



THE SOIL PROFILE

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Leaves From City Shade Trees Benefit Soils

Farmland near urban areas can benefit from leaves collected from municipal shade trees. New Jersey State regulations allow collected leaves to be applied to agricultural land in a layer up to six inches deep (equivalent to about 20 tons per acre on a dry weight basis). State regulations also require that tillage be used to incorporate the leaves into the soil. From the inception of the practice there were questions about how land application of collected leaves would impact soil quality and crop production. The agronomic, environmental and economic aspects of land application of collected leaves has been under investigation by Rutgers Cooperative Extension for about a decade. This issue of The Soil Profile Newsletter will highlight findings of that research.

Research Questions and Findings

- *Once municipal collected shade tree leaves (MCST) have been delivered to the farm, what is the best way to handle and land apply the material?*

New Jersey State regulations require the material be spread on land within 7 days of delivery to the farm. The application rate must not be greater than a layer six inches deep. Tillage must be performed after land application to mix the leaves into the soil.

Experience with land application of collected leaves at the Rutgers Snyder Farm found that a manure spreader works well for applying the material

and a chisel plow is an effective tool for soil incorporation. (Before incorporation it is generally a good practice to walk over the field to pick up the occasional bottle, aluminum can or other litter that may come with MCST-leaves.)

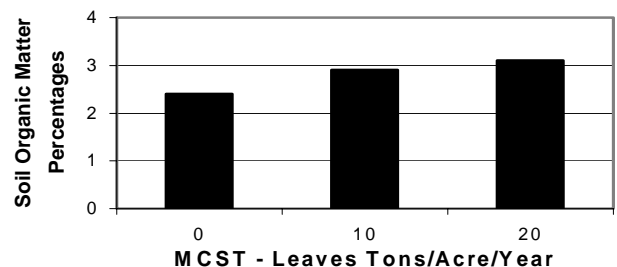
- *What does the chemical composition of MCST-leaves reveal about the suitability of the material as a soil amendment?*

MCST-leaves have a relatively low concentration of most plant nutrients (1.0% N, 0.1% P, and 0.4% K) and an average carbon to nitrogen ratio of 50 to 1. Plant residues with C to N ratios greater than 30 to 1 do not rapidly release mineral N in the soil. Thus, the low nutrient content and high C to N ratio of MCST-leaves allows for heavier application rates of the material than would be environmentally acceptable for sewage sludges or animal manures. A valuable attribute of MCST-leaves is that the material may be applied at rates that rapidly build up soil organic matter without causing a rapid release and buildup of available N and P.

- *How much is soil organic matter content increased from land application of MCST-leaves?*

Soil analysis was performed one year after a period of three years of annual applications of MCST-leaves at 0, 10, and 20 tons/acre to a Quakertown silt loam. Soil organic matter content was increased from 2.4% in the unamended soil to 2.9% for the 10-ton/acre/year rate of MCST-leaves and 3.8% for the 20-ton/acre/year rate (Figure 1). Calculations indicate that about 17% of the organic

Figure 1: Soil Organic Matter Levels Following Three Years of Applying MCST - Leaves



Research Description

Field experiments were conducted on a Quakertown silt loam soil at the Rutgers Snyder Research and Extension Farm in Northern New Jersey. Municipal collected shade tree (MCST) leaves were applied in 0, 3, and 6-inch layers to field plots annually each November for three consecutive years. In the following spring of each year the plots were cropped to soybean and corn. Soybean plots were split to compare 0 and 100 lbs/acre of N fertilizer while on plots cropped to corn, N fertilizer rates of 150 and 250 lbs/acre N acre were compared. Crop response measurements included yield, plant tissue analysis, and soybean nodulation. Changes in soil conditions from land application of collected leaves was studied by performing soil tests for nutrients, heavy metals, pH, cation exchange capacity (CEC), soil moisture and organic matter content.

Experiments were also conducted in the greenhouse to investigate whether leaves from different species of shade trees contain allelopathic substances that may inhibit soybean growth and symbiotic N₂-fixation.

In another study, the nutrient contents and chemical characteristics of municipal collected leaves from across New Jersey were surveyed. These results were compared to samples of hand collected leaves of various tree species from residential lawns.

carbon that was added to the soil as MCST-leaves remained in the soil one year after the end of the three-year period of annual applications. Soil analysis also revealed that soil organic nitrogen levels were also increased from 0.10% for the unamended soil to 0.14% for the 10-tons/acre/year rate of MCST-leaves and to 0.20% for the 20-tons/acre/year rate. The increased soil organic matter content, thus, provides slow release N for long term soil fertility.

- *Were increases in soil organic matter content from the addition of MCST-leaves associated with changes in soil moisture status and crop water relations?*

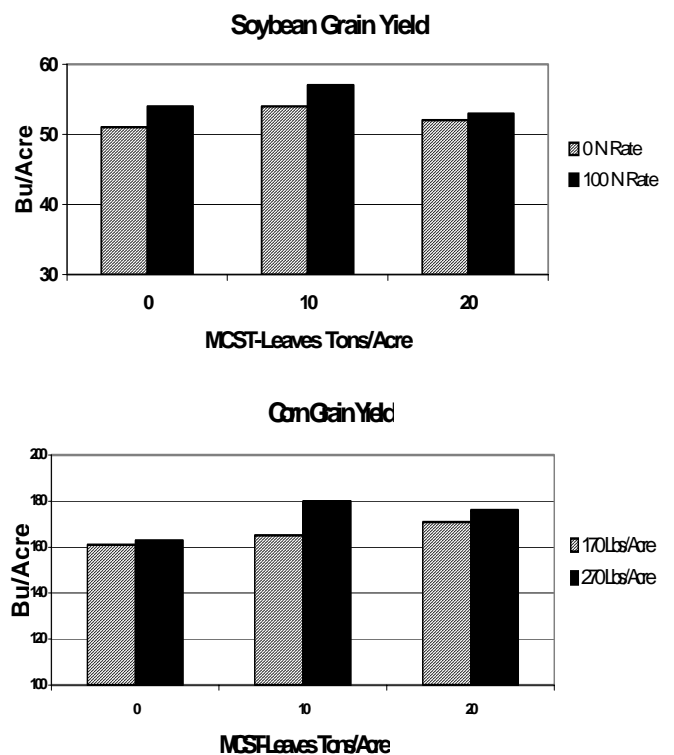
Yes, during periods of drought soil water content was measured and found to be greater in soil amended with MCST-leaves when compared to unamended soil. Corn plants grown on amended soil appeared to benefit from the improved soil moisture status during periods of drought by exhibiting less severe symptoms of leaf rolling. A potential concern with soils amended with MCST-leaves is that because they dry more slowly, this may cause tillage, planting, and crop establishment to be delayed when spring weather is wet.

- *Due to the high C-to-N ratio of MCST-leaves, is more N fertilizer recommended for crops grown on soil recently amended with MCST-leaves?*

The addition of MCST-leaves to soil does, as expected, cause immobilization or "tie up" of some of the available soil N. In our research we found that plants exhibit severe N deficiency when grown in pots filled with soil newly amended with MCST-leaves. Crops grown in the field, however, on soils amended with MCST-leaves the previous fall, generally exhibit only mild to no symptoms of N deficiency. Soybean, prior to development of a well

nodulated root system, may become temporarily N deficient but this generally does not reduce soybean grain yield. Plant tissue analysis performed on soybean and corn during the reproductive growth stage of the crops revealed that applying N fertilizer to soybean or additional N fertilizer to corn was not necessary to counteract soil N immobilization and prevent crop N deficiencies that were expected to occur with the application of a high C-to-N ratio material to soil (Figure 2).

Figure 2: Soybean and Corn Grain Yield Responses to Application Rate of MCST-Leaves and Rate of N Fertilizer in 1991.



It was also found that supplemental N fertilizer was not necessary for producing comparable soybean yields on soil amended with MCST-leaves and on unamended soil. For corn grown on amended soil we found that the same rate of N fertilizers as usual practice for unamended soil produced comparable grain yields. When a higher rate of N was applied to corn grown on soil amended with MCST-leaves, grain yields were generally increased by the additional N fertilizer. Further research is needed on crop N requirement when MCST-leaves are applied to soil.

- *How can MCST-leaves be used without causing immobilization of available soil N?*

We found little problem with soil N availability to corn or soybean grown on land amended with MCST-leaves. To minimize the immobilization of N fertilizer, we applied the N as a band with the corn planter and also applied N in a narrow strip beside the row when sidedressing. We assumed that broadcasting N fertilizer over land amended with MCST-leaves would probably cause a greater amount of the applied N to be immobilized. An alternative way to avoid a problem with soil N immobilization is to have the MCST-leaves composted before land application.

- *How did the application of MCST-leaves impact soybean and corn grain yield?*

Soybean and corn yields on soil amended with MCST-leaves were generally comparable or better than yields on unamended soil. Better crop yield may be related to the improvements in soil quality and soil water holding capacity.

- *What was the effect of MCST-leaves on the concentration of macronutrients and micronutrients in soybean and corn leaf tissue?*

Soybean and corn ear-leaf tissue often had increased concentrations of Ca and sometimes decreased concentrations of Mg when grown on soil amended with MCST-leaves. Findings suggest that the application of MCST-leaves to soil is an effective way to enhance the supply and uptake of Ca by crops. The concentrations of other nutrients in soybean and corn tissue were generally not influenced by MCST-leaves.

- *How were soil fertility test results influenced by the addition of MCST-leaves to soil?*

An application of MCST-leaves at 20 tons/acre would add an estimated 45 lbs P/acre, 171 lbs K/acre, 108 lbs Mg/acre and 738 lbs Ca/acre. Annual applications of MCST-leaves over a three-year period at this application rate did not significantly increase the Mehlich-3 soil test level of P or Mg. The Mehlich-3 soil test K level and especially the Ca level was significantly increased with application of MCST-leaves. Base saturation percentages of soil CEC changed with the application of MCST-leaves; the Mg percentage decreased from 23% saturation on unamended soil to 20% on amended soil and the Ca percentage increased from 54% to 60% respectively. For micronutrients, applications of MCST-leaves did not change the Mehlich-3 soil test levels of Cu, Mn, or Zn but it did increase B from 0.4 ppm on unamended soil to 0.6 ppm on amended soil.

- *Does the application of MCST-leaves influence soil pH and lime requirements?*

The application of MCST-leaves tends to cause a slight increase in soil pH. We observed a soil pH of 6.2 on unamended soil and a pH of 6.4 on amended soil. Although MCST-leaves do not appear to significantly influence the agricultural limestone requirement, the selection of the type of liming material for future maintenance of a balance between Ca and Mg in the soil may be a consideration for crops that are more susceptible to Mg deficiency.

- *What are the concentration levels of heavy metals found in MCST-leaves?*

The maximum concentrations of heavy metals found in MCST-leaves do not exceed, and in most cases are well below, the limiting concentrations of these pollutants in the USEPA 503 rules and regulations for sewage sludge. The median concentration of Cd and Pb (1.3 ppm Cd and 18 ppm Pb) in MCST-leaves sampled from across New Jersey are considerably lower than the median concentrations of these heavy metals (3.6 ppm Cd and 73 ppm Pb) found in New Jersey sewage sludges.

Occasionally a sample of MCST-leaves may have a high concentration of Pb as a result of contamination with urban soil containing Pb. Leaf collection practices should strive to minimize picking up urban soil to prevent Pb contamination of MCST-leaves.

Soil analysis performed after three years of applying MCST-leaves to soil at the Rutgers Snyder Farm did not detect any increase in Mehlich-3 extractable level of heavy metals.

- *Do fallen shade tree leaves contain allelopathic chemicals that are harmful to crops?*

Leaves and other residues from numerous plant species contain allelopathic chemicals that inhibit the growth of sensitive plants and soil microorganisms. Juglone, for example, is a well-known allelopathic chemical that inhibits plant growth of many species including legumes and symbiotic N₂-fixing organisms. Juglone is present in leaves from black walnut trees and other members of the walnut family (*Juglandaceae*). Walnut leaves, however, are generally not present in significant amounts in MCST-leaves. Leaves from various species of oak and maple make up the bulk of MCST-leaves in New Jersey.

To assess the potential impact of allelopathic chemicals coming from shade tree leaves, we conducted a greenhouse study that compared the effects of leaf litter and common crop residues on soybean nodulation and symbiotic N₂-fixation. The type of leaf litter included leaves freshly fallen from shade tree species of oak, maple, sycamore and walnut. Crop residues included corn stover and rye straw. Our investigation found no indication of an allelopathic inhibition from any of these shade tree or crop residues on nodulation or N₂-fixation. Soybean plants produced 40% more root nodules when grown on soil amended with leaf litter or crop residues as compared to unamended soil. The increased nodulation was related to the increased dependence of soybean on N₂-fixation as a result of immobilization of available soil N on amended soil.

- *What are the future research plans for agricultural uses of MCST-leaves?*

A new research project funded by a USDA-SARE grant was initiated in the fall of 1999 to study the potential uses of MCST-leaves as a mulch under peach trees. This research is being conducted by Drs. Robert Belding, Specialist in Pomology and Joseph Heckman, Specialist in Soil Fertility. We are particularly interested in the effect of MCST-leaves on the Ca nutritional status of peach trees as it relates to fruit quality.

In another study with tomatoes, the effect of MCST-leaves will be evaluated for its potential to

control blossom end rot, a physiological disorder related to Ca nutrition.

References:

Heckman, J.R., and D. Kluchinski. 1995. Soybean growth and nodulation on soil amended with plant residues. *Biol. Fert. Soil.* 20:281-288.

Heckman, J.R., and D. Kluchinski. 1996. Chemical composition of municipal leaf waste and hand-collected leaf litter. *J. Environ. Qual.* 25:355-363.

Heckman, J.R., and D. Kluchinski. 1999. Agronomics of land application of municipal collected shade tree leaves: I. Soil properties.

Heckman, J.R., and D. Kluchinski. 1999. Agronomics of land application of municipal collected shade tree leaves: II. Soybean and corn production.

Heckman, J.R., D. Kluchinski, and D.A. Derr. 1998. Plant nutrients in municipal leaves. Rutgers Cooperative Extension Fact Sheet FS 824.

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