The Effects of Compost Tea and Municipal Solid Food Waste on Soil Quality in a Strawberry Plasticulture System

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Abstract: Municipal solid food waste compost (MSFW) and compost tea are becoming popular in agriculture and horticulture industries. Information on their interactions with fertigation and the effects these combinations have on non-nutrient soil parameters is variable. My objective was to measure soil N parameters to determine soil quality with the addition of these amendments in a strawberry plasticulture system. The study took place in the summer of 2012 at Dykeview farms in Kingston, Nova Scotia. Three levels of fertigation and compost tea were applied, and four levels of MSFW. Four N soil biological parameters were measured. Compost tea and MSFW compost amendments did not affect N measurements. However, the highest level of fertigation significantly increased particulate organic matter C and N, and Total N and C levels.

Keywords: Municipal solid food waste compost (MSFW), compost tea, fertigation, strawberries, nitrogen (N)

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1.0 Introduction

The practice of incorporating municipal solid food waste (MSFW) compost, compost tea and fertigation into strawberry plasticulture in Nova Scotia occurs without knowledge of how the amendment interacts with soil biology. Municipal solid food waste compost and compost tea alone do not provide sufficient nutrient levels to maximize yield, so synthetic water-soluble fertilizer must be used to supplement the compost amendments. The use of these is increasing in horticulture and agriculture. However, little is understood about how MSFW compost and compost tea affects soil quality. This may be leading to increased losses of nitrogen (N) to the environment, and decreased profitability for the producer. The purpose of this study was to help the producer identify how MSFW compost, compost tea and fertigation rate affected soil quality in the second year of a day-neutral strawberry plasticulture.

1.1 Background Information

1.1.1 Strawberry production in Nova Scotia

Currently, Nova Scotia provides eight percent (8%) of Canada's cultivated strawberries, and in 2010, has a farm gate value of four and a half (4.5) million dollars CAD (Statistics Canada, 2012). Farmers who operate intensely managed strawberry systems are faced with economic and environmental challenges. Strawberry production uses intensive fumigation prior to planting in order to extinguish harmful organisms from the soil, as these organisms interfere with crop production. However, this process also kills neutral and beneficial soil microorganisms (Leandro et al., 2007). The addition of fertilizers and organic amendments is then necessary in order to establish a high yield and replenish soil fauna.

1.1.2 Waste in Nova Scotia – Using Municipal Solid Food Waste and compost tea as organic amendments

Municipal solid food waste compost, made from mostly kitchen and yard waste (Hargreaves et al., 2007) is becoming more readily available in Nova Scotia. As more is diverted from landfills, and as the province produces more waste, there is a higher demand to utilize the compost in an efficient manner (Warman et al., 2009). Compost tea is distinguished as an extracted liquid of solid compost incubated with or without a microbial food source to extract the soluble nutrients and plant beneficial microbes into the solution (Shrestha, et al., 2012). This product provides an option for boosting yield and soil biology in the second year of biennial crops such as strawberries (Robin Horsnell, personal communication, 2012). In a study performed on brussel sprouts, Radin et al., (2010) stated the potential of using compost tea as a nutrient supplement simultaneously with soil applied compost, but not as a complete nutritional supply for crops. However, the nutrients supplied in compost tea are claimed to be a more readily available, compared with solid compost (Hargreaves et al., 2009).

1.1.3 MSFW and compost tea as organic amendments for strawberry production

We are fully aware that a stable and active soil microbial community is related to agricultural sustainability. The extensive fumigation used in strawberry production kills the beneficial organisms, and tillage, harvesting, and pesticides reduce soil organic matter (SOM). The addition of fertilizers and organic amendments are then necessary, in order to establish a high yield. How can we rebuild the soil community and soil organic matter while continuing to use the land as a production system? Municipal solid food waste and its products, such as compost tea, are an option producers have to steer away from rising fertilizer prices. Furthermore, MSFW and compost tea can hopefully grow to be an innovative value-added product that leads agriculture and horticulture on a more sustainable path, functioning to reduce the build-up of compost in facilities and providing opportunity for diversification.

1.1.4 Nitrogen transformations in strawberry production

Compost tea and MSFW may or may not provide sufficient nutrients to crops, but how do they affect soil biological activity, particularly within the microbial community, in terms of inorganic and organic nitrogen (N)? One of the challenges growers have is finding optimal amounts of available nitrogen to add to their crops. Soil amendment rates need to be adjusted accordingly to maximize yield and decrease the amount of excess N within the environment. Through detecting the N response of the soil we can determine how well the soil is mineralizing and immobilizing the soil, thus supplying available N to the plants. Nitrogen is one of the most important nutrients in strawberry production (Dale et al., 1989). This means application rates are important for producers, as excessive N applications contribute to an adverse cascade of environmental impacts (Canfield et al., 2010) and are detrimental to the economic sustainability of farming operations. This also leads to fruit softening and over growth of vegetation (Dale et al., 1989). Application of organic amendments is not always beneficial because it is unknown when the release of nitrogen will happen (Anon, 2000).

1.2 Objectives

This project is part of a study on the effect of MSFW compost and fertigation adjustment in strawberry plasticulture yield and fruit quality, which was performed in the summer of 2011 and 2012. To differentiate, the performed study was done to explore how different rates of compost tea and MSFW affect some soil biological indicators, rather than providing available nutrients. Although there have been several studies on nutritional value of MSFW compost and its effect on yield in horticulture crops, limited information is available on non-nutrient effects of MSFW compost. Recent reports have indicated significant reduction in horticulture crop yields, quality, and have linked this reduction to degradation of soil organic matter and reduction in soil biological activities. A major goal in this study is to gain better understanding of MSFW compost and compost tea application on soil health, while concentrating on nitrogen parameters within the plots measured.

The objective of this project is to analyze the effect of municipal solid food waste (MSFW) compost, compost tea, and fertigation adjustments on soil quality, by measuring nitrogen (N) soil biological parameters. Measuring such parameters can help distinguish how the different soil amendments and rates are affecting the soil community and their function in sufficing nutrients to plants. This study can help further determine whether the organic amendments can be used as an alternative fertilizer. Since there is an abundance of MSFW compost, pressure to find a use for the compost is increasing. The possibility that the organic compost can have improved recognition in the agriculture industry, through replenishing soil quality, is very feasible. Using compost tea as an amendment may provide strawberry producers with a soil biological stimulator and alternative source of nutrient that can improve soil quality and be financially feasible. My hypotheses are that the compost tea and MSFW will have significant effects on soil biological measurements.

2.0. Methodology

2.1 Experimental Design

The experiment took place at Dykeview strawberry farms in Kingston, Nova Scotia, in the summer of 2012. Last year's plots from the experimental design were still intact for the second year of that project except for superimposing of compost tea treatment (figure 1). The layout was a strip-strip plot design with three factors and three replications. Treatments consisted of three rates of MSFW compost from year one (2011) of (0, 5, 10, and 20 Mg ha^{-1} fresh weight basis), three rates of fertigation (25%, 75%, and 100% of recommended rate; due to compromised data last year the 50% fertigation rate unfortunately had to be excluded from the project) which consist of potassium nitrate, calcium nitrate, and magnesium sulphate. Compost tea was applied monthly at random rates of 0, 60 L ha^{-1} and 120 L ha^{-1}, through drip irrigation (Figure 2). The recommended rates of fertigation last year (2011) were developed based on soil test results and crop nutrient requirement. Subplots dimensions are 4.0 m x 4.8 m. Each plot consists of three flat hills (75cm wide x 10cm high), and there were two strawberry rows 30 cm apart on each hill. Three strawberry plants from each side of the data row and each subplot data row consist of 20 strawberry plants.

Figure 1: Strawberry plots in Mid June 2012.

Municipal solid food waste compost was obtained from Northridge Farms and treatments were applied in April 2011. Compost was only applied to the hills and was shallowly incorporated using a cultivator. The fertigation rates started in May 2011 using water-soluble fertilizers. The compost tea, which was brewed at Northridge Farms, was applied monthly to the strawberry plots. The first application was in April 2012 and continued until September 2012. This is done through drip irrigation system, which is running through the hills of the strawberry rows. Monthly samples of compost tea were taken and sent for analysis.

	CT 60	CT 120	CT 0	CT 120	CT 0	CT 60	CT 0	CT 60	CT 120	
Rep1				18	20		22		24	MSFW 20
										MSFW 10
										MSFW 5
				17	19		21		23	MSFW 0
Rep2				10	12		14		16	MSFW 0
										MSFW 5
										MSFW 10
				9	11		13		15	MSFW 20
Rep3										MSFW 10
				2	4		6		8	MSFW 0
				1	3		5		7	MSFW 20
										MSFW 5
	Fertigation 75%			Fertigation 25%			Fertigation 100%			

Figure 2: Dykeview farm experimental plots with MSFW, Compost Tea (CT), fertigation and three replicates. The highlighted plots are the plots being analyzed for soil N parameters

2.2 Soil sampling

Composite soil samples (ten auger samples with 2.5cm diameter; 0-30 cm depth) were collected from 24 plots in mid-season (late July). We used a “W” shape to randomly select places to insert the auger within the plots. The plots used in the study are the extremes of each treatment; 0 and 20 Mg ha^{-1} fresh weight of MSFW compost, the 25% and 100% of the fertigation rate, 0 and 120 L ha^{-1} of the compost tea and for each replication (Figure 2).

2.3 Methods for soil sample analysis

Four different research analyses are being used in this project; measurements of inorganic N, N-mineralization, particulate organic matter C and N, and microbial biomass C. These are all biological indicators of soil quality

2.3.1 Inorganic N

The amount of inorganic N can tell us how much available N mineralization, to ultimately be taken up by plants is. Soil was air dried for 24 hours. The soil was then half filled in vials with different size metal rods (one small, on medium, and one large). These vials were then placed on a roller mill for 48 hours at a 20-watt speed. Finally, one gram of grounded soil was placed in the Elementar for analysis. This is the concentration of N_2O being emitted from the soil solution. The rate of N_2O emissions is determined by plotting the change is N_2O accumulation against the exact number of minutes.

2.3.2 N-Mineralization

The N-Mineralization supply test tells us how much NO_3^- and NH_4^+, is available for plant uptake. This was done adding 0.5 M KCl over 10 grams of subsoil in 100 mL French bottles, then shaking the bottles for an hour. After, they are attached to a vacuum filter and transferred into smaller sample bottles and kept frozen until analysis. The samples were sent for analysis, which measured leachate from the soils before and after incubation. N-mineralization is a measure of the active portion of soil organic N (M. Sharifi, personal communication, 2012). Net N mineralization was determined by analyzing total soil inorganic N before and after incubations. Inorganic N was extracted from soil by shaking 20 g fresh soil samples end-over-end with 1 M KCl (1:2.5 soil: solution ratio) for 1 hour. Samples were then filtered (Whatman No. 42), and the filtrate frozen until analysis for NH4+ and NO3− on a flow injection analyzer (Lachat QuikChem 8000).

2.3.3 Particulate Organic Matter C and N

Ashagrie et al. (2006) proposed was that large stocks of POM in soil have been linked with noticeable mineralization of nutrients, such N, and therefore related to higher soil fertility and productivity. A common technique of measuring POM is widely used in the soil community; a few which studies have measured POM, such as Gartzia (2009) and Ashagrie (2006), both used the procedure done by Cambardella and Elliott (1993), which is what I have done also. Roughly 20 grams of subsoil sample, and passed through a 2 mm sieve after being air dried. Then set dry oven at 40 degrees Celsius for 24 hours. These were then put in French bottles with 100 mL of sodium hexametaphosohate solution and shaken overnight. The suspension was then poured onto a 53 um sieve. The silt and clay-sized were washed through the sieve. The POM (sand and larger aggregates, larger particles of organic matter) is left in the sieve. Particulate organic matter was dried in an oven overnight at 60 degrees Celsius, placed in a pestle and mortar for grinding, then sent to a lab for determining Carbon and Nitrogen pools (M. Sharifi, personal communication, 2012). Samples were analyzed on an Elementar varioMAX CN Analyzer. All C concentrations of POM were carried out though the same method.

2.3.4 Microbial Biomass Carbon (MBC)

The amount of microbial biomass measured indicates the response of soil biota to management, environmental changes, disturbances, and pollution (Ellen Kandeler, 2007). Soil microbes are also strong indicators of various element cycles (C, N, S, & P, and various metals) through stoichiometric biomass production, and the selection of the alternative electron acceptors under various reduction-oxidation (redox) conditions (Kandler, 2007). I first weighed 25 grams of subsoil sample in 100 mL french bottles for both fumigated and non-fumigated soils. The chloroform fumigation incubation (CFI) is a sensitive indicator of changing soil conditions (Carter, 2007). The method exposes soil to ethanol free CHCl3 for 24 hours to kill the microorganisms. Placing the fumigated soils in a large desiccator lined with wet paper towel to keep the desiccator moist and dark does this. The ethanol free CHCl3 (with boiling beads) is also placed in, and followed by an airtight seal of the desiccator. The soils and CHCl3 are than subject to high vacuum filtration until CHCl3 has boiled. The soil is then ready to rest for 24 hours. Un-fumigated soils are used as a control to compare with fumigated soils from the same plot. After the 24 hours is up 0.5 M K2SO4 is added to both fumigated and non-fumigated subsoil samples, which are then shaken for an hour. After shaking, the soil suspension is filtered through Whatman filter paper gravitationally or by using a vacuum filter system. The samples can then be transferred into smaller 5-20 mL bottles and frozen until analysis. From the removal of the fumigant, a flush of mineralized CO2 arises. The C02 that is accumulated in the headspace of the sample containers is measured by gas chromatography. In CFI a moisture content determination was needed for each treatment.

2.4 Statistical analysis

A strip-strip plot design was used with fertigation crossed with 3 blocks of MSFW compost and three rows of compost tea. The fertigation was randomized to the strips that ran north south while the MSFW compost was randomized within the blocks that ran east west in rows, and the compost tea was randomized in triplicates running north south. The treatment factors were defined as three fertigation rates (25%, 75%, and 100%), four MSFW compost amendment rates (0, 2 500, 5 000, and 10 000 kg ha_{-1}) and three rates of compost tea (0, 60, and 120 L ha^{-1}). There were three replicates of MSFW compost, and compost tea. An ANOVA was used to analyze differences between the treatments and significant was accepted at a < 0.05 probability level. The compost tea, MSFW and biological responses were analyzed as a two –factor factorial experiment in Latin square design with three replications, using the mixed model procedure in SAS. The fertigation was not involved in this analysis due to it not being replicated. The fertigation and the soil biological parameters were analyzed as a three factor ANOVA using JMP.

3.0 Results

There was no significant interactions between the MSFW, compost tea and soil biological parameters. However, there was significant increase of POM N and C, and Total N %N and %C with the 100% fertigation adjustment, when compared to the 25% recommended rate and increased microbial biomass carbon, the over all CN ratio (Table 1).

Table 1: Table of means of significantly increased soil quality indexes (highlighted, (minus MBC, which is not significant but has slightly increased)) from 100% recommended rate of fertigation.

	Recommended Fertigation Rate	
Measurements	25%	100%
POM C (%)	15.56	22.21
POM N (%)	5.88	9.46
Total C %C	77.74	87.60
Total N %N	59.70	66.75
MBC	97.62	103.88

4.0 Discussion

4.1 POM N and C

Particulate organic matter is said to be a sensitive soil organic matter (SOM) indication of the effects of cultivation (Gartzia et al., 2009). With POM increasing within the soil from the fertigation adjustments, it may mean it is reversing the effects of intense tillage. Tillage breaks soil aggregates and exposes previously protected organic matter within aggregates to microbial decomposition (Horwath, 2007), resulting in depletion of POM and mineral-associates (Gartzia et al., 2009). There are also indication that increasing the amount of POM has been linked with noticeable mineralization of nutrients, such N, and therefore related to higher soil fertility and productivity. The CN ratio of POM fraction of the bulk soil, which is usually considered as an indicator of the quality increased, but not significantly.

4.2 Total N and C

Soil microbial activity is a result of the degradation of organic compounds mostly for their energy usage (Sharifi, personal communication, 2012). Soil microbial population dynamics are important for N availability to plants (Lipson, 1999). There are variable processes that occur in soil that allow for the uptake of nutrients. Mineralization is a process that releases nitrogen as a by-product from the requirement of inorganic nitrogen (N), which allows uptake by plants and other microbes (Robertson et al., 2007). But the levels of N and the soil's ability to contribute N to the crop will vary depending on mineral content, organic matter, and water movement (Anon, 2000). With the increase in Total N %N, because of fertigation, this leads to more available N for mineralization. A constant threat to producers is their need and loss of N for crops: when too much nitrogen is added, money can be lost, and this can also have a harmful environmental impact. When not enough N is present, yields decrease (Hargreaves et al., 2008). As previously mentioned, when incorporating MSFW compost into a production system the available N is not adequate for optimal plant growth (Hargreaves et al., 2008), because of this, fertigation is added. However, soil amendments such as MSFW compost may reduce nutrient leaching because of its high organic matter content which has been shown to retain nutrients in soil (Pimentel et al., 2005). This may mean that less than the 100% recommended rate of fertigation could be applied. Furthermore, compost is far less likely to leach nutrients compared to synthetic fertilizers (Reganold et al., 1990). Although environmental costs are difficult to measure, it is apparent that MSFW compost could reduce the environmental impact of food production systems in Nova

Scotia. Since N is such a valuable macronutrient to soils for heavy production systems, further studies need to done to find the exact rates at which to apply soil amendments and fertigation rates for economic and environmental concerns.

4.3 Microbial populations and MSFW

There was a significant increase in soil microbial biomass carbon (MBC) with the recommended fertigation rate of 100%. Increasing microbial activity benefits berry yield and fruit quality (Shrestha, 2012). The amount of microbial biomass measured indicates the response of soil biota to management, environmental changes, disturbances, and pollution (Ellen Kandeler, 2007). Soil microbes are also strong indicators of various element cycles (C, N, S, & P, and various metals) through stoichiometric biomass production, and the selection of the alternative electron acceptors under various reduction-oxidation (redox) conditions (Kandler, 2007). According to Hargreaves et al. (2008), MSW compost increased soil microbial biomass (bacteria and fungi populations), C, and soil respiration after different applications of 2.5, 10, 20, and 40 mg ha^{-1}, and after just one application to soil, biomass N, C, and S showed an increase for up to one month, while biomass P showed an increasing trend for five months.

4.4 Soil organic matter (SOM)

Since the fertigation increased most soil N parameters (POM, total N and MBC), then it may be improving soil organic matter (SOM), thus improving overall soil quality. And while the organic amendments compost tea and MSFW did not significantly adjust N biological measurements, they may have an effect on soil in other ways such as improving SOM. Organic amendments are widely available and have advantages such as improving soil properties, adding nutrients, and recycling waste (Leanor et al., 2007). A primary benefit of Nova Scotia's MSWF compost is that it is high (30 -54% fresh weight) in organic matter and has a low bulk density (Hargreaves et al., 2008). Soil organic matter (SOM), which is formed by decaying plant residues, soil microorganisms, soil fauna, and the by-products of decomposition (Horwath, 2007) can decrease with conventional agriculture practices, such as tillage and intensive production systems. According to Reganold et al. (1990), a central component of sustainable agriculture is the addition of organic composts to the soil. Repeated addition of MSFW compost and compost tea increases soil organic matter (SOM) content and gives a greater C/N ratio than unamended soil (Hargreaves et al., 2008). The increase of SOM leads to improved soil structure, water holding capacity, and infiltration (Smith et al., 2007). The positive impacts of SOM are important in degraded soils that have long been used in conventional production systems and have depleted SOM levels (Reganold et al., 1990). The principle component of soil organic matter is soil humus. Soil humus largely improves water retention, nourishes biological activity, enhances soil structure, reduces erosion, and improves the cation-exchange capacity of the growing medium (Reganold et al., 1990).

4.5 Fertigation vs. organic amendments

In a study preformed by Hargreaves et al. (2007), the main objective was to determine if different types of non-aerated compost teas were a sufficient nutrient amendment when compared to MSFW composts and inorganic fertilizers in the cultivation of strawberries. In their conclusion, it showed that ruminant composts, MSFW composts, and non-aerated compost teas made from both composts, provided equivalent levels of nutrients to strawberries compared to inorganic fertilizers. Conflicting results were found in study performed for my fourth year project. In the study performed Shrestha (2012), the effects of non-aerated (anaerobic) compost teas/extracts, aerated (aerobic) compost teas, and a control, their solubility of minerals and mineralization of organic matter on tomatoes were measured. Soil microbial populations were measured through plate counts, the populations of the culturable bacteria were significantly higher in the compost tea extract when compared to a control and chemical fertilizer. When the aerobic and anaerobic compost tea treatments were compared, the colony forming units were twice as high with the aerobic compost tea.

These are reasons why further studies of MSFW compost and compost tea should be encouraged, because of its positive benefits for the soil, the environment, and profitability to the producer. In a study by Hargreaves et al.,(2007) soil and leaf calcium concentrations were reported higher with the addition of MSFW compost, and may be an important resource for soils, which are deficient in Ca. It was also found that soil potassium levels decreased with the compost tea application, compared to the compost or inorganic fertilizer. All in all, the two-year study found that compost tea maintained plant nutrient concentrations comparable to the ruminant compost, MSFW compost, and the inorganic fertilizer (Hargreaves et al., 2007). Compost extracts may therefore be used to maintain soil nutrient levels by growers who are restricted from using inorganic fertilizers, with the advantage of easier distribution (e.g. through irrigation systems) than is possible for solid compost (Shrestha, 2012).

4.6 More research on MSFW and compost tea should take place

The Nova Scotia mandated curbside-pickup residential composting program has been successful in diverting greater than fifty percent (50%) of its wastes from landfills in some areas of the province (Radin, 2011). The positive environmental externalities that would result are difficult to quantify; much like organic waste diversion could have been difficult to quantify when it first began in the mid 1990s. However, the step was taken; and the environmental benefits have been surmountable. For instance, in Lunenburg County, sixty five percent (65%) of solid waste has been diverted from the landfill (Radin et al., 2010), and Nova Scotia has become a global leader in recycling and composting. This could be taken a step further if Nova Scotia farmers could restore their soils, maintain high productivity, reduce their dependence on fossil fuels, and lessen environmental hazards associated with synthetic fertilizer application. Municipal solid food waste will continue to accumulate in the compost facilities if a reliable use is not found. The MSFW compost may have the potential to be a renewable resource if research is continued. Furthermore, MSFW compost tea can be an innovative value-added product that leads agriculture and horticulture on a more sustainable path, as well as reducing the build-up of compost in facilities and providing opportunity for diversification. Synthetic fertilizer prices are increasing every year as energy prices and the demand for crops increase. The environmental impact, which fertilizers create, will be a greater price to pay in the future such as acidification of soil and water resources, eutrophication conditions, loss of biodiversity, increased invasive species, greenhouse gas emissions and more (Motavalli et al., 2008). In terms of energy saving, both transportation and production costs of every kilogram of synthetic fertilizers will be reduced. The research of using our own food waste as a soil amendment could further boost Nova Scotia's position as a waste management role model in the world (Sharifi, personal communication, 2012), and we would truly be recycling our food waste.

A study performed by Hagreaves et al. (2007), outlined other benefits, which pertain to MSFW, such as reducing the volume of the waste, killing pathogens that may be present, and decreasing germination of weeds in agricultural fields. It is also mentioned that the benefits may vary:

> "The quality of MSW compost is dependent on many sources of variation including the composting facility design, feedstock source and proportions used, composting

procedure, and length of maturation. In addition to the differences between MSW composts, when it is applied to different types of field soils, there are further variability's in plant response." (Hargreaves et al., 2007)

Another study performed by Hargreaves et al. (2009), was the effects of MSFW compost and compost tea on mineral element uptake and fruit quality of strawberries. It was completed to compare the three different application rates of MSFW tea on selected soil, plant, and fruit quality parameters in the cultivation of strawberries. By doing further research on compost tea, additional ways to reduce landfill build-up, resulting in more economical and sustainable communities, may be attained.

4.7 Strengths and limitations

The original project included 108 plots, with four treatments of MSFW, three treatments of compost tea and three treatments of fertigation with three replicates. I only sampled 24. Measuring all 108 samples could be beneficial, because there could be more specific detail of the variation within and between treatments. This is also a strength because I was able to get very distinct results from just the extremes of the treatments. This project did not take into account the soil analysis before compost tea was added. Early season, mid season, and end of season soil analysis could give great detail and maybe more significant results. However, this would of lead to work beyond a fourth year project. Another limitation is the fact that soil samples, were stored correctly, but through traveling, and from taking soil samples out of the fridges to take sub samples, this may have disrupted the soil microbial activity. This project included a lot of people. Throughout the summer and fall of 2012 there was communication between several summer students, lab technicians, and supervisors and funding professionals, as well as traveling of samples, and supplies. From what I experienced and to the best of my knowledge everything went smoothly. There were quite a few bumpy times, but in the end everything seemed to work out. This I would say is a strength because the work was shared with very knowledgeable and supportive people, but also a challenge with increased number of people working on one project, there are always chances of loss of information.

4.8 Other options

Based on past literature, it seems that increased rates, and continuous of applications of MSFW, and compost tea improve soil, plant, crop, and yield in different but significant ways. This project only included one application of MSFW in year one of the study, and monthly applications of compost tea for only five months. This may be a reason why there were no significant changes from the soil N parameters measured. Other reasons may have included human or technical error throughout sampling, lab or statistical areas.

5.0 Conclusion

Based on these results, increasing fertigation from 25% to 100% increases important soil N parameters thus improving soil quality. Compost treatments did not affect the soil N parameters in mid season. The amendments may have some other non-nutrient, and nutrient effects that need to be explored in more details.

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