phosphate leached rapidly in acid media and became somewhat more stable at about pH 6.5 (Table 1, Fig. 1). Such a high pH may not favor growth of some plants. Holly, azalea and juniper made the best growth in pine bark at pH 5.4 and lower, when nutrients were adequately supplied (1). Dicalcium phosphate showed promise of a favorable solubility at pH 5.6 (Table 1, Fig. 1). Excessive leaching occurred in more acid media, and at pH 7 it was so nearly insoluble as to restrict the availability of P needed for plant growth (Table 1). Dicalcium phosphate may not be commercially available for fertilizer use at reasonable prices. Various forms of P with low solubility should be investigated, especially under nursery conditions.

Significance to the Nursery Industry

Phosphorus is rapidly leached from acid soilless media amended with soluble forms of phosphorus such as superphosphate and treble superphosphate. The leaching can be reduced by liming to raise the pH to 6.5, but nursery crops may not make the best growth at high pH levels. Phosphorus sources with low solubility, such as dicalcium phosphate used in this study, may provide release rates that do not leach rapidly near pH 5.5, but supply a phosphorus concentration adequate for plant growth. Slowly soluble forms of phosphorus should be investigated as amendments for soilless media.

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Amended Backfills: Their Cost and Effect on Transplant Growth and Survival[1]

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Abstract

Amendment of backfill soil at planting with peat moss, fired montmorrilonite clay or a "superabsorbent" gel had no significant positive influence on growth and establishment of container grown *Liquidambar styraciflua* L., sweet gum, plants placed in well-drained Arredondo fine sand soil. A cost estimate indicated the addition of amendments to backfill soil would increase installation costs 27 to 30% over those for control plants.

Index words: landscape contracting, landscape installation, plant growth, plant establishment, *Liquidambar styraciflua,* sweet gum, soil amendment, "superabsorbent" gel

Introduction

Recent research studies have shown no consistent improvement in growth and establishment of woody plants from incorporation of soil amendments into the backfill at planting (2, 5, 7, 10, 12). According to Harris (4), soil dug from the planting hole is satisfactory for backfilling around roots of trees and shrubs in most landscape installations. Whitcomb (13) recommends using no soil amendments when planting. Despite this evidence, most landscape installation specifications still routinely require backfill amendment. The most common specification in Florida is 1 part by volume peat moss and 2 parts by volume topsoil (3, 8, 11). In addition, manufacturers of "superabsorbent" gels are encouraging use of their products as backfill amendments claiming that improved soil water holding capacity will reduce drought stress thus increasing survival of newly transplanted trees and shrubs (1).

The objectives of this research were: 1) to determine the influence of peat moss, fired montmorillonite clay and a "superabsorbent" gel, Terrasorb (Industrial Ser-

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vices International, Inc., Bradenton, FL, USA) used as backfill amendments on growth and establishment of container grown sweet gum trees under environmental conditions that might be considered typical of a medium to large-scale landscape project and 2) to estimate the relative costs of using these materials in landscape installations.

Materials and Methods

Sweet gum seedling liners obtained March, 1983, from the Florida Dept. of Forestry were potted in Metro-Mix 500 (W.R. Grace & Co., Cambridge, MA, USA) in 3.8 L (#1) containers. Plants were placed in a nonheated saran shade structure (47% light attenuation), fertilized with surface applied Osmocote 18.0N-2.4P-10.0K (18-6-12) at a rate of 12 gm (0.42 oz) per container every 3 months and watered as needed.

On February 9, 1984, 72 uniform plants averaging 99 cm (3.25 ft) in height with an average stem caliper of 1.15 cm (0.45 in) 15 cm (6 in) above the soil line were selected for transplanting into the field. Three rows of trees were planted 3 meters (10 ft) on center in a well-drained Arredondo fine sand soil with bahia grass cover. According to standard recommendation (4), holes were hand dug 2 times the diameter of the container or 30 cm (1 ft) in diameter and, because the soil was sandy, 5 cm (2 in) deeper than the root ball or 20 cm (8 in) deep. Excavated topsoil was placed on black plastic and backfill soil amendments were thoroughly incorporated. Backfill treatments were: 1) on a volume basis, 1 part peat moss to 2 parts soil (PM); 2) on a volume basis, 1 part fired montmorillonite clay to 2 parts soil (FMC); 3) following manufacturer's recommendations, 20 gm (0.67 oz) of the "superabsorbent" gel Terrasorb a "gelatinized starch-hydrolyzed polyacrylonitrile graft co-polymer" (TS); 4) control, no amendment. Newly planted trees were thoroughly watered and a 61 cm (24 in) diameter earth rim for a watering basin was constructed around each transplant (4). After 6 months, growth and establishment in response to ambient rainfall were to be measured, however, prolonged dry periods in May-June and again in August, 1984, necessitated hand watering the trees 4 times.

Leaf xylem pressure potential (^{P}leaf) measurements of water status were made with a Scholander pressure chamber (9) on the first 4 mature leaves at the apex of 4 trees randomly selected from each treatment on May 18. Plants had been watered 24 hours before measurements were taken. Height and caliper 15 cm (6 in) above soil-line were measured at transplanting and again at experiment termination. Plants were visually rated according to the following scale on September 14, 1984: 1 = dead; 2 = more than 75% top dieback; 3 = 25% to 75% top dieback; 4 = less than 25% top dieback; 5 = no dieback. After visual evaluation, 5 plants rated at 5 were randomly selected from each treatment, their root systems carefully excavated, cleaned, and dry weights of the top and new root growth extending from the original soil ball were taken.

The experiment was a completely random design with 18 replications per treatment. Visual ratings and growth data were evaluated by one-way analysis of variance with ^{P}leaf values for individual trees treated as nested variables.

Results and Discussion

^{P}leaf measurements, a direct means of estimating plant water stress, were taken at midday, under light levels of 1,670 uEm^{-2}sec^{-1} and relative humidity of 28% on plants watered 24 hours earlier. Results indicate ^{P}leaf values (Table 1) for backfill treatments were not significantly different.

Backfill amendment did not significantly influence height and caliper growth or visual rating of sweet gum in this experiment (Table 1). Dry periods in May-June and August stressed the trees and, as a result, 1 PM, 4 FMC, 2 TS and 2 control trees died.

Backfill amendment did not significantly affect total top and new root dry weights of 5 randomly selected plants from each treatment rated at 5 on the visual scale (Table 1). In Figure 1, a representative root system from each treatment shows that root extension into the backfill was not significantly altered by the addition of

Table 1. Influence of backfill amendment on growth and visual rating of sweet gum six months after transplanting from 3.8 liter (#1) containers.

TREATMENT	^{P}LEAF[w] (MPa)	Height Growth[x] (cm)	Caliper Growth[x] (mm)	Visual Rating[x]	New Root Growth Dry Weight[y] (gm)	Total Top Dry Weight[y] (gm)
1 Peat Moss: 2 Soil	-0.38	11.2	2.2	4.3	11.8	54.8
1 Fired Montmorillonite Clay: 2 Soil	-0.58	11.1	2.1	3.5	9.1	55.9
20 gm (.67 oz) Terrasorb	-0.38	8.8	1.7	4.0	15.4	54.6
Control—No Amendment	-0.48	9.9	1.8	3.9	12.5	63.5
Significance Level	NS[z]	NS	NS	NS	NS	NS

[w]^{P}leaf averages are based on 4 leaves per tree from 4 trees per treatment.

[x]Numbers in the height, caliper and visual columns represent mean values of all plants treated.

[y]Root and top dry weights are the average of 5 plants per treatment.

[z]Based on analysis of variance, NS = treatment differences not significant at the 5% level.

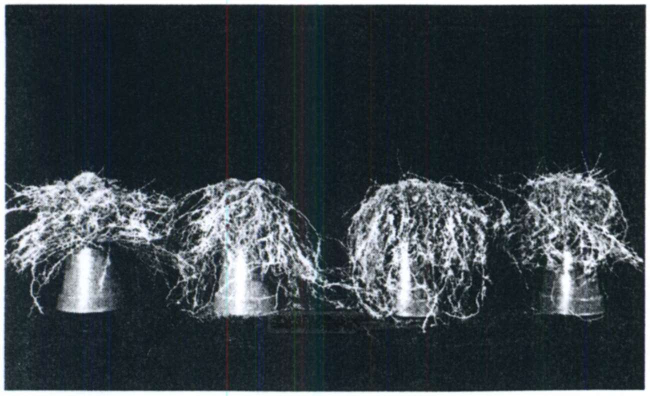

Fig. 1. Root development of sweet gum six months after transplanting. Treatments are from left to right: 1 Peat Moss: 2 Soil; 1 Fired Montmorrilonite Clay: 2 Soil; 20 gm Terrasorb; Control, No Amendment.

amendments at planting time. Small particles of peat moss, montmorillonite clay and Terrasorb were observed clinging to the fine roots of excavated plants.

Installation costs on a per plant basis were estimated for each treatment assuming a single laborer did the work and using prices from the 1983 edition of *Cost Data for Landscape Construction* (6). Material costs for FMC and TS represent manufacturer's 1984 prices. Table 2 shows a breakdown of the total installation cost of each treatment. Using the Kerr (6) costing system it is estimated that addition of backfill amendments increased the per tree cost by 27% to 30% or $0.43 to $0.48. The increased installation cost was not offset by a concommitant increase in growth and establishment of the sweet gum plants in this experiment.

Most recently, Corley (2) reported results from 9 years of experimentation with organic amendments on 6 woody species in clay topsoil and compacted clay subsoil and concluded that backfill amendments produced no consistent positive growth response. Townsend's (12) six year study of sawdust or peat backfill amendments in a sandy loam soil showed unamended highbush blueberry plants to be more vigorous and higher yielding than plants in amended backfills. Schulte and Whitcomb (10) found no benefit from the use of soil amendments with silver maple seedlings transplanted into either a good clay loam or a poor silt loam soil. Our results show no significant benefit in growth or survival of sweet gum from addition of peat moss, fired montmorrilonite clay or the "superabsorbent" Terrasorb to an Arredondo fine sand soil and can be added to the growing body of evidence (2, 4, 5, 7, 10, 12, 13) indicating amending backfill as a matter-of-course is a costly and unnecessary landscape installation practice. The 27 to 30% increase in installation costs due to backfill amendments could be better spent on the construction of an earth-rim watering basin and adequate follow-up watering during droughts for newly planted trees and shrubs.

Significance to the Nursery Industry

The addition of amendments to backfill soil at planting time is estimated to increase installation cost for a #1 containerized plant 27 to 30% over the unamended backfill installation cost. Yet backfill amendments produced no significant increase in growth and establishment of sweet gum trees in this experiment. Results indicate that as a standard procedure, amendment of backfill soils is an expensive and unproductive landscape installation practice.

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Table 2. Cost estimation for installation of a single #1 container grown sweet gum plant using different backfill amendments. Installation cost estimates based on prices in *Cost Data for Landscape Construction* (6). Assumed a medium soil and work hand done by a single laborer, plant material not included.

TREATMENT	Excavate Pit $	Material Cost $	Mix Backfill $	Set Tree $	Backfill Pit $	Total Cost $	Cost Increase[z] %
1 Peat Moss: 2 Soil	0.58	.25	0.22	.81	.21	2.07	29
Fired Montmorillonite Clay: 2 Soil	0.58	.21	0.22	.81	.21	2.03	27
20 gm Terrasorb	0.58	.26	0.22	.81	.21	2.08	30
Control, No Amendment	0.58	—	—	.81	.21	1.60	—

[z]Backfill amendment versus nonamended control.