comparable total marketable to Pic-Clor60. Mustard meal at the full rate (Must Full), molasses at the ½ rate (Mol ½), a mustard meal at ½ rate (Must ½ rate), and compost/Cover crop (CC + Comp generated intermediate yields and did not offer a benefit compared to the untreated control covered in TIF with no amendments of fumigant (UTC STD). The plots covered with clear plastic, amended with molasses full rate (Mol Full CLR) or not amended (UTC CLR) had the lowest yields.

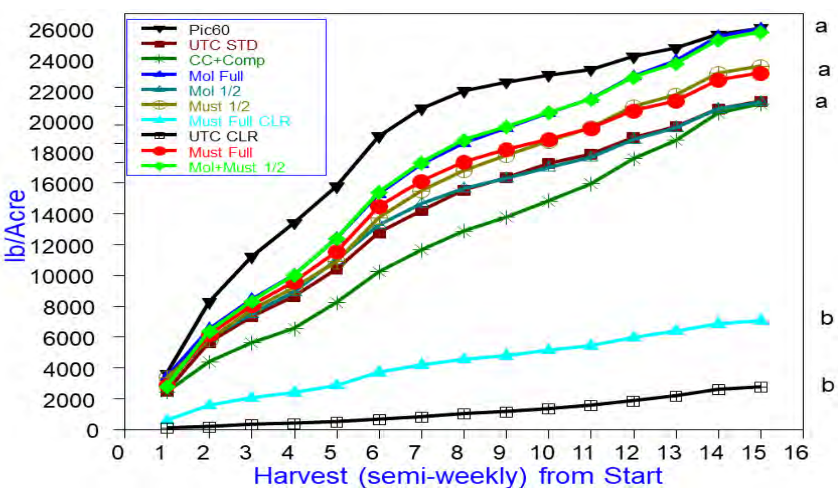


FIGURE 1. Cumulative marketable yield progress curves at semi-weekly harvests. Each curve followed by the same letter are not significantly different from each other based on repeated measures analysis and the Fisher Protected LSD (*P* = 0.05).

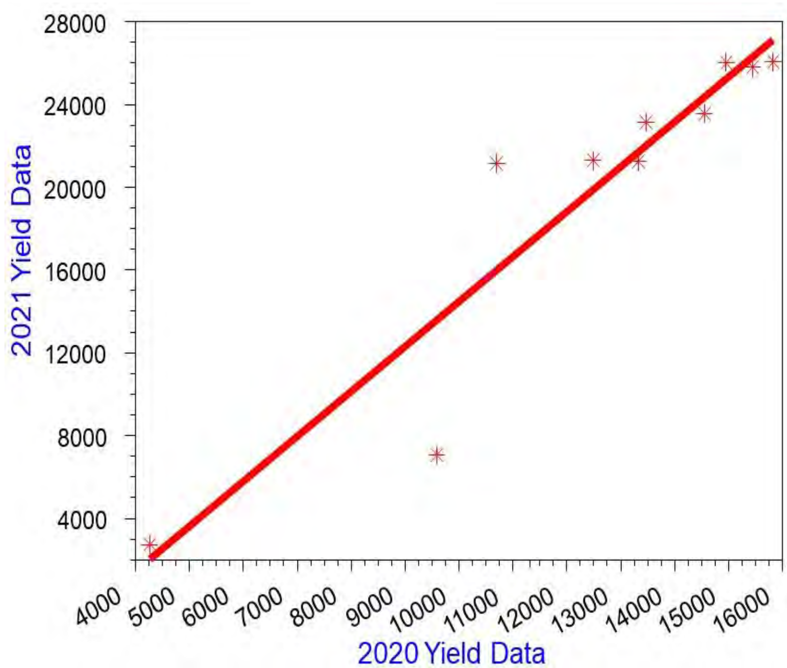


FIGURE 2. Spearman's correlation coefficient between the 2020 and 2021 yield data.

Total yields were suppressed in plots where clear plastic was used. The remainder plots did not neither vary significantly in total yield nor marketable yields. However, independence analysis showed the treatment ranking of total yield secured in the 2020 and the yield secured in the 2021 was highly significant. The Spearman's correlation coefficient statistic was 0.98 (*P*-value >0.0001) (Figure 2), indicating that the treatments that generated the highest yield in the 2020 also generated the highest yield in the 2021.

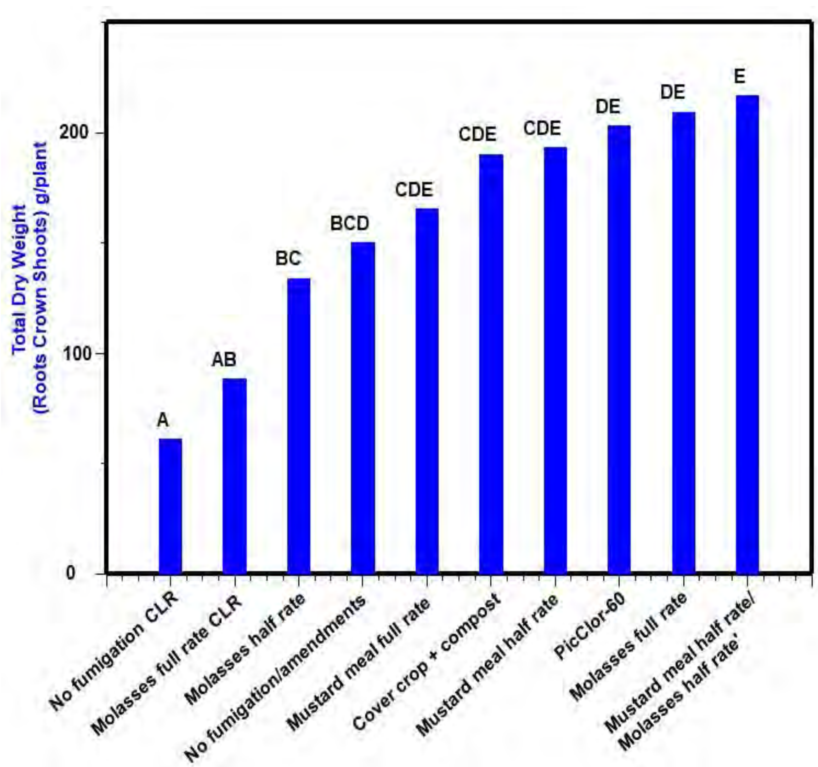


Figure 3. Total dry eight biomass (roots and crown shoots) during 2020-2021 season.

The fumigant and two ASD-treatments with molasses at the ½ rate (Mol ½), a mustard meal at ½ rate (Must ½ rate), and molasses applied at full rates (Mol Full) had significantly higher dry biomass of strawberry (Figure 3). The plots covered with clear plastic, amended with molasses full rate (Mol Full CLR) or not amended (UTC CLR) had the lowest dry biomass.

## OUTREACH

Findings of this study will be presented at the Agents Jan 5-6, 2022, Savanah, GA. Biologically based soil treatments were as effective as the standard fumigant in advancing plant growth and associated total yields. Effective treatments will be repeated in the 2022 experiment.

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