GROWTH OF BLACK WALNUT SEEDLINGS DURING THE FIRST SEASON AFTER TRANSPLANTING

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Black walnut trees planted as 1-0 seedlings generally show little, if any, net height growth during the first year. Possible reasons for slow first-year growth include transplanting shock, lack of root regeneration, unfavorable environments, and unsuitable genotypes. To help understand reasons for the slow growth, we studied the first-year growth of black walnut seedlings grown in four environments.

Seedlings (families) from 18 parent trees were grown in the Union County, Illinois, State Tree Nursery in 1970. Twelve parent trees from several locations in southern Illinois and six from Kentucky, Tennessee, and Arkansas were used in the study. The growth rate and form of parent trees are best described as average or random; no minimum standards for plus-tree selection were imposed. The seedlings were lifted in the fall and stored in a cooler at about 2° C. until spring. Before planting, taproots of the seedlings were pruned to 25 cm. In general, the seedlings had few lateral roots.

Two seedlings from each family were planted in each of three blocks in each of four environments. The four environments were: (1) stovepipe pots (60 cm. tall x 15 cm. diameter) filled with very fine sand and shredded peat (1:3) containing complete fertilizer II-D (Baker 1957); (2) Union State Nursery, spaced 0.6 m. x 0.6 m.; (3) bottomland field, Haymond silt loam, spaced 1.2 x 3 m.; and (4) upland field, Hosmer silt loam, spaced 1.2 x 3 m. Haymond silt loam is considered good for walnut, while the Hosmer silt loam is questionable because of a fragipan condition in the lower profile (Losche *et al.,* 1972).

Immediately after planting, the shoots were cut off at 2.5 cm. above ground on half of the seedling—one seedling from each of the two seedlings per family per block. Additional dry fertilizer of blood meal, superphosphate, and potassium sulfate was added to the pots three times during the summer. The pots were placed in a shade house and watered 2-3 times per week. Trees in the nursery received at least one inch of water per week until late August. Although total rainfall in the field was about normal (16 inches) for May through August, there was a 5-week dry period in June and early July. Weeds were controlled in the nursery and the field using simazine and atrazine.

Root volume before planting, stem diameter, shoot length, crown horizontal surface area, and crown length were measured on all trees. After the trees were lifted from the pots and the nursery in the fall, root volume and shoot and root dry weight were determined. Since trees were of unequal size at planting time, height and diameter were analyzed as percent of size at planting time.

RESULTS

Differences Among Environments

The coppiced and intact (not coppiced) seedlings in the nursery grew about twice as much in height during the season as seedlings in ,*each of the other environments (Table 1). Within each environment, coppiced seedlings grew about twice as much in height as the intact seedlings, but they still did not attain the height they had before they were clipped. At the end of the growing season, the intact trees were about twice as tall as the coppiced seedlings. Intact trees were 111 percent as tall as their original (April) height, while coppiced trees were only 50 percent of their original. The coppiced seedlings grew taller in the nursery than in the other environments.

Intact trees in the nursery grew more (percentage-wise) in diameter than intact trees in the pots and in the fields. The nursery trees were 163 percent of their original diameter at the end of the season compared with 108 to 133 percent for trees in the other environments. Coppiced trees in the nursery grew to 126 percent of the original (April) diameters, while coppiced trees in pots, bottomland field, and upland field grew to only 53, 89, and 97 percent of their respective original diameters. For the coppiced trees, the diameter increase (percentage-wise) was greater than the height increase, which indicates the coppiced trees are stockier than the original seedlings. Although coppicing results in a stockier tree the first year, within a few years growth differences beween coppiced and non-coppiced trees disappear?

The height-growth pattern for the 1971 growing season differed by environment. In the nursery and fields, 90 percent of the height growth was completed by mid-July for both the coppiced and intact trees. This is about normal for walnut trees in southern Illinois (Bey, Toliver, and Roth, 1971). For trees in pots, 90 percent of the height growth was completed by mid-June. The high soil temperature seems like the most probable explanation for the earlier cessation of tree

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growth in pots. Although we did not measure soil temperature in this experiment, in 1972 in similar pots and soil we recorded temperatures as high as 37 C. in the center of the pot 20 cm. below the surface—about 10 C. higher than that in the field. Harris (1968) and Larson (1970) have shown that high soil temperatures can reduce root growth in some tree species. Since supplemental fertilizer was added to the pots, and since deficiency symptoms in the leaves were not apparent, insufficient nutrients were probably not a factor in early growth cessation.

Roots of trees in the nursery and pots grew to about 500 and 175 percent of their original volume, respectively. The increase was largely due to growth of lateral roots. We estimated that no more than 20 percent of the increase resulted from taproot growth. High soil temperature in the pots presumably reduced root along with shoot growth. There were no apparent practical differences between root volume for coppiced and intact trees in either the nursery or the pots.

Within the nursery, the roots of the coppiced trees weighed about the same as the roots of the intact trees; in the pot environment, the same was true. On the other hand, shoot weights for coppiced and intact trees were much different within the same environment. Shoots of intact trees were about twice as heavy (dry weight) as the shoots of coppiced trees in the nursery and pots. Corresponding to these relative weights, the coppiced trees had a lower shoot/root ratio. The fact that root weights and volume are about the same for coppiced and intact trees suggests that root growth and food storage are also about the same, and may explain why differences in shoot growth between coppiced and intact trees disappear in a few years.

The trees in the nursery had the largest crowns (area and volume) followed by trees in the fields and the pots. In all environments except the upland field, coppiced trees had larger crowns than intact trees, but since the weight of coppiced shoots is about half of that of intact shoots, the apparent response to coppicing is to produce a larger proportion of leaves to stems. Root development seems to have a higher priority or demand for food produced than shoot growth.

Correlation.;Among Characters

In general, size of seedlings at the end of the first year was positively correlated with the original (before planting) size of the trees (Table 2). However, there were some low and non-significant correlations between fall size and spring diameter, and fall size and spring root volume for the intact trees in the nursery and bottomland field. Since spring root volume and fall size were generally more highly correlated for coppiced than intact trees, one might speculate that coppiced trees depend more on the food reserves in the roots than do intact trees. More likely, however, the shoot may also provide some food reserve for the intact trees and correspondingly reduce the correlation between spring and fall size. In other words, the correlation is highest where we have the most accurate estimate of available food.

Under more stressful conditions (pots and upland field), the correlations between spring and fall measurements are high and about the same for coppiced and intact trees. The higher correlation under stress rather than non-stress conditions means that a greater proportion of the growth for trees under stress is dependent on stored root food. Although this study suggests that it is more important to use large seedlings under more severe environmental conditions than under favorable conditions, other studies have shown that large seedlings are preferable to small seedlings on good as well as poor sites (Williams, 1970).

In general, correlations between spring height and diameter and seedling size in the fall were as high as correlations between spring root volume and seedling size in the fall. In one situation, intact trees in the nursery, spring root volume was not even correlated with fall size. As would be expected spring and fall heights generally had higher correlations than spring height and fall diameter. And, conversely, spring and fall diameters generally had higher correlations than spring diameters and fall heights. Spring root volume is definitely not better than spring height or diameter as a predictor of fall shoot size.

Differences Among Families

There were growth differences among families in only three situations: diameter of trees in pots, height of trees in bottomland field, and height of trees for all environments combined. Since trees were of unequal size at planting time, the analyses were made on height and diameter growth expressed as percent of size at planting time. For diameter of trees in pots, only the families with smallest (about 1 mm.) and largest (about 4 mm.) increases were different. For height of trees in the field, only one family, which grew about 11 cm., differed from 5 other families, which each grew about 23 cm. For height growth in the combined environments, one family differed from 2 other families. The combined analysis over all environments indicated that the family by environment interaction was not significant.

Since there are so few differences among families in this study, but wide differences among environments, I believe that the genotypes of the trees should generally not be considered the reason for lack of growth during the first growing season. The genotypes included in the study came from a wide geographic area that would approximate a practical seed collection zone for southern Illinois.

Unfavorable environmental conditions are apparently responsible for lack of growth during the first growing season. Irrigation in the nursery during June and July undoubtedly changed the soil conditions and is probably primarily responsible for the differences among environments. Although we did not study specific environmental variables, soil moisture, soil temperature and perhaps mycorrhizae and nutrients seem to be the most logical environmental components responsible for the observed differences.

Table 1. Average growth for all (18) families grown in four separate environments

Environment	1971 terminal growth	Height	Diameter	Root volume	Shoot dry weight	Root dry weight	Shoot root ratio	Crown area Aug.	Crown vol. Aug.
	cm.	Percent of original (April) seedling size			g.	g.		sq.cm.	cu.cm.
Nursery									
intact	20	119	163	554	48	115	0.42	3,932	44,024
coppiced	40	71	126	496	28	103	.27	4,192	51,367
Pots									
intact	8	110	108	167	18	32	.56	1,194	4,974
coppiced	20	37	53	182	7	37	.19	1,418	8,187
Bottomland field									
intact	10	107	113	—	—	—	—	2,655	13,667
coppiced	25	48	89	—	—	—	—	2,880	22,130
Upland field									
intact	9	107	124	—	—	—	—	2,881	18,901
coppiced	24	45	97	—	—	—	—	2,409	15,027
Environments combined									
intact	12	111	127	360	33	73	.49	2,666	20,392
coppiced	27	50	91	339	18	70	.23	2,725	24,178

Table 2. Correlation coefficients (*r*) for black walnut growth characteristics before planting and at end of first growing season

Trait	Intact				Coppiced			
	Height October	Diameter October	Shoot weight	Root weight	Height October	Diameter October	Shoot weight	Root weight
	Nursery				Nursery			
Height	0.66[1]	0.39	0.48	0.28	0.85	0.76	0.68	0.64
Diameter	.24	.38	.32	.11	.86	.83	.69	.67
Root volume	-.02	.14	.05	.04	.74	.75	.60	.64
	Pots				Pots			
Height	.65	.64	.74	.71	.85	.75	.67	.64
Diameter	.78	.90	.72	.71	.85	.83	.69	.67
Root Volume	.76	.90	.62	.65	.73	.75	.60	.63
	Bottomland field				Bottomland field			
Height	.75	.21	—	—	.96	.81	—	—
Diameter	.35	.41	—	—	.86	.88	—	—
Root volume	.13	.38	—	—	.71	.80	—	—
	Upland field				Upland field			
Height	.96	.81	—	—	.95	.80	—	—
Diameter	.86	.88	—	—	.84	.86	—	—
Root volume	.71	.80	—	—	.70	.80	—	—

[1] All *r* values less than -.14 or greater than +.14 are significant at .05 level.

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