EFFECTS OF SOIL AMENDMENTS AND FERTILIZER LEVELS ON THE ESTABLISHMENT OF SILVER MAPLE (ACER SACCHARINUM) IN TWO SOIL TYPES

By

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CHAPTER I

INTRODUCTION

In developing a landscape, the establishment of woody ornamentals is a major concern. Various articles, published in popular gardening magazines, newspaper columns and books written for amateurs give suggestions and advice on planting procedures. Two main points in these publications are the addition of soil amendments to the planting hole and the time and rate of application of fertilizer to the newly planted landscape materials.

The soil amendments to be placed in the planting hole is a topic of divergent views. Most suggest the use of some form of soil amendment (8, 26). Others go so far as to recommend digging the hole a year in advance and filling it with leaves and organic matter to be composted (5). Their recommendations, however, are seldom referenced by research findings.

The same point is true for the addition of fertilizers. Some authors maintain that fertilizer should not be applied to newly planted landscape material the first year, stating that it takes a year for new feeder roots to develop (8, 9, 14). Others advocate the use of diluted solutions of soluble fertilizers, but fail to mention the rate and frequency of application (11, 18, 26).

This study was undertaken to determine the actual effects of various combinations of soil amendments and fertilizer rates on the establishment of young woody ornamental trees in the landscape. Four soil amendments, three fertilizer rates, and two soil types were studied in the research.

CHAPTER II

REVIEW OF LITERATURE

Soil Amendments

Bark, Woodchips, and Sawdust

Numerous investigations have been initiated concerning the utilization of wood by-products as amendments to soils used for growing various landscape plants. Large quantities of these products are available as waste material from lumber-associated industries, in the form of bark, woodchips, or sawdust and from both hardwood and softwood species.

Researchers conducting studies on the use of wood by-products for soil improvement have found these materials to reduce the amount of available nitrogen to the plant material under study. Allison and Anderson (2), using sawdust for soil improvement, observed harmful effects on crop yields when sawdust was applied alone. It depleted nitrogen in the form of ammonium and nitrates. Rigby (29) used ground pine bark as a growing medium for container nursery stock. His results showed that the newly planted material required additional nitrogen fertilizer for the first few months.

Further studies using container-grown plants in bark-amended soils were conducted by Gartner et al. (19). They worked with several species of plant material and various mixes of bark, soil, and perlite. The decomposition of the bark in the mix caused a severe nitrogen deficiency that was not corrected by normal fertilization practices. This problem was solved, however, by the addition of slow-release nitrogen to the basic mix. Later studies by Gartner, Meyer, and Saupe (20) demonstrated that a slow release fertilizer incorporated in bark-amended mixes prevented nitrogen deficiencies. The nitrogen, phosphorus, and potassium levels increased after the initial mixing with the slow release fertilizer and, thus, nitrogen deficiency was no longer a limiting factor.

Joiner and Conover (21) found that shredded pine bark proved to be an accessible, inexpensive substitute for peat as the organic component of soil mixtures with sand for container-grown pittosporum. However, where a high amount of bark was used, the addition of preplant nitrogen during early plant growth was necessary to help compensate for that utilized in microbial decomposition of organic matter.

Numerous experiments were undertaken to study the high correlation between nitrogen requirements and decomposition rates of various woods. Hardwoods had high decomposition rates (40-50% in 60 days) and high nitrogen requirements while softwoods had much lower decomposition rates and thus, lower nitrogen requirements (23). Allison and Murphy (3) and Allison (4) found that hardwoods decomposed at a faster rate than softwoods; the hardwoods were attacked more readily by the microorganisms that decomposed them and consequently required more immediate nitrogen. Salomon (30), in agreement with other studies, found that nitrate depression from decomposition mostly occurred in the first six months.

In further studies with wood by-products, Viljoen and Fred (34) and Lunt (22) reported that there was no toxic effects on plants due to the sawdust and woodchips used in their experiments. Reuzer, Cook and Graham (28) showed that soil acidity was not increased when sawdust was incorporated in the soil. They also found that one good quality of wood residue was its ability to improve the soil physical characteristics.

Peat Moss

Patek (24) defines peat as partially decomposed vegetative matter consisting of plant remains which have accumulated under the relatively airless conditions of bogs and marshes. Sphagnum peat is derived from various species of sphagnum moss. Boodly (10) states that peat moss is usually free of most disease organisms and weed seeds, when used directly from the bale. However, according to Joiner (21), peat is becoming less available and more expensive and varies a great deal in physical and chemical properties.

Salter and Williams (31) studied the moisture characteristics and crop yields of sandy loam soils amended with farmyard manure and peat. Treated plots had a higher available water capacity than control plots. Farmyard manure treated plots always produced the highest yields but these yields were not always significantly different than peat or control plots. Yield differences in the peat and control plots were small and inconsistent.

Feustal and Byers (17) studied the moisture absorbing and retaining capacities of peat soil mixtures. Finding high evaporation rates from peat, they explained their results by comparing peat to a sponge. Internal soil moisture was transferred through capilliary action to the surface and evaporated. Fibrous-moss peat lost moisture at a greater rate than the more decomposed and granular reed peat. An exception, however, occurred in experiments with peat and sand mixtures. In this case, slightly improved moisture conditions occurred. From their conclusions, they stated that moisture retention properties alone should not be the basis for incorporating peat with soil and they did not recommend it as a soil amendment for these reasons.

Baker (7) and Patek (24) in further studies with peat reinforced the use of peat with sandy soils. They showed peat increased water holding capacity.

In comparative studies with other soil amendments, Pellet (25) found that the addition of peat to the fertile soils of central Minnesota resulted in no better growth of landscape plants than unamended soil. In agreement with Pellet, Townsend (33) used a 50% sandy loam soil and 50% peat mixture and tested the effects of soil amendments on the growth and productivity of highbush blueberries. His results revealed that, although not generally statistically significant at the 5% level, the unamended control plot yielded larger plants and better fruit over a five year period than the peat amended soils. Smalley, Pritchett, and Hammond (32) found similar results in experiments with bermudagrass putting greens. Peat amended soils had little effect on grass growth response.

Vermiculite

Vermiculite, weighing six pounds per cubic foot, is an inorganic mica-structured material that has been heated to 1400^{o}F and is sterile. Its characteristics include a platelike structure, a high cation-exchange capacity, and a resistance to rapid pH changes. It is capable of holding and releasing large quantities of water and nutrients, such as magnesium and potassium necessary for plant growth and permits the use of higher fertilizer rates without plant damage (10).

Dunham (15) experimented with sand, peat moss and vermiculite amended soils using chrysanthemums grown in compartments in a greenhouse bench. Measuring plant nutrient content, he found that more potassium but less magnesium and manganese were present in plants grown in vermiculite, as compared to plants grown in the other soils. The plants grown in the peat mixture contained less potassium, phosphorus and calcium than the others. More potassium was made available to the plant with vermiculite while peat moss decreased the supply. From these findings, he concluded that vermiculite amended soils required less replenishment of nutrients than peat amended soils.

In studies with four soil amendments, Smalley, Pritchett, and Hammond (32) noted that the addition of vermiculite to a loamy fine sand putting green soil increased yield significantly at the 1% level. It was not advantageous to use more than 10% vermiculite in the mixture except during drought periods when 20% proved to be more beneficial.

Pellet (25) studied the effect of various soil amendments on the growth of landscape plants in two Minnesota soils. He found that plant growth in unamended soils at both sites was not significantly different from growth in perlite, vermiculite or sawdust amended soils. His best results were obtained by substituting soil types in the planting hole, rather than adding amendments. The treatment that replaced the existing clay loam or loamy coarse sand with a loam soil consistantly ranked highest.

Sand

Sand is the heaviest of all the amendments normally used in altering the conditions of soil. A cubic foot of dry sand weighs approximately 100 pounds (10). Therefore, weight is a major factor to be considered when using sand as a soil amendment. There are generally no available nutrients for plant growth in sand, and added nutrients are easily leached. Sand has no buffering capacity and a relatively large particle size (10). However, excellent plant growth has been obtained in containers using sand and peat mixtures (7).

Little research has been undertaken to study the effects of sand as a soil amendment for the establishment of plants in the landscape. Chadwick, Bushey, and Pletcher (13) conducted root distribution studies in various combinations of soils. They found that plants grown in sand produced distinct tap roots but sparse root branching. Aldrich-Blake (1) concurs and maintains that poor sandy soils promote great growth in length with poor branching while branching is much more abundant in richer soils.

Fertilizer

The number of technical research articles written on the subject of fertilization of woody ornamentals during the first growing season is minimal.

Wyman (36) planted 400 young pin oaks in the fall of 1930 and spring of 1931. He then started a three year fertilizer study using ammonium sulphate and ammonium phosphate. The trees received an initial eight ounces of ammonium sulphate or 12.8 ounces ammonium phosphate, applied in the planting hole 2-1/2 feet from the base of the tree. After the first year of growth, he concluded that neither rate of fertilizer proved beneficial to the development of the trees. The following year, Wyman (37) conducted a root analysis on several of the pin oaks planted the previous year. The results showed that placement of the fertilizer 2-1/2 feet from the tree base was too distant. Fertilizer was reapplied in May at the same rates and resulted in extensive leaf damage to several trees in a heavy clay soil. Trees in a gravelly soil displayed less leaf injury. Repeated fertilizations throughout the summer at the same rates resulted in no further damage to the trees. After the second year his results showed a decided increase in growth in the trees receiving fertilizer, as compared to control trees. The data, however, also showed that applications of ammonium phosphate were more beneficial to tree growth than those of ammonium sulfate.

Chadwick (12) undertook research with 500 Moline elms of less than one inch caliper in the fall of 1931. The trees were fertilized in either spring, spring and July, July and fall, or fall. He applied an inorganic 12-6-4, an organic 6-6-4, ammonium sulphate, or a mixture of ammonium and superphosphate fertilizer to each of the trees, in addition to setting up control plots. Each plot received approximately the same quantity of nitrogen at each application. Data was not taken the first year the trees were planted, but judging from the increase in caliper during the first year's growth, all trees receiving fertilizer treatments were larger than control trees. Subsequent data (2-4 years after planting) showed that applications of a complete fertilizer high in nitrogen and ammonium sulphate plus superphosphate were most beneficial.

In later studies, Farmer, Snow, and Curlin (16) reinforced the effectiveness of both nitrogen and phosphorus fertilization in an experiment with yellow poplars. Phosphorus was effective only when combined with nitrogen, and a combination of both stimulated growth during the first two years.

Pellet (25), studying the effect of soil amendments on the growth of *Syringa chinesis* and *Lonicera korolkowi zabeli*, used Agriform (20-10-5) Planting Tablets placed in the bottom of the planting holes. With almost all treatments, stem growth was stimulated by the fertilizer the first year and was still significant at the five percent level at the end of the second season.

CHAPTER III

METHODS AND MATERIALS

May 20 and 21, 1974 an experiment using 216 Silver Maple, *Acer saccharinum*, trees was set up to study the effects of soil amendments and fertilizer rates on the establishment of ornamentals in the landscape. A 9x3 factorial set of treatment combinations in randomized block design with four replications was used on two soil types. 108 trees were planted at the Oklahoma State University nursery in a clay loam soil (26% sand, 43% silt, and 31% clay) with a pH of 5.8. 108 trees were planted at a site southwest of Stillwater, Oklahoma in a disturbed silt loam subsoil (14% sand, 70% silt, and 16% clay) with a pH of 7.1. This soil was very high in calcium and magnesium and low in organic matter due to removal of two to four feet of surface soil in preparation for a housing development. The soil treatment combinations used in the experiment are listed in Table I.

The planting holes were 24 inches in diameter and 12 inches deep, spaced five feet apart with six feet between rows. To insure a uniform size, an auger mounted on the back of a tractor was used to dig the holes. The soil at the existing site removed by the auger was placed in a five cubic feet cement mixer and combined with the proportionate

TABLE I

TREATMENT COMBINATIONS OF AMENDMENT LEVELS BY VOLUME AND FERTILIZER RATES

Amendment Levels	Fertilizer Levels
1. Check	1. 0
2. 20% Bark	2. 20 lbs. 10-20-10/1000 sq. ft. /mo.
3. 40% Bark	3. 40 lbs. 10-20-10/1000 sq. ft. /mo.
4. 20% Peat Moss*	
5. 40% Peat Moss	
6. 20% Sand	
7. 40% Sand	
8. 20% Vermiculite**	
9. 40% Vermiculite	

*Sunshine brand, sphagnum peat moss, product of Western Peat Moss Ltd., New West Minster, British Columbia.

**Terra Lite brand, vermiculite, product of Construction Products, Division of W. R. Grace and Co., Cambridge, Massachusetts.

volume of soil amendment listed in Table I. With check treatments the existing soil was placed back into the planting hole with no amendments added. The seedlings, which had been kept in cold storage prior to the planting date, were individually selected for uniform size and quality. They were placed in the planting hole and thoroughly watered on May 20th and 21st.

The trees were fertilized June 20, July 20, and August 20 using a 10-20-10 fertilizer at the rates listed in Table I. The trees to be fertilized received a surface application over the original two foot diameter planting hole.

Replacement trees were planted in containers at the time the experiment was set up and were used to replace trees that died or did not break dormant buds within two weeks after planting. After the two week time period, it was felt that the treatment caused the subsequent death of a tree.

To determine when the trees needed watering, tensiometers were installed at both locations at the base of nine trees, each with a different soil amendment. When watering was necessary, the trees were spot watered or watered with an overhead irrigation system. During the months of May and June the area received 5.76 and 2.39 inches of rainfall, respectively. Some spot watering was necessary at the end of June. During the month of July, .63 inches of rainfall was recorded. A Rainbird irrigation system was used to supplement rainfall that month. One inch of water was applied each week during this dry period.

The area received over five inches of rain in each of the remaining months of the experiment. Therefore, no supplemental irrigation was necessary.

Weeds were kept out of the experimental blocks by manual hoeing throughout the growing season.

Top Growth Response

On August 30th, midway through the experiment, total new growth of all trees at both locations was recorded. New growth was defined as the growth initiated from dormant buds after the trees were planted. On November 21st, just prior to leaf abscission, measurements were taken of total new growth of each tree, height in inches and stem caliper in centimeters approximately one inch above the soil surface.

Analysis of variance with "F" test was used to analyze data collected in the experiment. Duncan's New Multiple Range Test was used to determine differences between treatment means at the five percent level.

Moisture Study

On September 8th, an experiment was started in the Oklahoma State University greenhouse to study the water-holding capacities and surface evaporation rates of the amended soils. Samples of each of the nine soil treatments from both locations were replicated five times. Samples were placed in one-quart plastic containers, holding approximately 52 cubic inches, and were thoroughly soaked. Free water was allowed to drain. An initial weight was recorded in grams for each container on this date and subsequent weights were taken every other day until September 16th. A final weight was recorded after the samples were oven-dried in the containers for 48 hours at 54°C. From the data collected, the water holding capacity and surface evaporation rates of each soil treatment were calculated.

Root Observation

February 9, 1975, nine trees representative of the nine soil treatments at the 0 fertilizer rate, were dug by hand at the Oklahoma State University nursery and observed. The following day the procedure was repeated, digging up nine trees from the plot southwest of Stillwater. All samples were tagged, soaked overnight to remove the soil, observed and photographed.

Soil Analysis

Physical

Soil samples were obtained from each site for a representative particle size analysis of the basic soil before amendments. Percent sand, silt and clay was calculated by standard laboratory procedures (6).

Chemical

Samples of amended and unamended soils were taken January 25th from all planting holes at each site. Five cores were collected from each amendment treatment and mixed. 100 grams of air dried soil was sifted through a #8 mesh screen, and placed in a container. It was then mixed in a 250 ml beaker with 100 ml of .025 N solution of sulfuric acid and soaked for thirty minutes. The saturated soil was placed in a size 3J Buchner funnel on filter paper and was fitted by a rubber stopper onto a 1000 ml side neck suction (Erlenmeyer) flask. The side neck was connected by rubber tubing to a vacuum. While the extract was being collected in the flask, the soil was leached with an additional 400 ml of .025 N H_2SO_4. 75 ml of extract was reserved for the nitrogen, phosphorus, and potassium analysis, conducted in the Agronomy Department Soil and Water Service Laboratory at Oklahoma State University.

An additional soil sample from each site was sent to the Agronomy Laboratory for a routine analysis of pH, NO_3, P, K, Ca, Mg, Fe, Zn and Mn.

CHAPTER IV

RESULTS AND DISCUSSION

Top Growth Response

Total New Growth

Trees grown at the OSU Nursery in clay loam soil and measured August 30th generally increased in total new growth as the fertilizer level increased (Table II). Forty pounds of 10-20-10 per 1000 square feet per month significantly increased growth compared to no fertilizer as a main effect. Total new growth of the trees, measured on November 21st, showed a further stimulation of growth by the high fertilizer level and was significant as a main effect (Table III). This trend was apparent for all soil amendment treatments with the exception of peat moss at the 40% level which grew less at the high fertilizer rate as compared to the lower rate.

Data collected on both dates at the OSU nursery showed trees growing in pine bark amended soils grew less than all other treatments at the same level of fertilizer. This can be seen more easily in a graphic presentation of the data (Figures 1 and 2). As the quantity of pine bark in the planting hole increased, the amount of new growth was

TABLE II

EFFECTS OF SOIL AMENDMENTS AND FERTILIZER LEVELS ON TOTAL NEW GROWTH (INCHES) OF ACER SACCHARINUM SEEDLINGS GROWN FROM MAY 20 TO AUGUST 30, 1974 AT THE OKLAHOMA STATE UNIVERSITY NURSERY

Soil Amendment	Fertilizer Rate Pounds of 10-20-10/Month			Soil Amendment Mean
	0	20	40	
Check	40.7*	46.5	57.2	48.1
20% Bark	35.5	31.0	53.0	39.8
40% Bark	14.0	18.5	45.5	26.0
20% Peat Moss	53.5	58.5	75.7	62.5
40% Peat Moss	45.0	64.7	37.7	49.1
20% Sand	27.7	59.5	53.2	46.8
40% Sand	51.2	64.2	73.2	62.8
20% Vermiculite	61.5	43.5	83.7	62.9
40% Vermiculite	61.7	62.2	83.0	68.9
Fert. Rate Mean**	43.4 a	49.8 ab	62.4 b	

*Each number represents the mean of four replications.

**Means followed by the same letter are not significantly different at the 5% level.

TABLE III

EFFECTS OF SOIL AMENDMENTS AND FERTILIZER LEVELS ON TOTAL NEW GROWTH (INCHES) OF ACER SACCHARINUM SEEDLINGS GROWN FROM MAY 20 TO NOVEMBER 21, 1974 AT THE OKLAHOMA STATE UNIVERSITY NURSERY

Soil Amendment	Fertilizer Rate Pounds of 10-20-10/Month			Soil Amendment Mean
	0	20	40	
Check	55.7*$_{a1}$**	64.0$_{a1}$	89.5$_{a1}$	69.7
20% Bark	42.0$_{a1}$	50.5$_{a1}$	83.5$_{a1}$	58.6
40% Bark	17.2$_{a1}$	32.2$_{ab1}$	76.0$_{b1}$	41.8
20% Peat Moss	68.5$_{a1}$	79.2$_{a1}$	115.7$_{a1}$	87.8
40% Peat Moss	62.2$_{a1}$	89.2$_{a1}$	54.0$_{a1}$	68.5
20% Sand	36.7$_{a1}$	71.7$_{a1}$	74.0$_{a1}$	60.8
40% Sand	59.7$_{a1}$	92.7$_{a1}$	94.5$_{a1}$	82.3
20% Vermiculite	85.7$_{a1}$	60.5$_{a1}$	100.7$_{a1}$	82.3
40% Vermiculite	76.5$_{a1}$	82.7$_{a1}$	108.7$_{a1}$	89.3
Fert. Rate Mean**	56.0 a	69.2 a	88.5 b	

*Each number represents the mean of four replications.

**Means in a row followed by the same letter or means in a column followed by the same number are not significantly different at the 5% level.

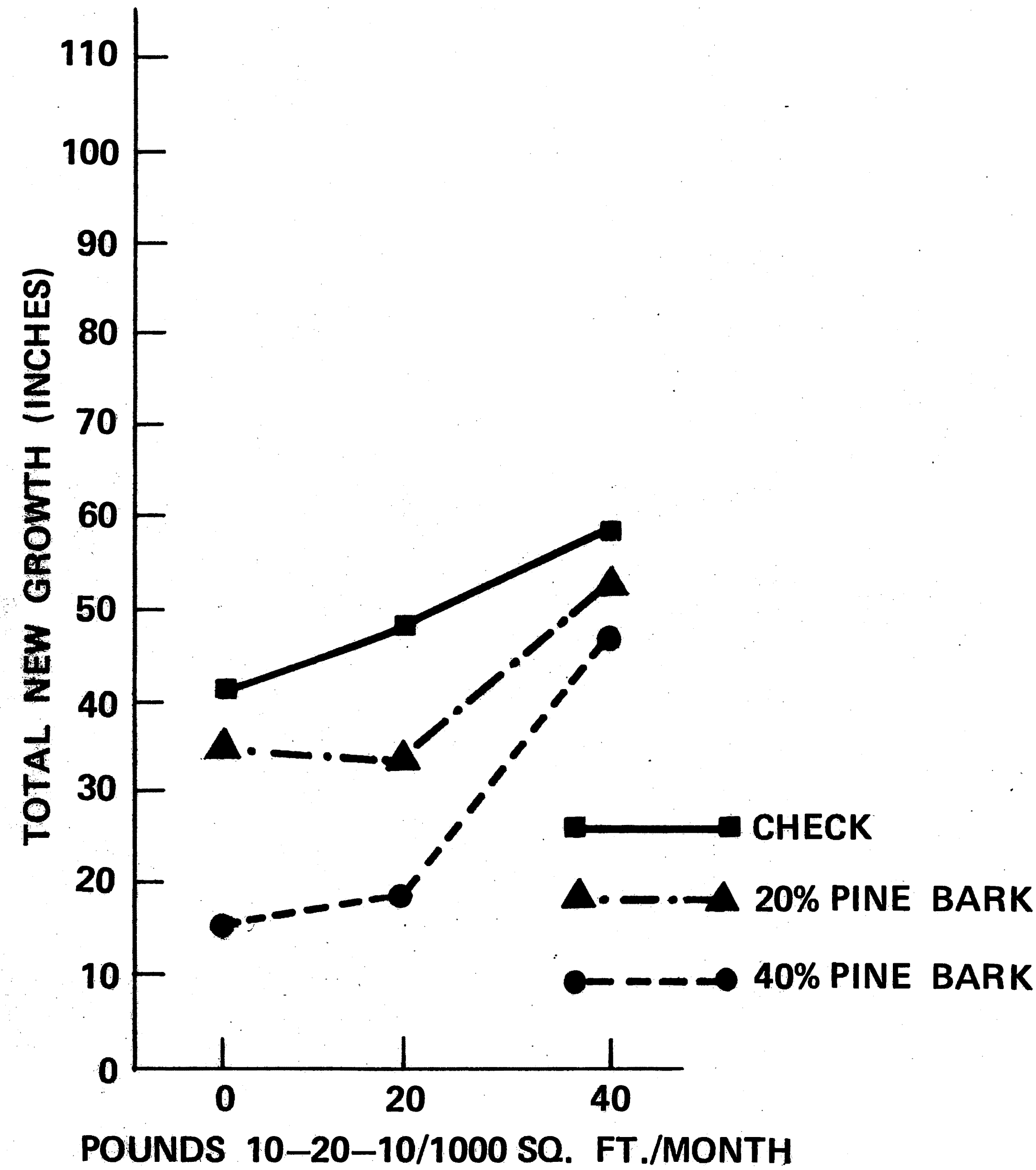

Figure 1. Effects of Three Fertilizer Levels and Pine Bark Treatments on Total New Growth of *Acer saccharinum* Grown from May 20 to August 30, 1974 at the Oklahoma State University nursery

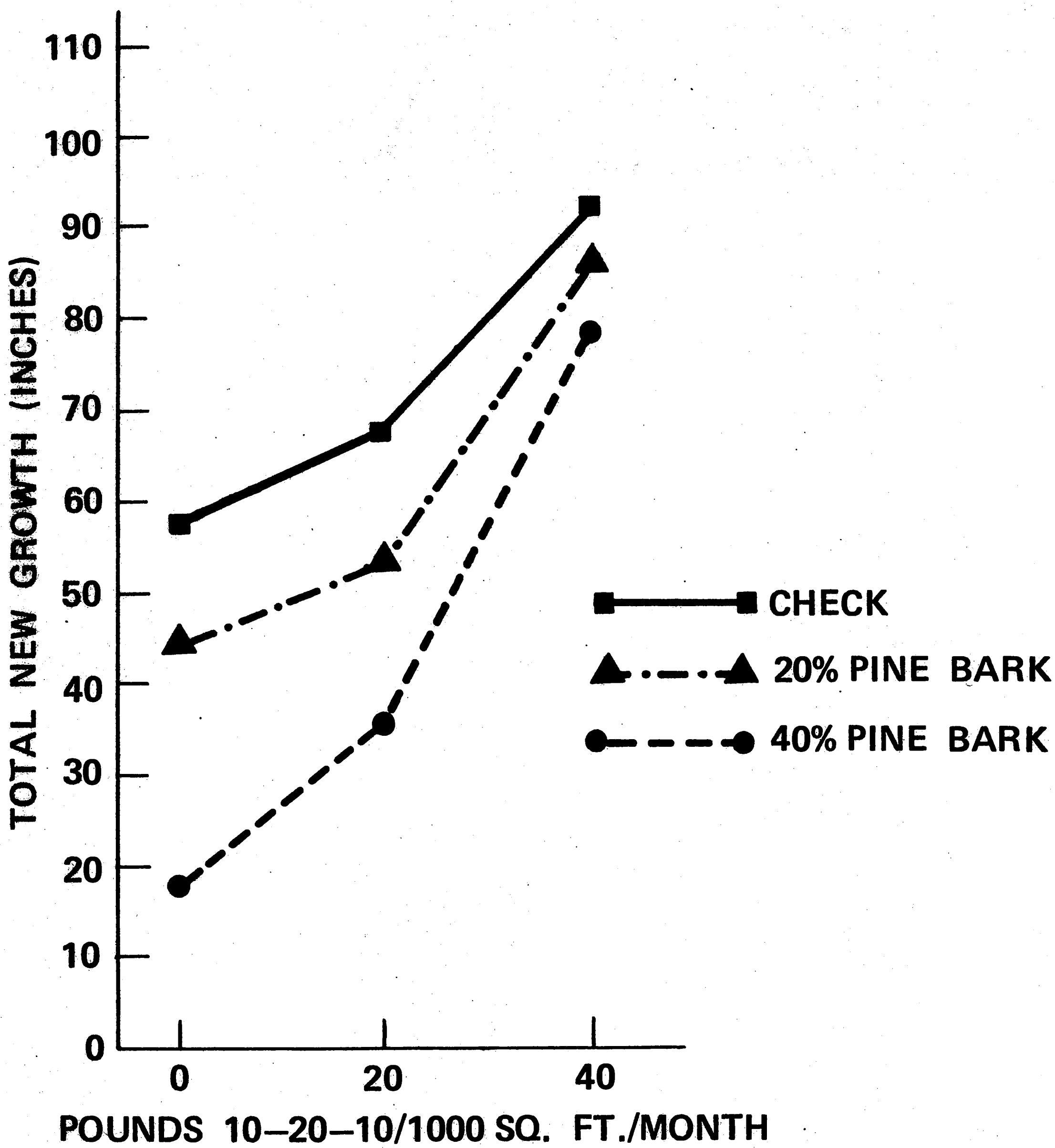

Figure 2. Effects of Three Fertilizer Levels and Pine Bark Treatments on Total New Growth of _Acer saccharinum_ Grown from May 20 to November 21, 1974 at the Oklahoma State University nursery

less, unless fertilizer was added. Available nitrogen at the 0 fertilizer level may have been used by microorganisms decomposing the pine bark, thus causing a nitrogen deficiency. The addition of fertilizer, particularly at the 40 pound rate, apparently provided nitrogen for tree growth and microbial activity. No significant differences were found between unamended controls and sand, peat moss, and vermiculite amended soils.

Growing conditions at the site southwest of Stillwater (disturbed silt loam subsoil) were so poor that total new growth was not significant for any fertilizer rates or amendment levels.

Stem Caliper and Tree Height

Both stem caliper and tree height at the OSU nursery increased significantly as a main effect with the use of fertilizer (Tables IV and V). Only the 40% peat moss treatment failed to respond to the high fertilizer rate.

The most dramatic difference was with the high rate of pine bark. Effects of bark treatments and fertilizer levels on stem caliper and tree height measurements as compared to controls can be seen more readily in graphic form (Figures 3 and 4, respectively). As noted earlier, microbial activity in the bark amended soil at the 0 fertilizer level may have been the cause of poor growth with the young trees. There is no evidence that the pine bark was toxic to the trees. Other researchers (15) found that pine bark increased the carbon to nitrogen

TABLE IV

EFFECTS OF SOIL AMENDMENTS AND FERTILIZER LEVELS ON STEM CALIPER (CENTIMETERS) OF *ACER SACCHARINUM* SEEDLINGS GROWN FROM MAY 20 TO NOVEMBER 21, 1974 AT THE OKLAHOMA STATE UNIVERSITY NURSERY

Soil Amendment	Fertilizer Rate Pounds of 10-20-10/Month			Soil Amendment Mean
	0	20	40	
Check	1.27^{*}_{a1} **	1.38_{a1}	1.53_{a1}	1.39
20% Bark	1.08_{a1}	1.15_{a1}	1.57_{a1}	1.27
40% Bark	$.37_{a2}$	$.97_{b1}$	1.60_{c1}	.98
20% Peat Moss	1.31_{a1}	1.54_{a1}	1.74_{a1}	1.53
40% Peat Moss	1.27_{a1}	1.69_{a1}	1.21_{a1}	1.39
20% Sand	1.09_{a1}	1.47_{a1}	1.43_{a1}	1.33
40% Sand	1.33_{a1}	1.47_{a1}	1.67_{a1}	1.49
20% Vermiculite	1.34_{a1}	1.39_{a1}	1.56_{a1}	1.43
40% Vermiculite	1.58_{a1}	1.57_{a1}	1.58_{a1}	1.58
Fert. Rate Mean**	1.18 a	1.40 b	1.54 b	

*Each number represents the mean of four replications.

**Means in a row followed by the same letter or means in a column followed by the same number are not significantly different at the 5% level.

TABLE V

EFFECTS OF SOIL AMENDMENTS AND FERTILIZER LEVELS ON HEIGHT (INCHES) OF *ACER SACCHARINUM* SEEDLINGS GROWN FROM MAY 20 TO NOVEMBER 21, 1974 AT THE OKLAHOMA STATE UNIVERSITY NURSERY

Soil Amendment	Fertilizer Rate Pounds of 10-20-10/Month			Soil Amendment Mean
	0	20	40	
Check	31.2* $_{a1}$**	34.5 $_{a1}$	27.5 $_{a1}$	31.1
20% Bark	25.0 $_{a1}$	24.0 $_{a1}$	34.0 $_{a1}$	27.6
40% Bark	7.5 $_{a2}$	18.0 $_{a1}$	30.2 $_{b1}$	18.5
20% Peat Moss	26.0 $_{a1}$	35.5 $_{a1}$	36.7 $_{a1}$	32.7
40% Peat Moss	26.2 $_{a1}$	35.0 $_{a1}$	22.7 $_{a1}$	27.7
20% Sand	23.5 $_{a1}$	26.7 $_{a1}$	27.7 $_{a1}$	25.9
40% Sand	29.5 $_{a1}$	26.5 $_{a1}$	28.0 $_{a1}$	28.0
20% Vermiculite	31.2 $_{a1}$	29.0 $_{a1}$	31.2 $_{a1}$	30.5
40% Vermiculite	27.5 $_{a1}$	35.7 $_{a1}$	34.2 $_{a1}$	32.4
Fert. Rate Mean**	25.3 a	29.4 b	30.1 b	

*Each number represents the mean of four replications.

**Means in a row followed by the same letter or means in a column followed by the same number are not significantly different at the 5% level.

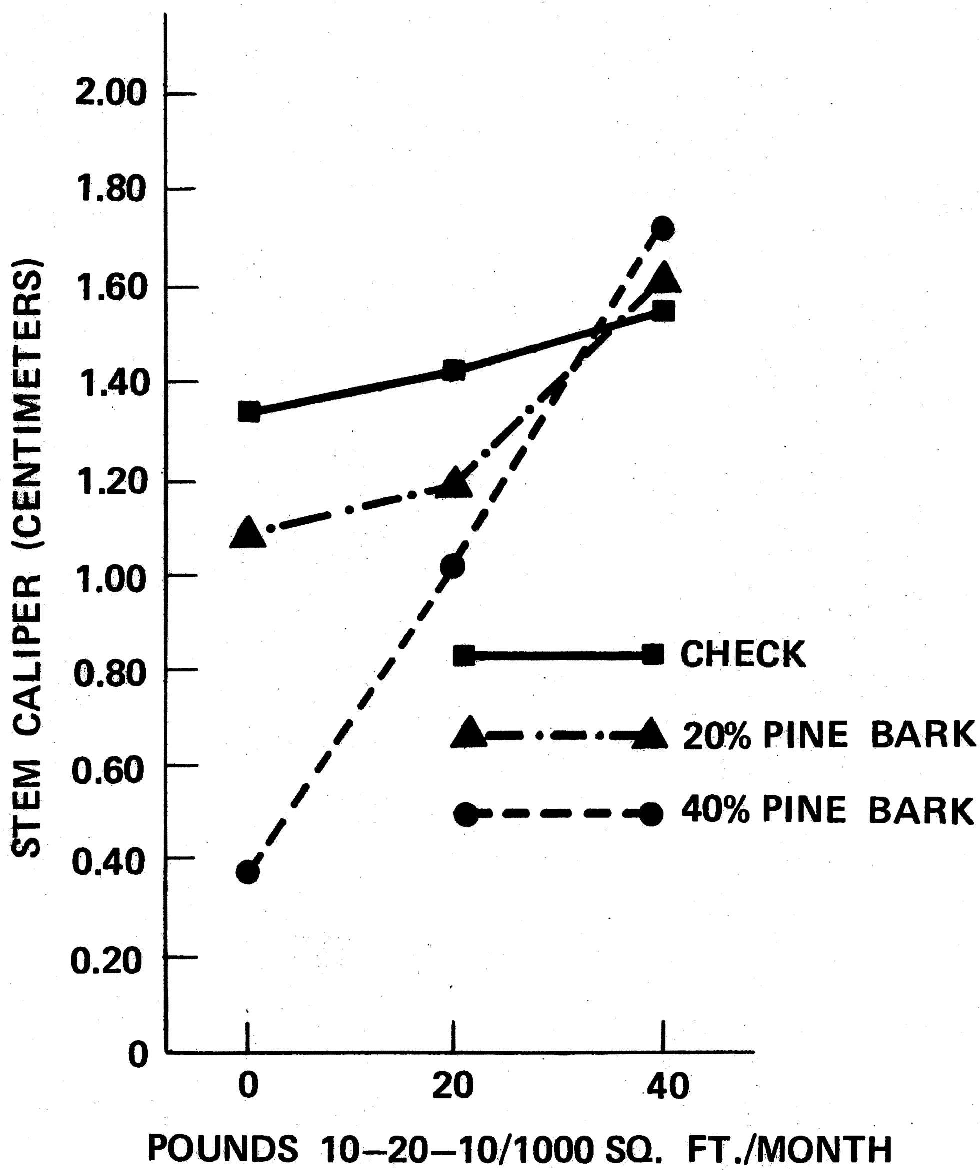

Figure 3. Effects of Three Fertilizer Levels and Pine Bark Treatments on Stem Caliper of Acer saccharinum Grown from May 20 to November 21, 1974 at the Oklahoma State University Nursery

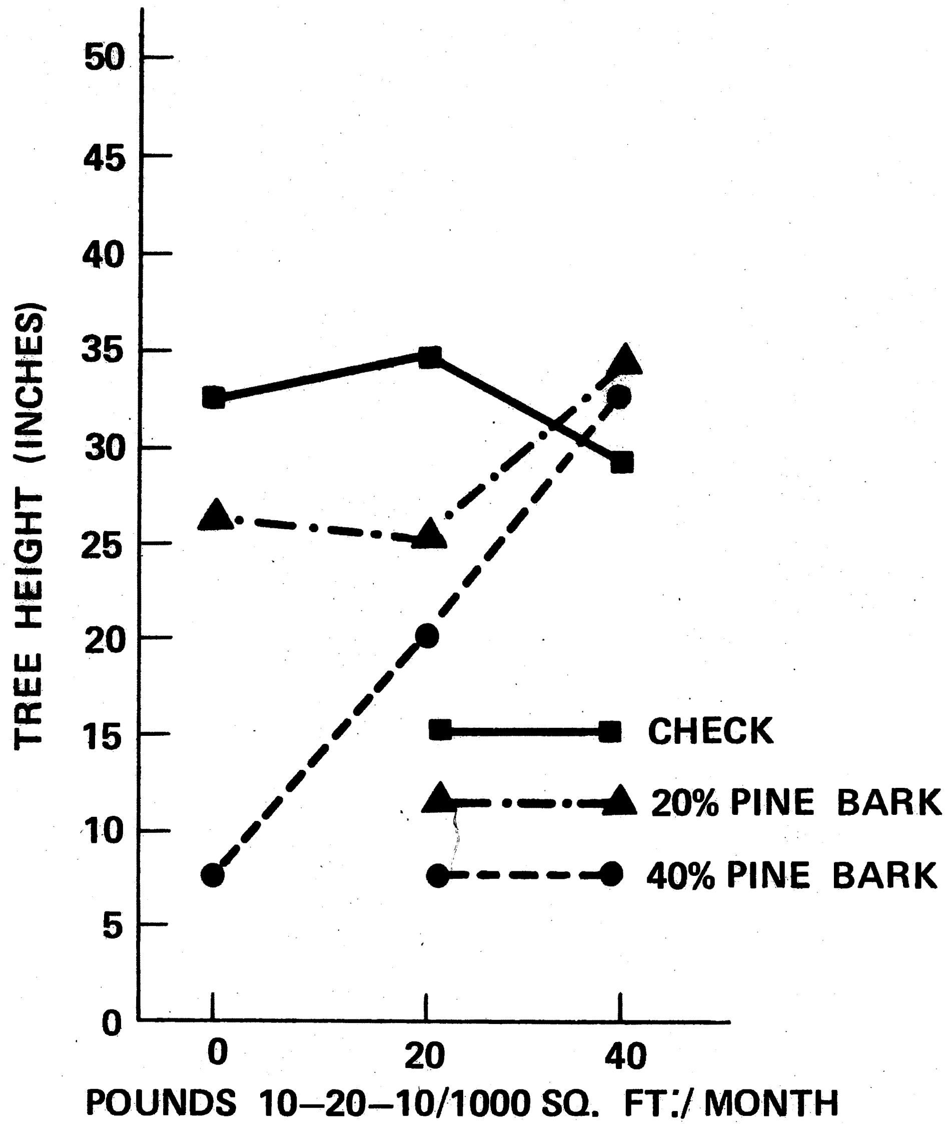

Figure 4. Effects of Three Fertilizer Levels and Pine Bark Treatments on Height of *Acer saccharinum* Grown from May 20 to November 21, 1974 at the Oklahoma State University Nursery

ratio to the point where nitrogen was the limiting factor rather than toxicity.

Data taken from the site southwest of Stillwater proved inconclusive with regard to tree height. However, a significant increase was found in stem caliper with the high rate of vermiculite used as an amendment (Figure 5). There were no significant differences between fertilizer rates. The increase in stem caliper may have been due to the high potassium content of the vermiculite.

Moisture Study

The moisture study conducted in the OSU greenhouse on all soil treatments shows the silt loam subsoil had a higher water-holding capacity than the clay loam soil (Figures 6 and 7). In most cases, as the amendment level increased, the amount of water held increased, but an increase in water-holding capacity was followed by a greater surface evaporation rate.

Peat moss amended soils held more water but also lost more water during the first eight days. As the rate of peat moss increased, the water-holding capacity also increased. However, the amount of water available was approximately the same as with control soils since the surface evaporation rate was also greater.

Vermiculite amended soils held more water than control soils and lost approximately the same amounts during the first eight days of the experiment. Therefore, the amount of water remaining in the soil

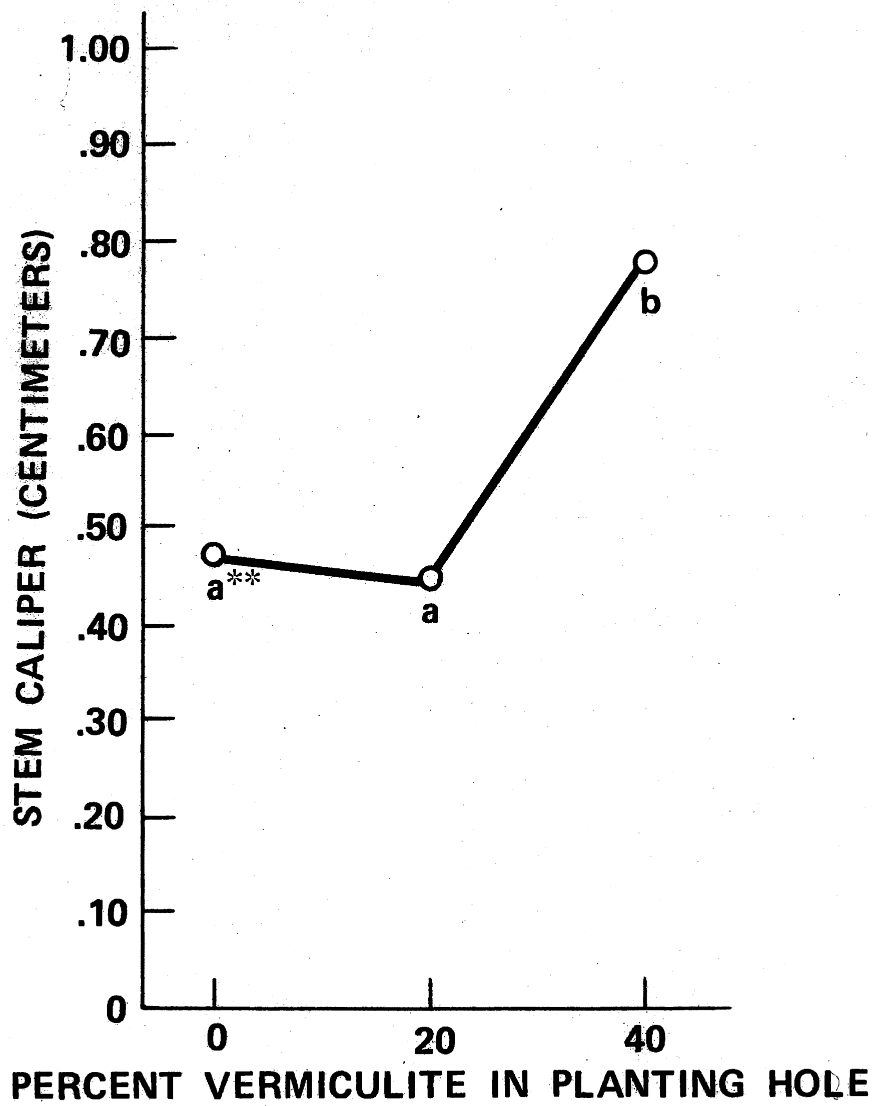

Figure 5. Main Effect Means* for Vermiculite Treatments with Regard to Stem Caliper of *Acer saccharinum* Grown from May 20 to November 21, 1974 at a Site Southwest of Stillwater

*Each number represents the mean of 12 replications.

**Means followed by the same letter are not significantly different at the 5% level.

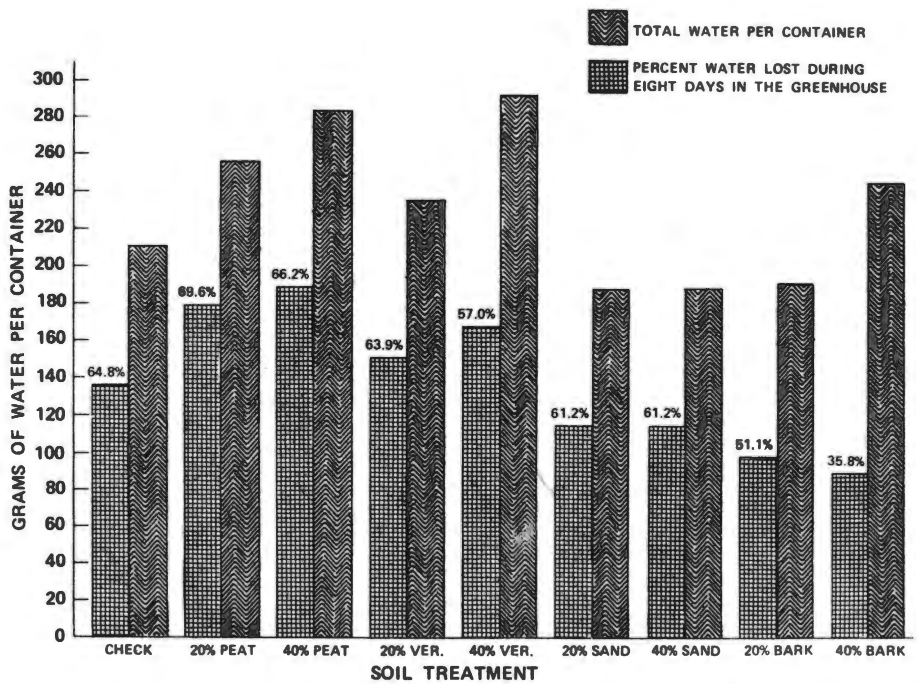

Figure 6. Grams of Water Lost Due to Evaporation in a Clay Loam Soil

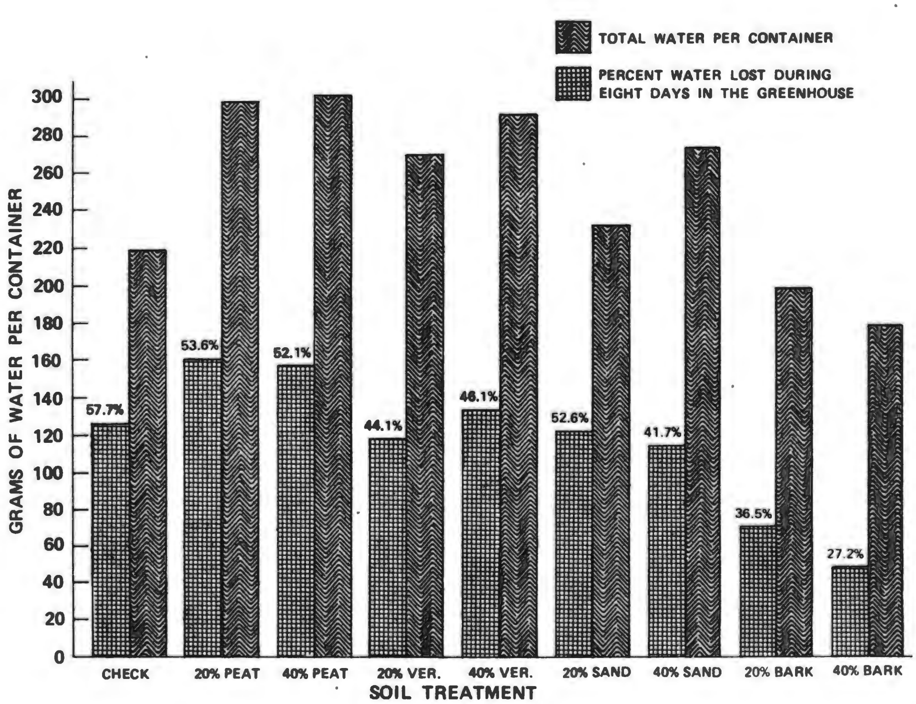

Figure 7. Grams of Water Lost Due to Evaporation in a Disturbed Silt Loam Subsoil

is greater with the addition of vermiculite.

In the silt loam subsoil, measurements showed that sand-amended treatments held more water and lost approximately the same amounts as control treatments. In the clay loam soil, sand-amended treatments held less water than control treatments but also lost less, making the amount of remaining water nearly equal after the first eight days.

Bark-amended soils lost the least amount of water during the initial eight day period. The total water weights were approximately equal to those of control, thus giving bark-amended soils a lower surface evaporation rate than control soils. The particle size of the bark was such that it easily separated from the smaller sized soil particles and floated to the surface. A bark-mulch was then formed which restricted evaporation from the surface.

Root Observation

Root observations showed that trees grown in the clay loam soil produced more new growth and stronger and more vigorous root systems than trees grown in the disturbed silt loam subsoil. These differences in root systems can be seen by comparing Figures 8 and 9 which are photographs of representative trees from the two soil types.

Trees in the unamended clay loam soil at the OSU nursery (Figure 8) grew well and the roots had a well balanced distribution and size variation. The root system extended well beyond the limits of the planting hole. Trees grown in the soil amended with 20% peat moss

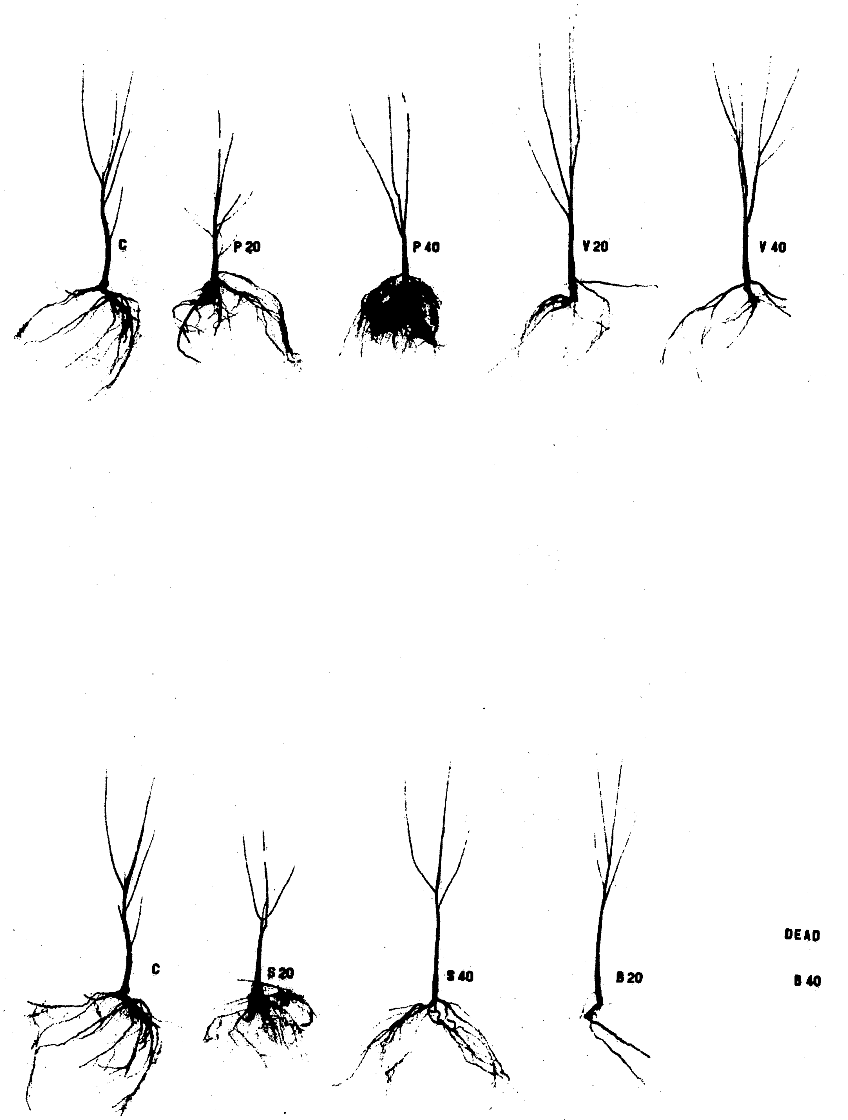

Figure 8. Representative Samples of Trees and Their Root Development Grown in Various Soil Treatments at the Oklahoma State University in a Clay Loam Soil. C = Check, P20 = 20% Peat Moss, P40 = 40% Peat Moss, V20 = 20% Vermiculite, V40 = 40% Vermiculite, S20 = 20% Sand, S40 = 40% Sand, B20 = 20% Bark, B40 = 40% Bark

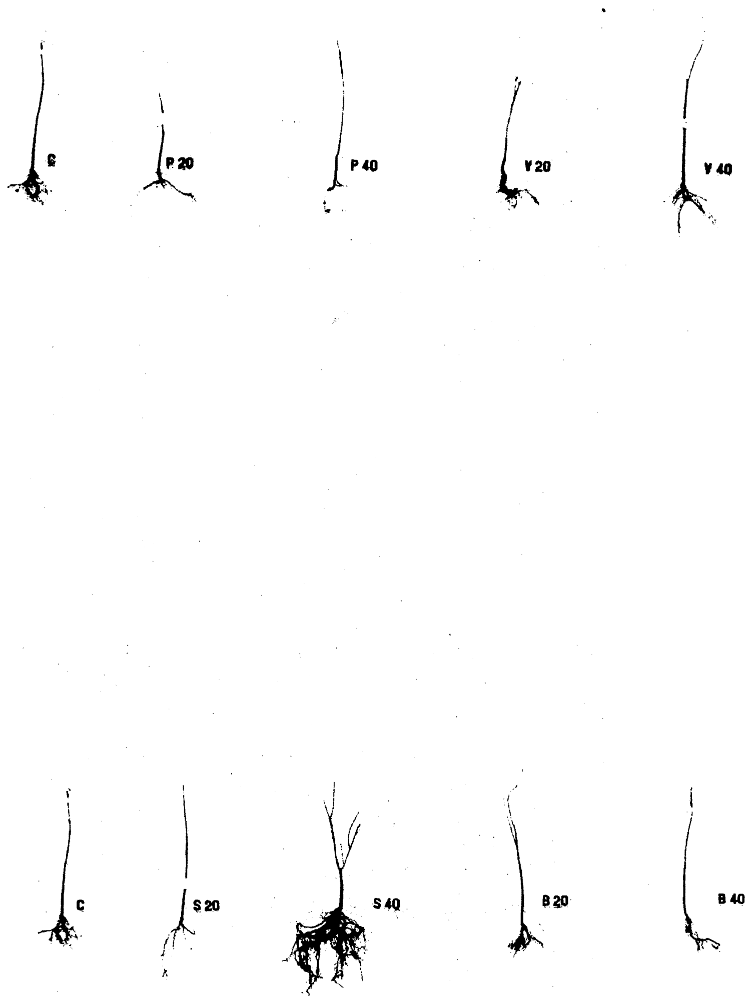

Figure 9. Representative Samples of Trees and Their Root Development Grown in Various Soil Treatments at a Site Southwest of Stillwater in a Disturbed Silt Loam Subsoil. C = Check, P20 = 20% Peat Moss, P40 = 40% Peat Moss, V20 = 20% Vermiculite, V40 = 40% Vermiculite, S20 = 20% Sand, S40 = 40% Sand, B20 = 20% Bark, B40 = 40% Bark

had similar root development with good distribution but few roots extended beyond the planting hole. Trees planted in soils amended with 40% peat moss had very fibrous roots. The many fibrous roots were matted and were difficult to separate from the wet soil. The root system did not develop beyond the amended planting hole.

Trees grown in soils amended with 20% or 40% vermiculite developed a less fibrous root system than the peat moss but roots extended well beyond the amended soil. Trees grown in soils amended with 20% sand had very long fibrous roots and poor stem growth and the root system did not develop out of the amended soil. The 40% sand treatment had good root development away from the crown, extending horizontally in all direction. Fibrous roots were most prominent at the edge of the planting hole.

Poorest roots were observed on trees grown in soils amended with 20% pine bark. Roots extended down and out of the amended soil and few secondary and fibrous roots were observed. With the 40% bark treatment, the majority of the trees died by midsummer.

Trees grown in the disturbed silt loam subsoil southwest of Stillwater (Figure 9) produced limited and fibrous root systems. The roots were inactive at the time the trees were removed for observation and none extended beyond the limits of the original planting hole.

Trees grown in soils amended with 20% or 40% peat moss had poor root systems with few fibrous roots. Trees grown in soils amended with 20% or 40% vermiculite grew well and had good root systems. There was good secondary root growth with fibrous development.

Trees grown in soils amended with 20% sand produced a root system a little larger than that of the control treatment but less fibrous. However, those grown in 40% sand-amended soil had the largest and most extensive root system of the trees removed for observation. Good secondary and fibrous root development was evident.

Trees grown in soils amended with 20% and 40% bark had very poor root systems. The few fibrous roots that developed along secondary roots appeared stunted and poorly developed.

Soil Analysis

Soil tests of the clay loam soil at the OSU nursery showed that as the level of pine bark in the planting hole increased, the amount of nitrogen available to the plant decreased (Figure 10). Available nitrogen in the NH_4 form remained low even with the addition of fertilizer and was probably the limiting factor for growth of the young trees. Microbial activity, breaking down the bark, utilized the nitrogen that the trees needed for growth. Leaching of nutrients, resulting from the coarse texture of bark amended soils, may have reduced the amount of available nitrogen as well.

Soil analysis also showed that as the level of fertilizer increased from 0 to 40 pounds of 10-20-10 per 1000 square feet per month, the levels of NH_4-N, NO_3-N, phosphorus, and potassium increased in the

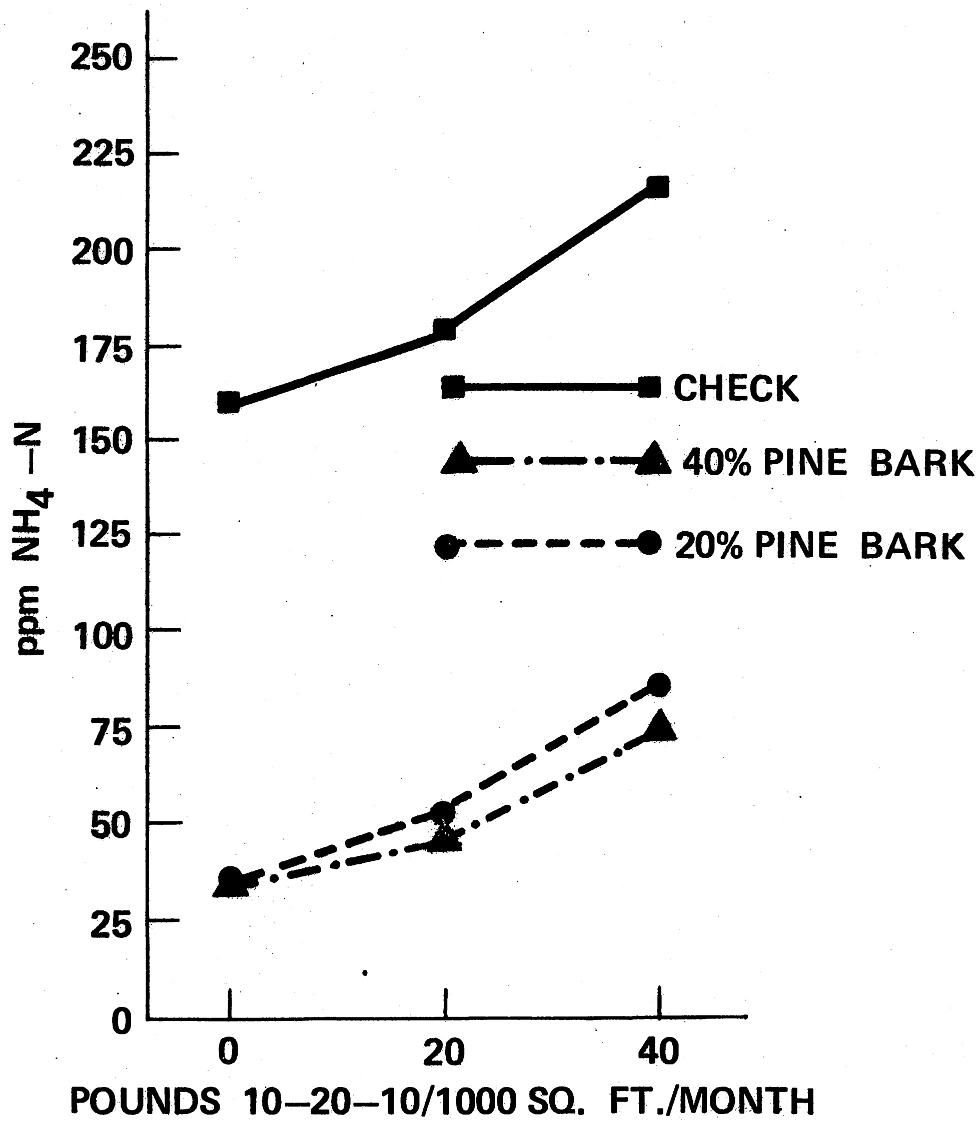

Figure 10. Parts per Million of NH_4-N at Three Fertilizer Levels and Pine Bark Treatments in a Clay Loam Soil

soil (Table VI). These results coincide with the increases in growth at the higher fertilizer rates shown in Tables II, III, IV, and V. The amount of fertilizer probably could have been increased further without damaging the trees.

Results from the silt loam subsoil analysis showed that the use of the high rate of vermiculite in the planting hole increased the amount of available potassium (Figure 11).

Overall Plant Response

Significant differences were noted with pine bark and vermiculite treatments when the data was analyzed regarding the overall plant response to the addition of amendments and fertilizer to the planting hole.

Data on trees grown in pine bark-amended soils at the OSU nursery (Figures 1, 2, 3, 4) showed that top growth response was directly related to nutrient availability in the soil. Soil analysis for NH_4-N, phosphorus and potassium for bark treatments was highly correlated with increases in total new growth, stem caliper and tree height ($r = 0.99$). Bark amendments in the clay loam soil had no effect on the availability of phosphorus or potassium (Table VI). On the other hand, bark treatments greatly influenced the quantity of NH_4-N available for plant growth (Figure 10 and Table VI).

Data on trees grown in the disturbed silt loam subsoil showed that an increase in stem caliper was related to an increase in the amount of vermiculite present in the soil (Figure 5). Soil test results

TABLE VI

PPM OF AVAILABLE NUTRIENTS AT THREE FERTILIZER LEVELS AND PINE BARK TREATMENTS IN A CLAY LOAM SOIL AT THE OKLAHOMA STATE UNIVERSITY NURSERY

Nutrients	Treatments	Fertilizer Rate Lbs 10-20-10/1000 sq. ft. /mo.			Mean
		0	20	40	
NH_4-N	Check	156.0	172.0	214.0	180.6
	20% Bark	33.0	42.0	72.0	49.0
	40% Bark	33.0	42.0	82.0	52.3
	Mean	74.0	85.3	122.6	
NO_3-N	Check	5.0	6.0	11.0	7.3
	20% Bark	5.0	9.0	14.0	9.3
	40% Bark	5.0	5.0	18.0	9.3
	Mean	5.0	6.5	14.1	
Phosphorus	Check	4.9	49.7	77.0	43.8
	20% Bark	5.1	33.7	93.7	44.1
	40% Bark	2.3	43.7	87.5	44.5
	Mean	4.1	42.3	86.0	
Potassium	Check	220.0	266.0	353.0	279.6
	20% Bark	211.0	270.0	372.0	284.3
	40% Bark	237.0	295.0	385.0	305.6
	Mean	222.9	277.0	370.4	

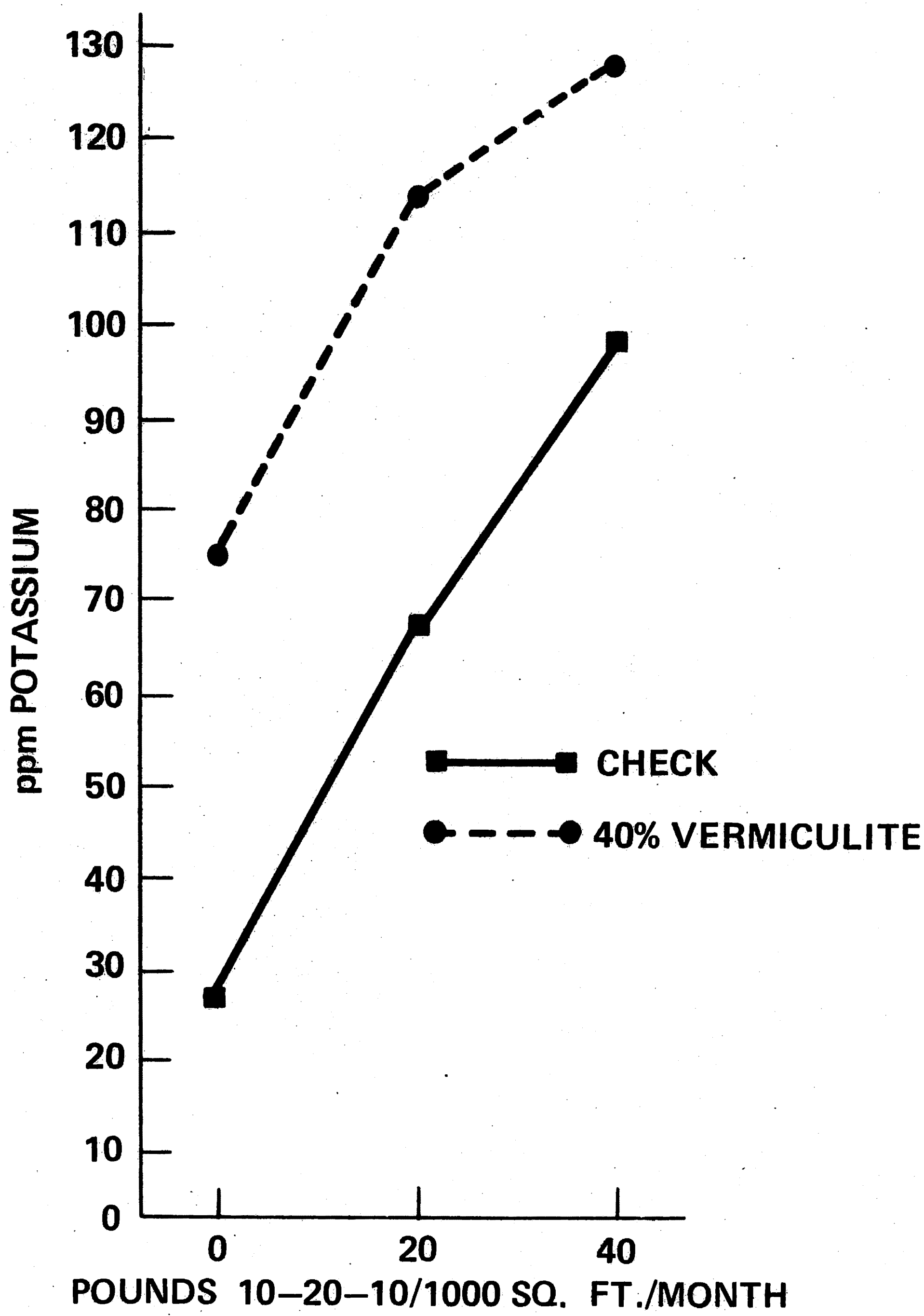

Figure 11. Comparison of ppm Potassium of Check Treatment and 40% Vermiculite Treatment at Three Fertilizer Levels in a Silt Loam Subsoil

indicated that the 40% vermiculite treatment had a higher amount of potassium than control treatments, which infers that the increased stem caliper was caused by the high potassium level in vermiculite (Figure 11).

Collectively, all the data in the research show no substantial increase in overall plant response due to soil amendments. Although some amendments may have improved the physical properties of the soil, measurements of top growth response (Tables II, III, IV, V), water-holding capacity (Figures 6 and 7), and root observations (Figures 8 and 9) indicate that amended soils, in general, hold no advantage over control soils at either location. The application of fertilizer, however, did significantly benefit the establishment of the trees (Tables II, III, IV, V). It supplied additional nutrients, beyond those of the two basic soils, to enable the trees to produce more growth during the first growing season.

The inherent quality of the soils should not be overlooked in the discussion of tree establishment. Although soil amendments did not prove to increase growth, the fertility and physical characteristics of the initial soil made a major difference in overall plant response (Table VII). Soil test results showed greater amounts of available potassium and iron in the clay loam soil with a more optimum pH for tree growth. Very high available calcium and magnesium levels in the disturbed silt loam subsoil caused a lack of available phosphorus which would have caused the poor growth response at this site. Even with

TABLE VII

COMPARISON OF TOP GROWTH RESPONSE MEASUREMENTS OF ACER SACCHARINUM IN TWO SOIL TYPES

Soil Type	Top Growth Response Measurements		
	Total New Growth (Inches)	Height (Inches)	Diameter (Centimeters)
Clay Loam Soil	68.78*	28.35	1.31
Silt Loam Subsoil	12.25	10.87	.45

*Each value represents the mean of 108 treatments.

the addition of fertilizer the very low phosphorus level was not increased substantially.

There is little reason to believe that the poor tree growth in the amended soils was caused by flooding conditions resulting from rainfall during the experiment. Reference material (27, 35) show that *Acer saccharinum* is a fast-growing tree that has commonly been called Creek maple or Swamp maple because of its adaptability to wet, semi-flooded conditions. Therefore, low nutrient content and poor physical characteristics of the subsoil are more likely responsible for the meager plant response in the disturbed silt loam subsoil.

CHAPTER V

CONCLUSIONS

1. Pine bark, peat moss, sand and vermiculite, when used as soil amendments, generally do not aid in the establishment of woody ornamentals in the landscape.

2. Surface application of 20 or 40 pounds of 10-20-10 per 1000 square feet per month effectively increased tree growth the first year.

3. Pine bark, when used as a soil amendment, is detrimental to tree growth when additional nitrogen is not supplied.

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