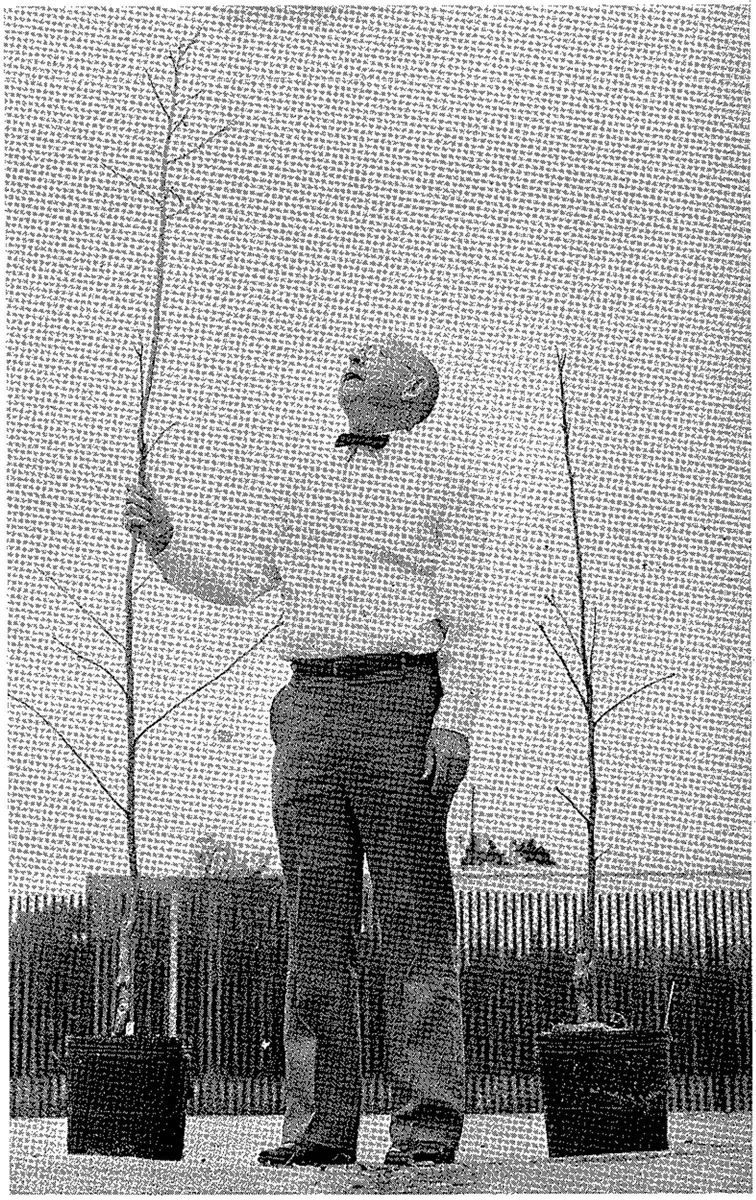
Bulletin 922 **October 1983**



J. P. Overcash examines 'Cape Fear' pecan trees in 3-gallon containers. The trees have three-year-old roots and two-year old tops.

Research With Pecan Nursery Trees in Containers and Orchards

MAFES MISSISSIPPI AGRICULTURAL & FORESTRY EXPERIMENT STATION
R. RODNEY FOIL, DIRECTOR MISSISSIPPI STATE, MS 39762

Mississippi State University

James D. McComas, President Louis N. Wise, Vice President

Research With Pecan Nursery Trees in Containers and Orchards

J. P. Overcash, Professor Emeritus
Mary Acock, Graduate Student
D. B. Bostian, former Graduate Student
R. C. Sloan, former Graduate Student
Department of Horticulture,
Mississippi State University

Summary

A number of nurseries now are producing container-grown, grafted pecan trees for commercial orchards and home landscapes. Success with this technique requires careful attention to the details of cultural procedures, some of which are as follow:

(1) Seed source should be selected carefully. Large, heavy nuts generally germinate well and produce larger seedlings than do those from poorly filled, small nuts (5). Nuts from one cultivar are better than nuts from randomly selected seedlings or cultivars.

(2) Seed should be stratified to encourage prompt and uniform germination. Store seed with moist peat moss at about 40°*F* for six weeks or longer before planting.

(3) Germinating seedlings often are disturbed (eaten) by pests such as rats, squirrels and various bird species. It is sometimes necessary to protect seedlings from these pests by covering them temporarily until they are well established. This can be done by covering them with a fine wire screen or loose mesh shade cloth or by germinating them in a greenhouse or wire cage. In research, three seed often are planted per container to assure one strong seedling. However, many seed can be germinated in containers or in a bed with a cage covered with a screen cloth. Strong seedlings are selected shortly after germination for transplanting, one per container, in the growing area. This is the most efficient use of seed.

(4) Several types of containers are available, but the 3-gallon black plastic nursery container is used most often. It holds enough potting mixture to permit supplemental addition of nutrients to grow large trees over a period of two to three years (2,3). Seedlings grown in the 10 x 20-inch nursery container have a larger root volume at transplanting time and may produce more tree growth when transplanted to the orchard.

(5) The Bostian-Overcash (3) potting mixture generally has been satisfactory for growing pecan nursery trees in container research. The mixture is about 50% pine bark ⅛- to ⅞-inch diameter, 38% mason sand and 12% fumigated soil (with weed-insect-disease control). The pH of the potting mixture must be adjusted to the proper range (6.0-6.5) if optimum plant growth is to be attained. Dolomitic lime (Ca & Mg) often is used. The pH should be checked at the end of each year and adjusted if needed. After three growing seasons the potting mixture still will support trees up to 4-7 ft tall. Other potting mixtures also may be fully satisfactory.

(6) Mineral nutrients must be supplied. "Slow release" minerals (N-P-K) plus other elements often are blended with the potting mixture at planting time. Small quantities of boron, calcium, copper, iron, magnesium, manganese, molybdenum, sulphur and zinc also must be supplied to the potting mixture, as dry supplements before blending or as liquid additions after the plants begin to grow.

Supplemental applications of N-P-K, and sometimes other elements, must be made to promote normal growth. During year two or three "slow release" NPK and other elements, or water soluble NPK, must be added to the top of the mixture regularly. Supplemental NPK should be added in the summer at regular intervals (weekly for water soluble and monthly for "slow release" nutrients).

(7) Frequent irrigation of nursery containers is very important because the container severely restricts the amount of roots and the water available to them. Commercial nurseries often use overlapping sprinklers controlled or automated by a time clock and solenoid valve. Overwatering seldom occurs with the open, well-drained potting mixture. Trickle irrigation can be used with an emitter or dripper in each container, and this also can be automated by time clock.

(8) When the seed are stratified and planted at the proper time in the spring and proper irrigation and fertilization practices are followed, it is possible to grow seedlings large enough to bud in August or graft in the following spring.

(9) Diseases and insects must be controlled if plants are to make optimum growth. Some nurserymen, who also have pecan orchards, design their nursery so that an air-blast sprayer can be used with the regular orchard chemicals. Periodic soil application of recommended chemicals can be effective for controlling diseases and insects without spraying.

(10) Skilled propagators can bud the seedlings effectively in late summer so that they will "take" and be ready for growth in the next spring. Other propagators effectively use whip grafts at the end of the dormant season. In any event, the "grafts" must be handled properly so that they will not break out of the graft union. Grafts should be set as high as possible on the seedling trunk.

(11) When the rootstock is of adequate size and healthy in early spring, it is possible to grow a strong new trunk for the scion variety in one growing season. Often they will grow from 2 to 6 ft and harden off. If the scion is not large enough to sell or set in the orchard, it can be grown a second summer in the container.

Research with Pecan Nursery Trees in Containers & Orchards

Pecans, *Carya illinoensis* (Koch), are an important horticultural crop. The latest Census of Agriculture reported 4.6 million bearing pecan trees and 2.3 million non-bearing (juvenile) trees in the United States. The average annual production (harvested) from 1977 through 1982 was 236 million lbs, and the average yield/acre was about 1000 lbs for mature bearing trees.

With 2.3 million juvenile trees (1-10 years) in the United States, it is apparent that pecan producers are interested in either expanding their present acreage or starting new orchards. Nurserymen in several states annually produce large numbers of grafted nursery trees in field nurseries. The trees are dug in the dormant season and are sold bare-rooted to growers for transplanting to orchards in late winter or early spring.

Standard nursery techniques consist of grafting or budding a named cultivar on a seedling rootstock growing in soil in a nursery. Rootstocks are established by planting nuts (often from known cultivars) in rows in late winter or early spring. The germinated seedlings require hand weeding, cultivating, fertilizing and pesticide spraying until they are large enough to bud or graft and the cultivar tree is large enough to sell. Establishing the seedlings usually requires from one to three years, and one or more years then are required to grow the cultivar grafts to a size suitable for sale.

Research and practical experience have shown the possibility of producing pecan nursery trees in containers (Figure 1) and transplanting them to the orchard (Figure 2). Production of nursery plants in containers (especially ornamental plants) has increased in the United States in the last two decades (11). The many advantages to nurserymen are (1) more plants can be grown per acre, (2) need for large fields of good soil is eliminated, (3)

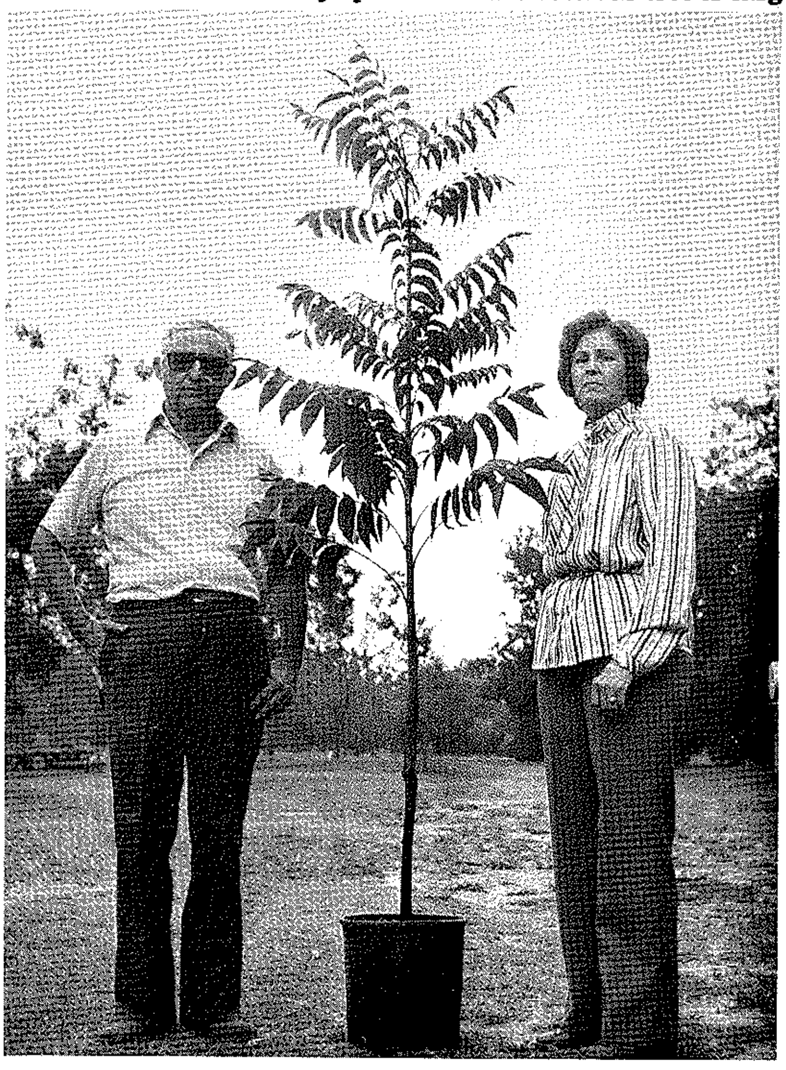


Figure 1. Mr. and Mrs. Bob Williams display a 'Melrose' pecan tree grown on a seedling root in their nursery at Newellton, Louisiana. The rootstock is three years old and the scion variety is one year old (Photographed October 1980).

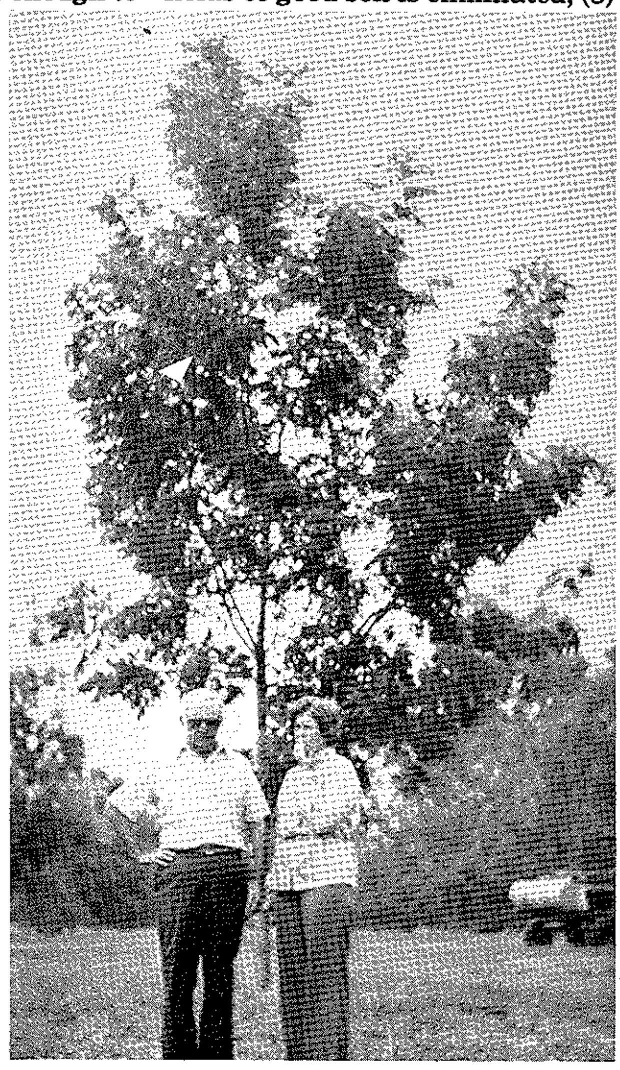


Figure 2. Mr.and Mrs. Bob Williams of Newellton, Louisiana produce pecan nursery trees in containers in their nursery. This is a 'Candy' tree in its fifth leaf and was transplanted from a 3-gallon nursery container.

many phases in container plant production can be mechanized, (4) the potting mixture can be prepared to provide suitable pH and nutrient requirements, (5) the potting mixture can be fumigated to reduce diseases, insects and weeds, and (6) plants grown in containers can be sold and transplanted to landscapes or orchards during the dormant or growing season.

Container production of pecan nursery trees requires well-drained potting mixtures that have good nutrient holding capacity and are of light weight (9,10). Containers restrict the root zone; therefore, frequent watering is required during the growing season. This can be automated for daily or more frequent applications to larger trees. Trickle devices or overhead sprinklers can be used to provide water.

Nursery site preparation for efficient container plant production requires provisions for water runoff as well as irrigation. Black containers exposed to full sun in the hottest part of summer may cause root injury unless containers are placed close together. Sprinkler irrigation at mid-day may be used to reduce build-up of heat in the nursery. Pecan nursery containers may need to be mulched with sawdust in the winter to protect the plants from severe cold. We have not observed winter killing of containerized pecan trees that were adequately mulched, even when the ambient temperature dropped to 0°F.

Mineral nutrition for container-grown nursery trees represents a complex problem (4,6). Nitrogen, phosphorus and potassium are recognized as major elements of the 15 recognized as essential for plant growth, because of the relatively large amounts needed. In recent years the N-P-K group has been developed as "coated" pellets with "slow release" availability. These generally are available in rated time-of-release groups, such as three-to-four or eight-to-nine months. Uniform soil moisture and ambient temperatures contribute to uniform release of these elements over time. However, soil moisture and ambient temperatures are not uniform over time, and nutrient release can vary with differences in growing-season conditions such as warm, high or very high air temperatures and normal or excessive natural rainfall (4,6). Elements in addition to N-P-K sometimes are included in the "slow release" pellets.

Several commercial formulations are Agriform®, Mag-Amp®, Osmocote®, Sulfurkote® and Sta-Green®. In addition to N-P-K, relatively small amounts of other elements are required for plant growth. These are boron, calcium, copper, iron, magnesium, manganese, molybdenum, sulphur and zinc. Carbon, hydrogen and oxygen are other essential elements.

Studies reported in this review of our research involved potting mixture, shape and size of containers, basic fertilizer types and rates, winter culture of pecan seedlings and transplanting experiments with container-grown pecan nursery trees.

Potting Mixture

Based on his experience with ornamental nursery plant production and pecan nursery trees in containers, Dr. A. J. Laiche, Jr., Horticulturist at the South Mississippi Branch Experiment Station at Poplarville, developed an empirical formula (Bostian-Overcash Mixture, Table 1) in 1974 (3). It has served as a basically successful mixture for several experiments with pecan nursery trees in containers. (1,2,7,8,12,13,14,15,16). About 50% of the potting mixture is southern pine bark obtained from a pole-peeling mill. It is worked through a soil shredder until it can be screened through 1-inch mesh. This gives a mixture of bark sized from less than ⅛-inch to ⅞-inch diameter. This fraction of the potting mixture adds lightness and porosity to the mixture and provides adhesion for mineral additions.

Table 1. Preparation of the Bostian-Overcash potting mixture used in production of pecan nursery trees in a container size-fertilizer study, Mississippi State University, 1978.

14 cu ft pine bark (screened below 1 inch)
10 cu ft mason sand
3 cu ft good soil (preferably fumigated with methyl bromide or other soil fumigants or steamed to 180°F for 30 minutes amd then allowed to cool slowly)
Add following chemicals, then mix thoroughly to insure even distribution of chemicals and potting mixture:
4.4 lb Osmocote® 18-6-12 (8-9 months)
6.6 lb Dolomitic limestone (Ca-Mg)
2.2 lb 20% superphosphate
1.1 lb Calcium sulfate
.55 lb Iron sulfate
.14 lb Peter's Fritted Trace Elements® (FTE No. 503) (18% Fe, 7.5% Mn, 7% Zn, 3% B, 3% Cu, and .2% Mo)

About 38% of the mixture is coarse mason sand, the type commonly used to make mortar for brick laying. The sand is a filler between the coarse bark particles and provides adhesive surfaces for good drainage and aeration.

The remainder of the potting mixture is silt or sandy loam soil, which is added as a source of small amounts of mineral elements. It also is a filler between coarse pine bark particles and provides adhesive surfaces for mineral additions to the mixture.

The pine bark and mason sand are relatively free of insect, disease or weed problems and are not fumigated. The soil is fumigated because of these problems. We steam fumigate the soil to 180°F for 30 minutes and then let it cool slowly. Proper use of MC²® (or other gaseous, solid or liquid fumigants) can effectively control pests.

Ingredients of the potting mixture are blended or mixed in a small electric concrete mixer or a commercial soil mixer or blender. The chemicals are added after the basic ingredients are partially blended. The iron sulfate and Peter's Fritted Trace Elements® are hand mixed with 1 gallon of moist sand and then added uniformly over the surface of the moving mixture. This precaution with the micronutrients is an effort to distribute the small quantities of these elements uniformly throughout the mixture. Mixing is continued for 15 minutes after the micronutrients are added. The potting mixture usually is prepared at the beginning of each experiment. The chemicals in the basic mixture sometimes are varied in research efforts to improve growth of pecan seedlings.

Experiments with Container Sizes Shapes and Fertilization

Evaluation of the long-held belief that nursery trees with long taproots (2-3 ft or more) are needed for successful establishment of pecan orchards was triggered by the upheaval of mature pecan trees by hurricanes such as "Camille" in south Mississippi in 1969. The uprooted trees had been transplanted with long taproots but were blown over with relatively shallow root balls, and no strong, deep taproots were present.

We made a study of seedling pecan trees grown in containers of various shapes and sizes. The five container types selected for the study are illustrated in Figure 3 and described in Table 2.

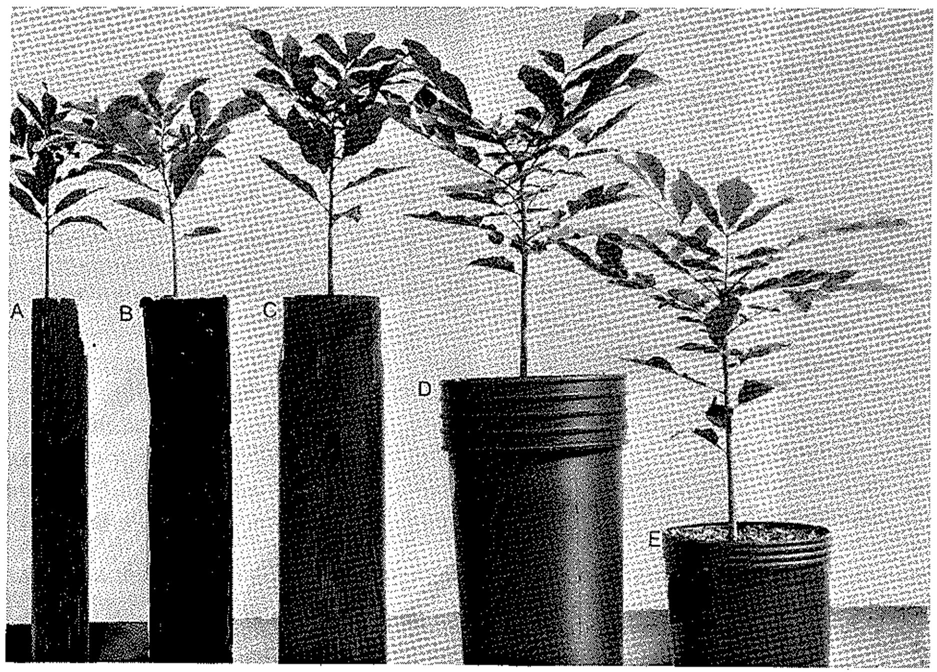


Figure 3. Average seedlings after one growing season in the nursery-container experiment. Containers are A, 3 x 24 inch; B, 4 x 24 inch; C, 6 x 24 inch; D, 10 x 20 inch; E, 10 x 10 inch.

Table 2. Dimensions of nursery containers used to produce pecan nursery seedlings in a container size-fertilizer study, Mississippi State University, 1978.

Code	Container	Height	Diameter Top	Diameter Bottom	Volume
		inches	inches	inches	gallons
A	3 inch PVC pipe	23.8	3.1	3.1	.8
B	4 inch flexible plastic sleeve	23.8	4.1	4.1	1.4
C	6 inch PVC pipe	23.8	6.0	6.0	3.0
D	6 gallon nursery can	19.9	10.2	8.6	5.9
E	3 gallon nursery can	10.2	9.9	9.6	2.9

Procedure

Nuts of the 'Stuart' cultivar were harvested in November 1977 and were stored dry at 40°F until March 1978. Nuts for planting were selected for uniformity at an average of 35/lb and were stratified by refrigeration in moist peat moss at 40°F until immediately before planting.

The eight- to nine-month type of 18-6-12 (N-P_2O_5-K_2O) Osmocote® was blended with Bostian-Overcash potting mixture at 4.4 lb per cubic yard of potting mixture (X rate), 6.6 (1.5 X rate) or 8.8 (2 X rate). The potting mixture with the X rate of Osmocote was poured into 80 containers of each shape and size, that with the 1.5 X rate into 40 containers of each shape and size and that with the 2 X rate into 40 containers of each shape and size. All containers were bumped to leave head space of 0.5 inch or more for watering. Three nuts were planted May 13, 1978 near the center of each container at a depth of twice the diameter of the nuts. The nuts were planted promptly after removal from stratification.

Seedling emergence was facilitated and seedling injury was prevented by moistening the surface of the growing medium when the seedlings started to emerge. Watering at that time and throughout the study was by hand. We used a water-breaker nozzle to reduce spatter of the potting mixture from the containers.

Seedlings in each container were thinned to the strongest if more than one emerged, and a healthy seedling was transplanted from another container if none emerged. The 160 containers were placed in full sun on a concrete floor of the greenhouse and plant-growing complex of the Mississippi State University Horticulture Department and were spaced equidistant and far enough apart to eliminate shading as a problem. The containers were supported by a frame constructed of 2 x 4-inch lumber, and spaces were subdivided into 10-inch segments by wood slats running across the width of the frame. Containers that would not stand independently (2 x 24-, 4 x 24- and 6 x 24-inch) were wired to the subdividing slats.

The surface of the mixture was kept moist throughout the study. Water was applied as needed, often daily in the absence of rain.

Fungicides and insecticides were supplied as needed to control diseases and insects.

One-half (40) of the containers filled with the potting mixture containing the X rate of Osmocote were fertilized with supplemental N-P-K, beginning 42 days after planting and once each week thereafter until September 24, 1978. A stock solution was made by mixing 2 lbs of water-soluble Peter's® 20-20-20 (N-P_2O_5-K_2O) in 1 gallon of water. Part of the stock solution was diluted in 200 parts of water, and two thirds of 1 pt of the diluted solution was applied each week.

Results

Trunk height and trunk diameter at the surface of the potting mixture were greatest for seedlings grown in the standard 10 x 10-inch, 3-gallon nursery container (Table 3). Taproot diameter at 4 inches below the surface of the potting mixture was greatest in the 10 x 10- and 10-20-inch containers (Table 4).

Overall performance (Tables 3 and 4) was poorest for seedlings

Table 3. Trunk height and trunk diameter at the surface of the potting mixture of pecan seedlings grown one season in a pine bark-sand-soil potting mixture, by size of nursery container, Mississippi State University, 1978.

Container size	Trunk height	Trunk diameter at surface
inches	inches	
3 x 24	8.9* D**	.28 D
4 x 24	9.5 CD	.33 C
6 x 24	10.0 C	.36 C
10 x 20	12.0 B	.42 B
10 x 10	13.5A	.46A

*Average of 8 replications of 4 fertilizer programs.
**Numbers in a column not sharing a letter in common differ significantly at the 5% level of probability as judged by Duncan's new multiple range test.

Table 4. Taproot diameter 4 inches below the surface of the potting mixture and trunk diameter 4 inches above the surface of the potting mixture of pecan seedlings grown one season in a pine bark-sand-soil mixture, by size of growth container, Mississippi State University, 1978.

Container size	Taproot diameter 4 inches below surface	Trunk diameter 4 inches above surface
inches	inches	
3 x 24	.41* E**	.18 C
4 x 24	.50 D	.21 B
6 x 24	.67 C	.22 B
10 x 20	.87 B	.30 A
10 x 10	1.09 A	.32 A

*Average of 4 replications of 4 fertilizer programs.

**Numbers in a column not sharing a letter in common differ significantly at the 5% level of probability as judged by Duncan's new multiple range test.

grown in the 3 x 24-inch plastic pipes. Pecan seedlings grown in 3-inch pipes have been transplanted successfully to an orchard where they grow well, but not as well as seedlings from larger containers (13).

The X rate of Osmocote did not provide enough NPK to sustain maximum growth throughout the season, and average tree weight was only 4.4 oz (Table 5). The best growth was by seedlings that received the X rate of Osmocote plus supplemental NPK.

Seedlings grown in the 10 x 10- and 10 x 20-inch containers were largest, and those grown in 3 x 24- and 4 x 24-inch containers were smallest (Table 5). Size of seedlings grown in 6 x 24-inch containers was intermediate.

Table 5. Average fresh weight of dormant pecan seedlings after one growing season in a pine bark-sand-soil potting mixture, by size of growth container and fertilization rate, Mississippi State University, 1978.

Container size	Fertilization rate X*	1.5X	2.0X	X + NPK**	Average
inches	oz				
3 x 24	2.6 fg***	3.2 efg	1.6 g	3.4 efg	2.7 C
4 x 24	2.0 fg	4.5 cdefg	3.1 efg	4.2 cdefg	3.5 BC
6 x 24	3.9 defg	5.3 bcdef	4.7 cdefg	4.7 cdefg	4.6 B
10 x 20	8.3 ab	7.3 abcd	7.7 abc	10.6 a	8.5 A
10 x 10	5.3 bcdef	6.5 bcde	8.4 ab	9.9 a	7.5 A
Average	4.4 E****	5.4 DE	5.1 E	6.6 D	

*Basic Osmocote® rate, 4.4 lbs per cubic yard.
**Basic Osmocote rate plus supplemental NPK applied once each week, beginning 42 days fter planting.
***Means within a column not sharing a letter in common differ (P < .05) as judged by Duncan's new multiple range test.
****Means not sharing a letter in common differ (P<.05) as judged by Duncan's new multiple range test.

Osmocote Monthly Supplement Experiment

Uniform nuts of 'Cape Fear' were collected in November 1980 and stratified from December 18 to February 10, 1981. They were then planted in 1-gallon nursery containers (three per container) using the basic Bostian-Overcash potting mixture (3).

The containers were kept in the greenhouse at 65°F or higher until April 30. They were then transplanted to 3-gallon containers with the same potting mixture and transferred to an outdoor concrete floor with 50% shade.

Uniform seedlings were selected for a fertilizer supplement study. Fourteen one-tree replicates were used. A no supplemental fertilizer check and four supplemental fertilizer rates ranging from 0.14 to 4.44 oz of Osmocote 18-6-12/3-gallon container were used at monthly intervals from May through August.

The plants were transferred June 11 to an outdoor concrete floor and spaced 2 ft between plants. They were watered as needed at one- or two-day intervals. The pH analyses of potting mixture in July indicated 6.0 to 6.7, which is within the desirable range. At the end of the growing season five plants from each fertilizer treatment were washed clean, and the weights of the roots (below surface) and trunks were recorded (Table 6). The root constituted 84% of the total plant weight.

The supplemental fertilizer rates were selected in an effort to range up to the toxic level. No differences in trunk size between treatments were significant (P< .05). Responses to no supplement and to .14 oz of Osmocote monthly did not differ. The best root growth followed monthly treatment with 0.44 oz or 1.41 oz. The highest rate of Osmocote retarded growth of the seedlings.

Table 6. Fresh weights of container-grown 'Cape Fear' pecan seedlings after one season of growth in Bostian-Overcash potting mixture supplemented monthly with Osmocote® 18-6-12, by rate of fertilizer application.

Osmocote applied monthly	Total plant	Roots	Trunk
	oz		
0.00	10.4ab	8.7 bc	1.7a
0.14	9.3 bc	7.8 cd	1.5a
0.44	13.0a	11.1a	1.9a
1.41	12.6a	10.5ab	2.1a
4.44	7.3 c	6.0 d	1.3a

Mean separation in columns by SNK at P < 0.05. Means in a column not followed by the same letter are statistically different.

Day Length and Growth of Pecan Seedlings

Researchers have shown that pecan plants can be grown from nuts, and that the trunks can be large enough to bud in a few months. The application of gibberellic acid (GA) to a small trunk accelerates its growth and makes budding feasible at an earlier date.

Our experiment explored the feasibility of growing seedlings in a greenhouse in winter. Day lengths and GA stem applications were included because pecan trees appear to thrive during long summer days or long natural photoperiods.

Nuts were harvested in November 1973 and stratified in moist peat moss at 40°F from December 1973 to September 1974 (3). They were planted in 3 x 12-inch plastic pipes containing Bostian-Overcash potting mixture. Seedlings emerged by October 3 and made good growth.

All plants received eight hours of natural daylight (8 am to 4 pm daily). Supplemental light (100 watt incandescent bulbs maintaining 50 foot candles at seedling level) was used for either eight or 16 hours daily. Plants were spaced 6 x 8 inches in cages covered with black cloth as needed to restrict day length periods to eight, 16 or 24 hours of illumination.

The GA was applied as the potassium salt prepared as a 5000 ppm solution in water and was mixed mechanically 1:2 (v/v) with USP lanolin to form a paste. The GA-lanolin paste application was centered around the trunk in a 1-inch band at 1 inch above the potting mixture surface. The lanolin kept the GA in place, and the trunks subsequently enlarged rapidly. Four applications were made, one each week beginning October 3.

Each increase in length of daily light period with or without GA application increased trunk height and numbers of leaves per plant (Table 7). Differences in height and numbers of leaves per plant due to GA treatment were slight. Trunk cross-sectional area was least for the shortest daily photoperiod but was increased appreciably by GA treatment in each photoperiod group.

Treatment of stems of young pecan seedlings with GA in a lanolin paste can produce stems large enough to bud or graft earlier than is possible without treatment. Use of longer daily photoperiods (16 to 24 hours duration with 50 foot candles at plant height) makes it possible to grow seedling pecan plants during the winter to sufficient size for budding in late winter or grafting in early spring.

Table 7. Plant height, numbers of leaves per plant and trunk cross-sectional area of pecan seedlings grown in 3 x 12-inch plastic pipes containing Bostian-Overcash potting mixture, by length of daily photoperiod, with and without gibberellic acid (GA) treatment[1].

Photoperiod daily	Height		Leaves/plant		Trunk cross section*	
	GA	none	GA	none	GA	none
hours	------inches------		------number------			
8	8.4 c**	6.7 c	8.8 b	7.4 c	.93 b	.34a
16	10.8 b	10.9 b	9.9a	9.0 b	1.23a	.32a
24	12.6a	13.7a	9.4 a	10.1a	1.22a	.24 b
Average	10.6	10.4	9.4	8.8	1.13	.30

[1]Seed planted September 18, 1974 and grown until December 15 in a greenhouse at 65-85°F.
*Calculated as a fraction of 1/4 sq. in.
**Means in a column not followed by the same letter are significantly different at .05 level.

Pecan Nursery Tree Transplanting Experiment

Nursery trees in containers have been transplanted to orchards readily, with unusually good liveability and subsequent growth (8, 12, 14). An experiment was established in 1974 on a Savannah sandy soil at Poplarville, Mississippi to study the influence of several preplant treatments on growth of trees for two years (12).

One-year-old seedlings that had been grown in 2-gallon nursery containers were included. Seedlings with taproots coiled around the inside of the container were used. One half of the taproot was removed from seedlings in one treatment for comparison of growth with that of seedlings that were not root pruned. The seedlings that were not root pruned weighed about 30% more than pruned trees after two years. Trees that were not root pruned also had larger primary roots and larger trunk diameters at 12 inches above the soil. Primary root diameters at 18 and 24 inches below the soil surface, two years after transplanting, were 80 and 160% larger, respectively, for trees that were not root-pruned.

Other treatments involved root pruning (one half of length removed) of the taproot of barerooted nursery trees. These trees lived and grew well but generally were somewhat smaller in subsequent years than where the whole taproot was planted. Small nursery trees with 3 ft-long taproots were established by removing all side roots and planting in a 1½-inch diameter hole bored with a soil auger. These trees all lived and grew satisfactorily, but not as well as trees planted differently.

Another experiment involved planting nuts in the orchard, bare-root planting of seedlings with 30 inch taproots and planting seedlings grown in six different types of containers (Figure 4). Seedlings emerging from the planted nuts were thinned to the strongest. Seedlings were removed from the containers and planted in holes dug slightly larger than the respective containers.

One half of the trees (four replicates) were trickle irrigated as needed to maintain optimum growth, with one emitter per tree at eight inches from the trunk the first two years and two emitters per tree at 12 inches from the trunk thereafter. Weeds were controlled manually, and the middles were disked the first year. A 4-ft wide weed-free band was maintained along the tree row by use of herbicides (paraquat, diuron and Roundup®) as needed after the first year. Native grasses formed a sod the second year, and this was mowed at two-week intervals.

The trees were maintained in the orchard for five years, and measurements were made annually. Branching was controlled by removing undesirable scaffold limbs when they were small and developing a central leader trunk where feasible. Trunk cross-sectional area often has been correlated closely to total tree top.

Irrigation had a profound influence on pecan tree growth (Table

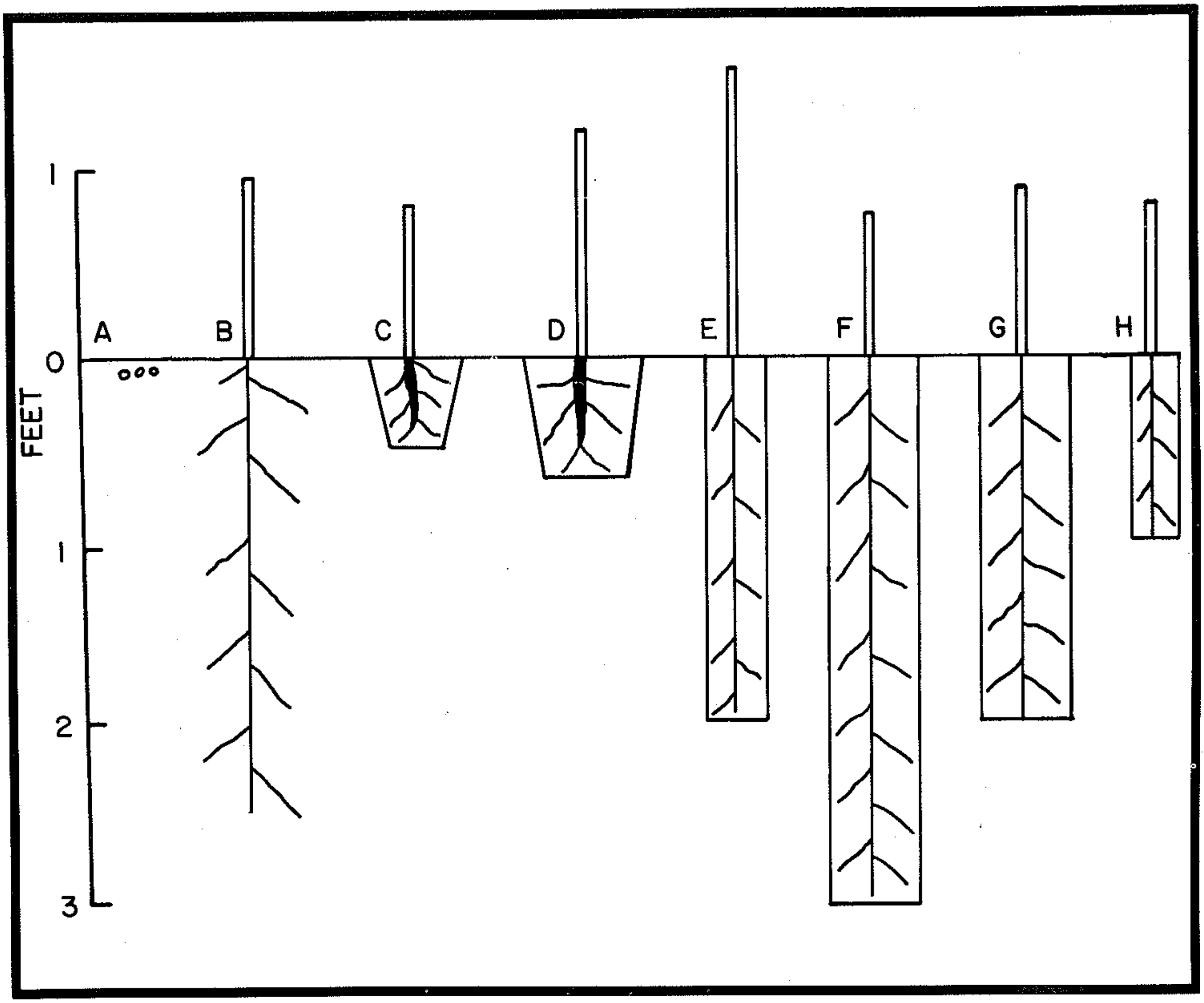


Figure 4. Diagram of pre-transplanting treatments in the pecan nursery tree transplanting experiment. Treatments are A, seed; B, bare rooted; C, 6-quart nursery container; D, 8-quart nursery container; E, 4 x 24-inch plastic tube; F, 6 x 36-inch plastic pipe; G, 6 x 24-inch plastic pipe; H, 3 x 12-inch plastic pipe..

8 and Figure 5). The average increase in trunk cross-section area was 77%. Trees from 2-gallon containers that were irrigated had almost a 100% gain in cross-section area. Nursery trees from the 2-gallon containers, 4 x 24-inch plastic sleeves and 6 x 24-inch pipes had the largest trunks. Barerooted trees transplanted with taproots 2.5 ft long had the smallest trunks after five years, except for the trees grown

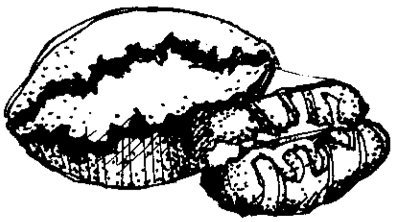


Table 8. Trunk cross section and total length of branches of pecan seedlings grown in an orchard for five years, by method of planting, with and without irrigation.

Treatment	Trunk cross section*			Length of branches		
	Check	Irrig.	Av.	Check	Irrig.	Av.
	--------sq inch--------			--------linear ft--------		
2 gallon can	6.3	12.4	9.4A**	121	156	138A
4 x 24 inch sleeve	6.1	11.8	8.9A	74	163	118 B
6 x 24 inch pipe	6.7	9.8	8.3A	96	99	97 B
1.5 gallon can	4.9	9.3	7.1 B	56	116	86 C
6 x 36 inch pipe	4.0	9.1	6.6 B	65	104	84 C
Bare root	4.8	6.7	5.8 C	63	94	78 C
3 x 12 inch pipe	5.6	9.1	7.4 B	56	87	71 D
Nuts planted in orchard	3.1	5.4	4.3 D	32	50	41 E
Average	5.2	9.2		70	110	

*Measured at 24 inches above orchard floor.
**Means in a column not sharing a letter in common differ significantly (P<.05) as judged by Duncan's new multiple range test.

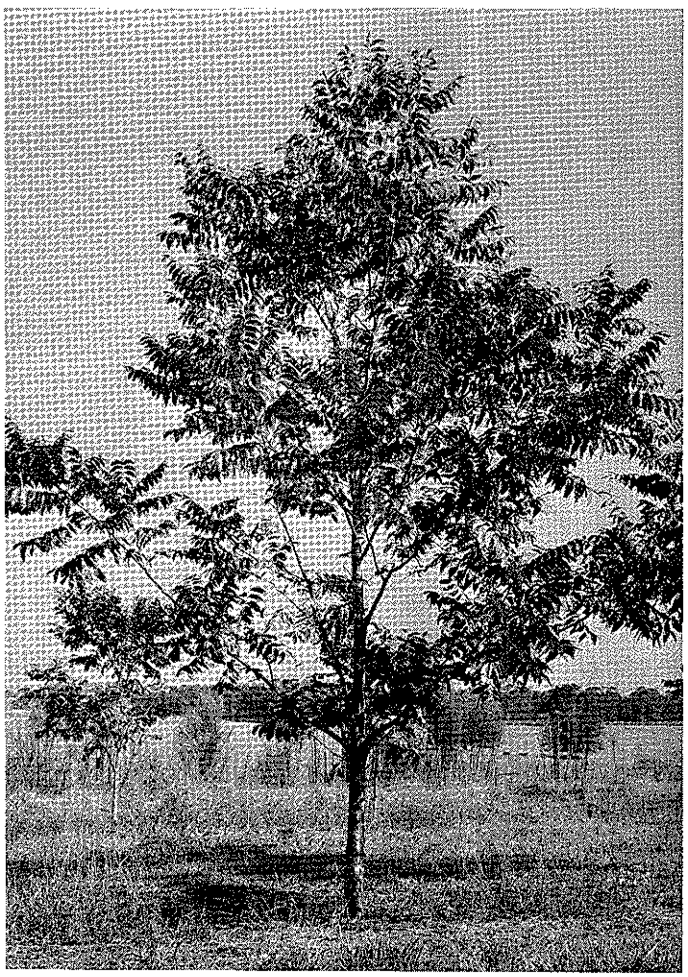


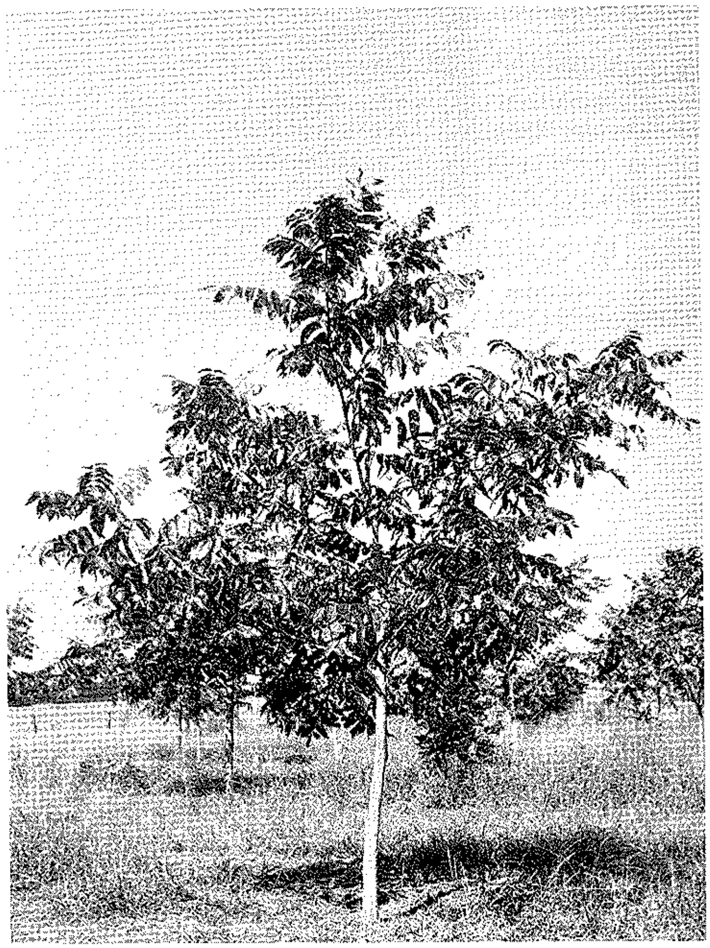
Figure 5. Pecan trees five years after transplanting to the orchard. Trees were grown in 2-gallon containers for one year before transplanting. Tree on left was irrigated and tree on right was not.

from seed, which were a year younger (Figure 6).

Total length of branches also is a good criterion for tree size. Trees from 2-gallon containers had the most branch growth, and trees from 3 x 12-inch pipes had the least growth, except for trees from nuts planted directly in the orchard. Five-year-old orchard trees from several containers were substantially larger than trees from seedlings that were transplanted barerooted.

Trees from 2-gallon containers were larger than those from 1.5-gallon containers. These differences were maintained year-after-year. Direct-seeded trees remained smaller than all others, and these trees had trunk cross section and total length of branches less than one half that of trees from 2-gallon containers.

No logical explanation has been found for better growth of trees from 6 x 24-inch pipes than that from 6 x 36-inch pipes. The results of this test clearly show that a pecan tree can be established under orchard conditions from trees grown in various shapes and sizes of containers. Trees from the smallest container (3 x 12 inch) were successfully established and made good growth, but not nearly as much as that from larger containers (e.g., 2 gallon).



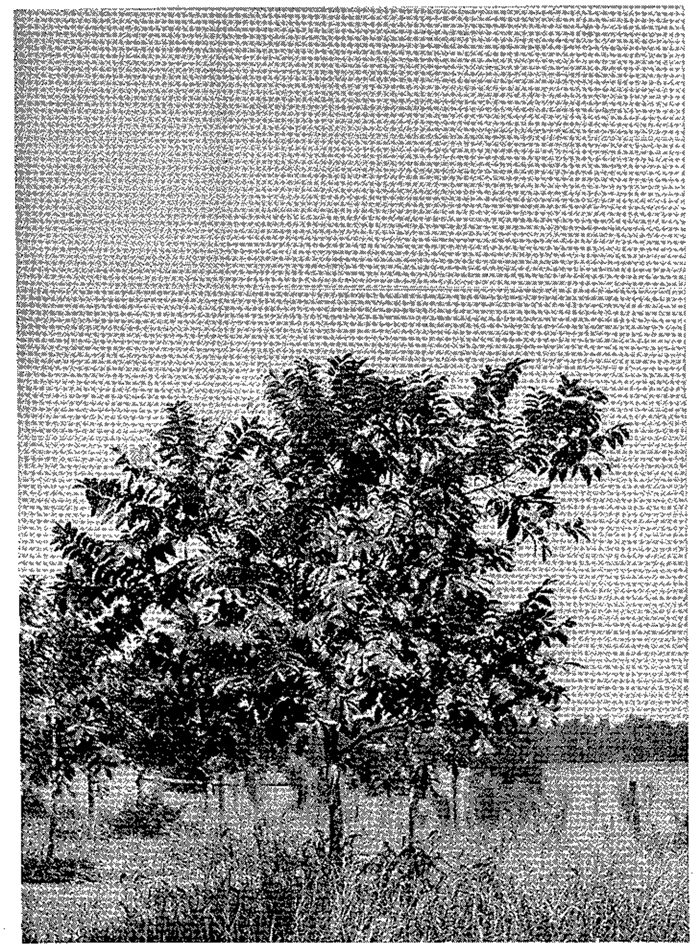


Figure 6. Pecan seedling trees after five years in the orchard. Tree on left was grown from a barerooted nursery tree with a 30-inch taproot. Tree on right was grown in place from a nut planted when the barerooted tree was set in the orchard.

REFERENCES CITED

1. Acock, Mary and J. P. Overcash. 1982. Mineral Nutrition of Pecan Nursery Trees in Containers. Proc. S.E. Pecan Grow. Assn. 75:139-144.
2. Acock, Mary C. and J. P. Overcash. 1983. Effect of Growing Medium and Cultivar on the Container Culture of Pecan Seedling Rootstocks. HortSci. 18(3):330-331.
3. Bostian, D. B. and J. P. Overcash. 1975. The Effects of Day Length and Gibberellic Acid on Growth of Young Pecan Seedlings. Proc. S.E. Pecan Growers Assn. 68:115-122.
4. Gilliam, C. H. and E. M. Smith. 1980. How and When to Fertilize Container Nursery Stock. Am. Nurseryman 151(2):7.
5. Herrera, E. and D. Martinez. 1983. Effect of Seed Size on Vigor of Pecan Seedlings. Pecan Quart. 17(1):18-19.
6. Jones, J. Benton. 1980. Nutrient Element Control in Soilless Mixes. Ornamentals South 2(6):12-15.
7. Laiche, Adolph J., Jr. 1976. Growth Evaluation Studies of One Year Pecan Seedlings of Selected Varieties, Seed Treatments and Growing Conditions. Proc. S.E. Pecan Growers Assn. 68:169-177.
8. Laiche, Adolph J., Jr., W. W. Kilby and J. P. Overcash. 1983. Root and shoot growth of field- and container-grown nursery trees five years after transplanting. HortSci. 18(3):328-329.
9. Matta, F. B. and J. B. Storey, 1981. The Effects of Container Design, BA and GA_3 on Root and Shoot Growth of Seedling Pecan Trees. HortSci. 16(5):652-653.
10. Matta, Frank B. and J. B. Storey. 1982. A Step Toward Containerizing the Pecan Industry. Pecan Quart. 16(4):20-22.
11. Overcash, J. P. 1981. Pecans - Their First Love. Pecan South 8(1):40-44.
12. Overcash, J. P. and W. W. Kilby. 1976. Transplanting Pecan Trees. Proc. S.E. Pecan Growers Assn. 69:149-157.
13. Overcash, J. P. and W. W. Kilby. 1976. An Experiment in Transplanting Pecan Trees. Proc. Texas Pecan Growers Assn. 55:47-50.
14. Overcash, J. P. and W. W. Kilby. 1978. Pecan Tree Transplanting Experiment. Proc. S.E. Pecan Growers Assn. 71:179-183.
15. Overcash, J. P. and R. C. Sloan, Jr. 1982. Growing Pecan Nursery Trees in ontainers. Pecan South 9(1):3-10.
16. Sloan, R. C., Jr. and J. P. Overcash. 1980. Growing Pecan Nursery Trees in Containers. Proc. S.E. Pecan Growers Assn. 73:149-157.

'Cape Fear' pecan trees with two-year-old roots and one-year-old scions in October and February (diameter of containers is 10 inches).