Final Project Report to the NYS IPM Program, Agricultural IPM 2001-2002

Title: The Impact of Organic Amendments on Soil Microbiology and Nutrients in a Three-Year Study of Trees Planted in Heavily Compacted, Poor Soil

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Type of grant: Cultural methods; sanitation; physical controls

Project location: Findings will apply throughout the Northeast and nationally

Abstract: This project adds new dimensions to a three-year study of the effects of soil amendments and drainage on the growth of three species of trees planted in heavily compacted soil. The research was originally intended to compare soil physical parameters. Striking differences in the growth of trees planted with organic amendments led to questions regarding the nature of long-term benefits derived from adding food compost at the time of planting. The proposed tests will allow comparison of soil nutrients, microbiological activity, and presence of beneficial nematodes as an indicator of healthy soil. This is a rare opportunity to observe differences in a randomized experiment with replicated treatments prior to the harvest of the trees.

Background and justification:

Trees planted in urban soils that have been disturbed by construction or heavy machinery, tend to be unhealthy and decline rapidly causing great environmental and economical loss. The primary cause of this decline is compacted soil in which the soil structure is destroyed, reducing aeration porosity and increasing bulk density. With decreased aeration porosity and increased bulk density, root movement through the soil becomes impeded and water drainage is reduced, resulting in poor root growth and function. The establishment of aeration porosity thresholds for woody plants, in particular Sugar and Silver Maple trees, and the correlation of these thresholds to percolation rates, is crucial for a better understanding of site evaluation, establishment, and management. At the end of the three-year trial, the trees in the food compost treatments were the most vigorous and well developed, compared to the trees planted with peat moss or no amendments.

The healthy growth of nursery trees correlates to proper site selection and planting methods. Many in-ground nursery operations improve their soil with amendments such as compost from municipal leaf waste, food composts such as brewery waste mixed with sawdust, or by planting cover crops during fallow periods. To achieve optimal growth of trees whether planting in a nursery or landscape setting the quality of the soil must be considered. An important feature is the biological portion of the soil ecosystem, including the earthworms, nematodes, bacteria, actinomycetes, and fungi. Many of these organisms compete with or suppress plant pathogens. The decomposers process organic matter over time to release nutrients to plants and microbes slowly, and increase porosity and aggregation of soil particles in a very beneficial way. A hot debate exists in the nursery and landscape industries about the best way to amend soils at the time of planting. The results of the study support the view that active composts are a preferable amendment to peat moss. A distinct advantage of food composts is the availability as a waste product, and that compost use will reduce the harvest of peat, an imported, non-renewable resource.

Design of the three-year study of trees planted in poor soil:
Soil dredged from the Cornell Plantations to create ponds was moved to a raised berm along highway 366 between the Stables and the Fleet Garage. Since landscaping attempts failed on the berm, Angela and Nina decided to use it as a test case for improving compacted poor soils such as are often found in urban sites. A trench was dug 18 in deep and 8 ft wide, and the soil was replaced in the trench, either mixed with peat moss or compost or not amended. One control treatment was to leave the soil alone, and plant directly into it. French drains were installed in half of the treatments. All treatments were replicated three times, and arranged randomly along the berm. Six trees, two bare-root specimens each of hardy rubber tree, silver maple and sugar maple were planted in each plot.

After three years, the trees in the food compost treatments appeared to have performed very much better than the other treatments. This IPM project was designed to take the opportunity to assay the microbial activity and the nutrient status of the different plots. The berm was not watered or fertilized for three years. Part of the explanation for the success of the trees in soil amended with food compost might be the enhanced microbial activity due to the addition of the active compost. Since peat moss is the product of many years of decomposition, it is not active compost. Our hypothesis was that the biological and nutrient content of the food compost might have played a role in the superior growth of the trees planted it, as well as the change in the aeration and porosity due to organic amendment. We at the NYS IPM Program would like to see greater use of active composts in planting due to benefits in disease suppression and slow, steady release of nutrients beneficial to the environment.

Ojectives:
1. Determine total microbial activity. Anu Rangarajan's laboratory staff will perform FDA hydrolysis assays for microbial activity. This enzyme assay does not differentiate between bacterial species and fungi, or beneficial or parasitic organisms. It is a measure of the total microbial population in the soil.

2. Determine the impact of the added composts on the nematode communities. Joseph Esnard will see if nematode communities can serve as a bioindicator of soil/tree health in Nina's plots. Results not included in this report.

3. Quantify the nutrients present in the different treatments.
    a. Total carbon and nitrogen testing in the ICP lab (Plant Science), Lucia Tyler
    b. Standard soil nutrient content by the Soil Testing Lab
    Results not included in this report.

Procedures:
Soil samples were taken prior to tree harvest in September 2002 from the 33 plots in the three year trial, sampling at about 15 inches from the tree trunks, and reaching six inches deep with the soil corer when possible. These samples were submitted for analysis in four different laboratories in Ithaca.
1. Determine total microbial activity
The microbial activity of soil was estimated by the rate of enzymatic hydrolysis of fluorescein diacetate (FDA) by soil microorganisms (Schnurer and Rosswall, 1982). Soil (.7 g fresh wt) was incubated in phosphate buffer for exactly 40 minutes. Enzymes produced by microorganisms in the soil cleave FDA to produce a yellow-green compound. The color intensity produced over the incubation period was compared to known concentrations of cleaved FDA. This provided an estimate of the rate of microbial enzymatic activity. Results were presented as the micrograms of FDA hydrolyzed per minute per gram dry wt of soil (ug/min/g dry wt). Higher rates of microbial activity resulted in higher FDA hydrolysis values. Some researchers have suggested that FDA hydrolysis values above 3.2 ug/min/g dry wt (Boehm

and Hoitink, 1992) were correlated to suppressiveness in potting media. Values from these analyses are useful for relative comparisons among treatments.

Schnurer, J. and T. Rosswall. 1982. Fluorescein diacetate hydrolysis as a measure of total microbial activity in soil and litter. Appl. Environ. Microbiol. 43:1256-1261.

Boehm, M.J. and H.A.J. Hoitink, 1992. Sustenance of microbial activity in potting mixes and its impact on severity of Pythium root rot of poinsettia. Phytopathology. 82:259-264.

2. Determine the impact of the added composts on the nematode communities.
The hypothesis is that different numbers and/or species of nematodes will become associated with the compost amendments over time. Plant parasitic and beneficial nematodes will be extracted from 100 cc of soil using a modified sugar flotation method. Plant parasitic nematodes in 3 sub-samples (each 25 g) of roots will be extracted by a Baermann pie pan method at root harvest. Beneficial nematodes will be identified to trophic level, and plant parasites to genus.

The soil samples were taken after an extended drought period, and contained very few nematodes. Joseph hoped to return to sample the roots at harvest for nematodes, but the trees were removed very quickly in one day by the Ithaca Parks Department in order to plant the trees in city sites, instead of destructively harvesting them. Joseph did not have a chance to complete his part of the project.

3. Analyze the nutrient status of the soil samples from the 33 plots
The results of soil testing labs were not sent to the IPM Program to be included in this report. An amended report will be produced after the nutrient testing results are received.

Results and discussion:

1. The microbial activity of the soil samples as measured with FDA hydrolysis was consistent with our hypothesis that food compost would contribute more to soil biology than peat moss. However, the variability in the data from the replicates was such that no significant differences were revealed. We can observe trends from the treatment averages:

- The samples from the peat moss amended plots, with and without drains, displayed microbial activity less than the overall average

- The samples from the plots with minimal digging displayed microbial activity greater than the overall average

- The samples from the plots where soil was removed but not amended, with and without drains, displayed microbial activity less than the overall average

- The samples from the food compost amended plots, with and without drains, displayed microbial activity greater than the overall average

Table 1. Assay for microbial activity

Treatments	ug/min/g soil FDA hydrolysis			average
25% peat moss	2.1	2.9	10.1	5
25% peat moss w/drain	6.4	10.1	3.6	6.7
50% peat moss	3.8	2.3	5.6	3.9
50% peat moss w/drain	3.6	10.4	5.5	6.5
25% food compost	12.0	5.8	6.8	8.2
25% food compost w/drain	9.9	13.7	9.6	11.0
50% food compost	11.7	4.8	10.3	8.9
50% food compost w/drain	4.0	4.4	12.6	7.0
no amendments	0.0	12.0	4.2	5.4
no amendments w/drain	4.1	3.1	3.1	3.4
minimal digging, tree pits	5.2	8.1	12.6	8.6
				6.8

It is possible that the minimal digging plots experienced less rapid decomposition of the natural level of organic matter present in the berm soil. Turning soil over aerates it and stimulates microbial decomposition. Therefore, the plots with no amendments where the soil was removed and replaced might be expected to have less microbial activity three years later than the plots where holes were dug just large enough to plant the sapling. It will be interesting to see how the tree growth data (tree pits versus no amendment) correlates with the microbial activity.

A study comparing microbial activity over time in plots with different organic amendments, including sampling before amending the soil, would provide clearer evidence of the importance of microbial activity in the tree root ecosystem. However, there appears to be a correlation between the success of the trees and the organic matter amendment. It is surprising to see such a difference three years after the treatments. Perhaps the evaluation of all the physical data and the tree measurements will reveal significant differences that relate to the source of the organic amendments and the microbial activity.

This work is part of a very large project that will be written as a PhD dissertation. However, this portion would make a good poster to use with nursery audiences. After the remaining information is collated, the collaborators will work together to produce an extension product.