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WOOD CHIP MULCHING AROUND MAPLES: EFFECT ON TREE GROWTH AND SOIL CHARACTERISTICS[1]

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Abstract. Studies were conducted to evaluate the effect of wood chip mulch on tree growth, soil properties and certain soil microorganisms. Plots were established with red and sugar maples on a clay loam soil and silver maples on a sandy loam soil. Mulched silver maples on the sandy loam soil had significantly greater height, diameter, root and current-year shoot growth than those not mulched. Only current-year shoot growth of the mulched red and sugar maples was significantly greater than the non-mulched ones on the clay loam soil. On mulched plots on the clay loam, soil moisture remained higher throughout the study, and soil temperature was lower during the spring and summer. Most soil physical and chemical properties were unaffected after one year of the mulch treatment, as were population levels of two potential disease-causing fungi and plant parasitic nematodes in the clay loam.

Soils in urban environments are often characterized as being disturbed and relatively structureless. Typically, these soils have no well-defined A horizon and often lack a decomposing organic layer. An organic mulch may have beneficial effects on urban soil much as a litter layer would on the forest mineral horizons. In addition to being a potential source of nutrients and organic matter, organic mulches insulate soil from extremes in moisture and temperature, prevent surface soil sealing and, therefore, increase water infiltration rates and control erosion.

Tree pruning chips are readily available in many municipal areas. Utilization of the chips as a mulch may be an effective means of amending urban soils to enhance growth and survival of trees while providing convenient disposal of trimmings. Improved growth and survival, through mulching, could be cost effective since, nationally, over 39% of municipal expenditures for tree care is spent for planting, removal, and disposal (Kielbaso and Ottman, 1976).

This study quantitatively evaluated the effects of a woodchip mulch on tree growth, soil physical and chemical properties and several types of soil microorganisms.

Methods and Materials

Study areas were established at Clemson in the upper Piedmont of South Carolina, and at Aiken, in the Sandhills region of the state in June, 1979. At the Clemson study site, the soil texture was a borderline sandy clay loam-loamy clay-loam (46.7% sand, 27% silt and 26.3% clay). Soils at the Aiken study area were a sandy loam (69.8% sand, 15.4% silt and 14.8% clay).

Each study area consisted of twenty paired plots with one tree in the center of each plot. Equal numbers of red maple (*Acer rubrum*) and sugar maple (*A. saccharum*) were used at Clemson. Only silver maples (*A. saccharinum*) were used at Aiken. Trees were paired on the basis of species, height, caliper, vigor and proximity to one another, as well as site factors (e.g., slope and aspect).

Study trees ranged from 2.1m to 6.7m in height and 5.7cm to 15cm in caliper. The trees were located along roadways or in parking lot malls and had been growing on site for at least four years.

Plots had a radius of 2.5m. Test plots were mulched to a depth of 10cm following the collection of the initial soil and tree data. Mulch used in the study consisted of fresh tree pruning chips obtained from local work crews. Roundup® herbicide was applied over the mulch on all mulched plots in September, 1979, and May and July, 1980, to control residual and invading weeds. A

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grass cover was retained around all control trees.

Soil variables which were evaluated initially and after approximately one year were: soil moisture, bulk density, organic matter content, pH and extractable phosphorus, potassium, calcium and magnesium. Six soil cores per plot were used for moisture content, bulk density and organic matter determination, and eighteen cores per plot were used for soil nutrient and pH evaluation. Cores were collected (Fraedrich, 1980) at distances of 0.85m and 1.7m from the plot center (inner and outer sampling points, respectively).

Tree height and caliper were measured annually. Current-year elongation of 12 randomly selected lower crown branches (shoot growth) was evaluated in July, 1980.

Root densities were estimated initially and after one year. Determinations were based on three inner and three outer 1.9cm diameter soil cores taken to a depth of 20 cm. Maple roots were separated out in the laboratory and dry weights determined.

Monthly determinations of soil moisture and soil temperature and evaluation of soil microorganisms were restricted to the Clemson study site. Three cores were collected to a depth of 20cm, at monthly intervals from 10 randomly selected paired plots for soil moisture determinations. Six mid-day soil temperature measurements were made at monthly intervals on ten randomly selected paired plots. Measurements were taken at the inner and outer sampling points at a depth of 8cm and replicated six times.

Populations of the soil-borne fungi, *Pythium* spp. and *Fusarium* spp., were evaluated at three-month intervals from five paired plots each of red and sugar maples at Clemson, while plant-parasitic nematode populations were evaluated on all Clemson plots every four months. At each sampling period one soil core for the fungal study and two cores for the nematode study were taken in each of the four cardinal directions at a distance of 0.2 to 0.3m from the tree base. For the fungi, soil dilutions were made, and *Pythium* spp. and *Fusarium* spp. counts were made on a modified Tsao-Ocana medium (Mitchell, 1974) and Nash-Snyder medium (Nash and Snyder, 1962), respectively. Nematodes were extracted with an elutriator and the rapid centrifugation flotation technique (Jenkins, 1966), identified to genus and counted.

Results

Height and diameter growth of silver maples were significantly greater (p=0.01) for mulched trees than controls at Aiken (Figures 1 and 2). Trees on mulched plots grew an average of 0.66m in height and 2.36cm in diameter during the one-year period while control trees grew only 0.16m and 1.63cm, respectively. No significant differences were obtained for these variables on the Clemson plots.

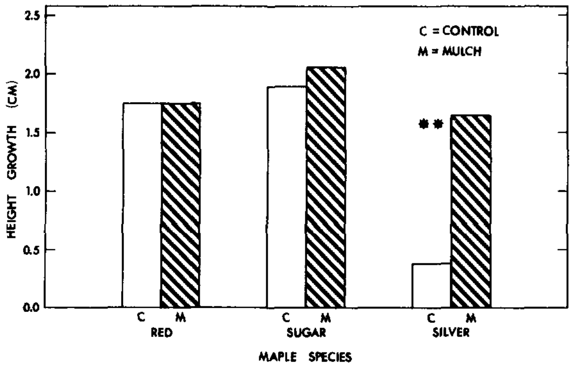

Figure 1. Average height growth of red and sugar maples on a clay loam and silver maples on a sandy loam one year after treatment.
****Indicates treatment difference at p = 0.01.**

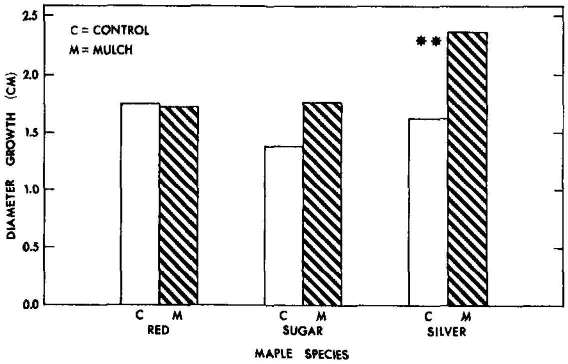

Figure 2. Average diameter growth of red and sugar maples on a clay loam and silver maples on a sandy loam one year after treatment.
****Indicates treatment difference at p = 0.01.**

Significant differences (p=0.01) in current-year shoot growth from the lower tree crowns were observed at both locations in July, 1980 (Figure 3). Shoot growth on mulched trees was five and two times greater than that of the controls at Aiken and Clemson, respectively.

Root distribution was greatly modified under mulch. At both study sites feeder roots were prevalent at the mulch/soil interface and frequently proliferated into the organic layer. Major lateral roots were also encountered at the interface. No significant treatment differences were observed for root weights at the inner sampling points at either location or for root weights at the outer sampling points at the Clemson site. However, on the sandy textured soils at Aiken, significant increases (p=0.01) in root weight occurred at the outer sampling points on the mulched plots (0.168g/170cm^3 of soil) as compared to the control plots (0.57g/170cm^3 of soil). During the spring and summer of 1980, mid-day soil temperatures at Clemson were significantly lower (p=0.01) and soil moisture readings were significantly higher (p=0.01) on the mulched plots (Figures 4 and 5).

No signficant differences were noted in bulk density, organic matter content or pH during the study period. Soil nutrient levels decreased on all plots at both localities, except for a highly significant increase (p=0.01) in potassium on the mulched plots at Aiken. Potassium increased from 53.7ppm to 93.1ppm on the mulched plots and decreased from 60.0ppm to 51.8ppm on the control plots. Although magnesium decreased on all plots, the level was significantly higher (p=0.05) on the mulched plots at both locations at the end of the study. Magnesium levels at Clemson decreased from 96.2ppm to 83.8ppm and 98.7ppm to 93.4ppm for the control and mulched plots, respectively, while the levels at Aiken changed from 64.5ppm to 41.7ppm and 59.1ppm to 43.2ppm for the control and mulched plots, respectively.

Mulching with wood chips had no discernible effect on population levels of any of the soil microorganisms investigated in this study. Seasonal variations occurred for the fungi and nematodes, but no treatment differences were detected.

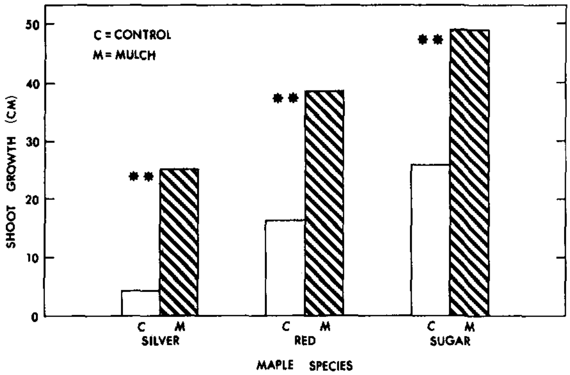

Figure 3. Average current-year shoot growth of red and sugar maples on a clay loam and silver maples on a sandy loam one year after treatment.
**Indicates treatment difference at p = 0.01.

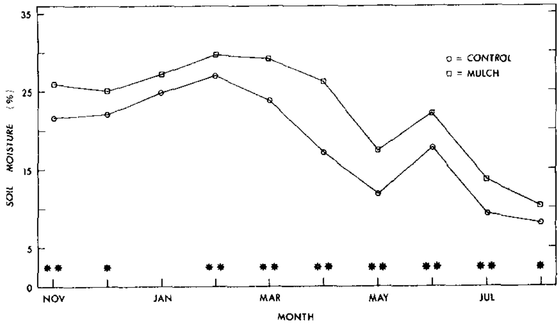

Figure 4. Average soil moisture content of a clay loam from Novemer, 1979, to August, 1980.
*Indicates treatment difference at p = 0.05.
**Indicates treatment difference at p = 0.01.

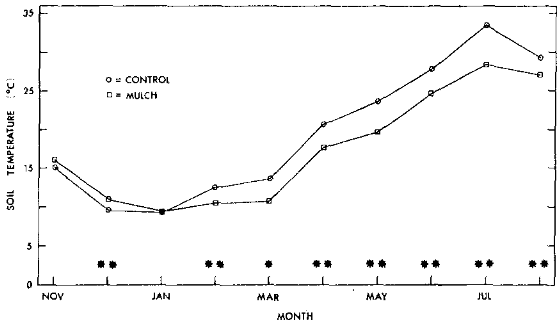

Figure 5. Average mid-day soil temperatures of a clay loam from November, 1979, to August, 1980.
*Indicates treatment difference at · = 0.05.
**Indicates treatment difference at p = 0.01.

Discussion

The enhanced tree growth on the mulched plots at both study sites was probably moisture related. This conclusion is supported by the consistently higher monthly soil moisture content on mulched plots at Clemson. A similar relationship for soil moisture on the control and mulched plots at Aiken most likely occurred although monthly measurements were not possible. According to Zahner (1968), 80-90% of the variation in tree diameter growth is related to moisture availability. Kramer and Kozlowski (1979) concluded that summer droughts often reduce current-year shoot elongation in species that exhibit free growth or recurrent flushing. Therefore, by maintaining a higher soil moisture content on mulched plots for a greater duration between rains mulching should reduce the effects of drought on tree growth.

The greater growth response of trees to the mulch treatment at Aiken, as compared with plots at Clemson, was most likely related to the distinctly different soil textures of the two sites. As soil texture becomes more coarse, available moisture storage decreases (Brady, 1974). Since total available moisture storage is relatively small for sandy soils (as at Aiken), conservation of that moisture is far more important than for loamy soils (as at Clemson). Moisture conservation consists both of minimizing soil evaporation and drainage below the root system. The fine textured soil at the Clemson site naturally retained available water for longer periods and, therefore, tree growth differences between treatments were not as pronounced.

The modifications in the horizontal and vertical root distribution under mulch resulted from changes in the soil microclimate. Improved water relations and temperature conditions in the upper soil strata, which are better aerated than lower layers, contributed to the increased root development in the surface soil and mulch layer. Such root distribution corresponds well to root distribution of forest trees where many small absorbing roots are confined to the soil surface layers (Kramer and Kozlowski, 1979). Studies in hardwood forests have shown that 80% or more of the small roots (2.5mm or less) are in the top 5 to 8 inches of soil.

The rate of root growth is influenced by both soil moisture and texture. At Aiken, the significantly greater root weights recovered from the outer regions of mulched plots as compared with controls, strongly suggests roots under mulch were able to grow greater distances over the one-year period. An inverse relationship exists between soil moisture and the subsequent ability of roots to penetrate through most soil (Taylor *et al.*, 1966; Zahner, 1968; Eavis and Payne, 1969). Due to the higher soil moisture regimes on mulched plots, physical resistance to root elongation was probably not as severe as on drier control plots. In addition, roots tend to proliferate more in sandy textured soils than heavier soils. The combination of high soil moisture levels and sandy texture of the Aiken soil would account for the significantly greater amounts of roots recovered from mulched compared to non-mulched plots at this study site. The higher clay and silt content of the Clemson soil was probably most important in limiting root elongation at this site, although species differences may also have been a factor.

A common practice when mulching landscape trees is to cover only a small area immediately around the base of the tree. Mulching a relatively large area (out to the dripline, for instance) around trees would appear to establish a larger zone which is conducive for root growth and provide ultimate long-term benefits for tree growth and vigor, especially in sandy soil.

Significant changes in soil bulk density or organic matter content after one year were not expected. Thorud and Frissel (1976) found that soils rebound at relatively slow rates from compacting forces. Although organic matter has a considerable influence in reducing bulk density, mulch degradation and incorporation into the A horizon is a relatively slow process. Consequently, a reduced bulk density and increased organic matter content should be anticipated long-term benefits.

Evaluating treatment effects on soil nutrients after a single year is essentially precluded because of the confounding effects of site conditions and previous years of fertilization. However, a significant increase in potassium, as occurred on the mulched plots at Aiken, has been observed in other mulching studies (Kemmerer, 1979;

Russell, 1973). The wood chips were undoubtedly the source of potassium, since it is a readily available macronutrient in tree tissue. The difference in potassium levels between mulched and control plots at Aiken may have accounted for the marked foliage color differences. Potassium deficiency is known to impede nitrogen metabolism (Kozlowski, 1971), and potassium deficiency in red maple results in uniformly chlorotic leaves (Walker, 1956). In this study the foliage of silver maple controls was consistently light green to yellow, suggesting deficiency, while mulch-treated trees had a darker green foliage. The study would have to be carried over a longer period to adequately evaluate the effects of mulch on soil nutrition.

Concern has been expressed that mulching produces soil conditions which favor soil microorganisms that could potentially increase disease problems. Previous studies have produced variable results (Vaughn *et al.*, 1954; White *et al.*, 1959). However, during the first year of this study, the mulch did not appear to favor a build-up of the potential disease-causing fungi, *Pythium* spp. and *Fusarium* spp., nor plant parasitic nematodes, around red or sugar maples.

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