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THE INFLUENCE OF CONTAINER TYPE AND POTTING MEDIUM ON GROWTH OF BLACK WALNUT SEEDLINGS

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ABSTRACT.—Container size and shape, potting medium, and genotype interacted to influence the growth of black walnut (*Juglans nigra* L.) seedlings. Larger containers tended to produce larger trees. In tall, narrow, vent-pipe containers, different proportions of peat and sand in potting media had no effect on total weight; a higher proportion of peat than of very fine sand in the potting media reduced the shoot/root ratio. In conventionally shaped pots, seedlings averaged 123 percent heavier when grown in a soil mix containing 75 percent peat and 25 percent sand than when grown in pure sand.

KEY WORDS: *Juglans nigra,* peat, sand, genotype, planting.

Continuing interest in intensive culture of black walnut (*Juglans nigra* L.) has prompted us to study techniques of growing black walnut seedlings in containers, not only for use as experimental plants, but also as trees potentially suitable for bench grafting or field planting in seed orchards or in special forest situations such as dry sites. We describe here the effects of pot volume, pot shape, and media containing different proportions of peat and sand on growth of black walnut seedlings raised from seed of 2 parent trees (Celmer 1970).

MATERIALS AND METHODS

Seed was collected from 2 southern Illinois parent trees, one each in Jackson and Randolph Counties, cleaned and stratified in polyethylene bags for 6 months at 2C, germinated in peat-filled flats, and transplanted to pots in early June.

Seedlings were grown in 6 container types, including all combinations of 3 volumes and 2 shapes, as follows:

Code	Approximate volume cm^3	Conventional shape	Cylindrical shape	Code
L	10,350	10-inch tarpaper pot	6 × 24-inch galvanized vent pipe	LL
M	3,450	8-inch plastic pot	4 × 24-inch galvanized vent pine	ML
S	1,150	5-inch plastic pot	1 quart milk carton	SL

The texture of the inner surface of pots may influence root development (Boden *et al.* 1969, Harris 1968) so the tarpaper pots were lined with 4-mil polyethylene to provide a smooth inner surface similar to plastic containers; holes were punched to allow drainage.

The media contained 4 proportions of very fine sand and shredded Canadian sphagnum peat as prescribed by Matkin and Chandler (1957): A—100 percent very fine sand; B—75 percent sand, 25 percent peat; C—50 percent sand, 50 percent peat; D—25 percent sand, 75 percent peat. At the time of mixing, 3.6 kg of dolomitic lime, 1.8 kg of 45 percent superphosphate, 0.3 kg of $MgSO_4$ and 37 g of fritted trace elements were incorporated in each m^3 of soil mix. Liquid 20-20-20 fertilizer was added weekly during the growing season and all pots were thoroughly watered 2 or 3 times each week. The seedlings were grown under 55 percent shade screens in a greenhouse with cooling that usually held day temperatures at a level not exceeding outdoor temperatures by more than 3C.

Treatments were replicated 3 times in a randomized complete block design. The containers were spaced sufficiently far apart to avoid crowding or shading of short pots by taller ones. After 6 weeks the blocks were interchanged and pots randomly rearranged within each block to reduce variation related to location in the greenhouse.

After 12 weeks, when the seedlings had dropped nearly all their leaves, total height of each seedling was measured to the nearest 0.5 cm and the plants were removed from the pots. Roots were washed free of potting medium and severed at the root collar. Shoots and roots were dried in an oven for 5 days at 48-50C, and weighed to the nearest 0.1 g.

Height, total weight, and shoot and root weights were analyzed following a conventional 3-way analysis of variance format (Celmer 1970).

RESULTS

The black walnut seedlings responded to all the pot type, soil mix and genotype treatments (table 1). Seedlings from the Randolph County parent (fig. 1) grew taller than did those from the Jackson County parent in all pot types and in all soil mixes. Genetic growth differences were most pronounced in the 2 smaller pot sizes in which the Randolph County trees were not only taller but also averaged more than 40 percent heavier (table 2). The taller Randolph County seedlings probably represent a seed-size effect; the nuts were about 1.7 times as large as those from Jackson County.

The Randolph County seedlings weighed slightly less than those from Jackson County, especially in the 6-inch vent-pipe containers (LL) (table 2). The Randolph County trees tended to be heavier with increasing peat content of the potting medium in the L, M, and ML pots. These trends may be related to differences in root form between the 2 seedling families in that 15 percent of the Jackson County seedlings were found to have developed multiple taproots

Table 1.—*Significance of pot type, soil mix, genotype, and interaction of these treatments on growth of black walnut seedlings as determined by analysis of variance*

Source of variation	Dependent variable			
	Height	Dry weight		
		Tops	Roots	Total
	cm	grams		
Pot type (P)	**[1]	**	**	**
Soil mix (S)	**	**	**	**
Genotype (G)	**	NS[2]	NS	NS
PS	**	**	**	**
PG	NS	NS	**	**
SG	NS	NS	NS	NS
PSG	**	**	**	**

[1]Significant at the 1 percent level.
[2]NS = nonsignificant.

Figure 1.—*Walnut seedling height (cm) in relation to container size and shape, soil mix C. Seedlings from Randolph County tree.*

Table 2.—*Ovendry weight of black walnut seedlings (grams) grown in different containers and media*[1]

Pot type	Jackson County seed tree Soil mix A	B	C	D	Randolph County seed tree Soil mix A	B	C	D	Mean
L	6.6	3.4	18.1	28.2	2.5	3.7	16.6	32.7	14.0
M	22.6	18.5	20.7	30.4	17.7	17.9	26.1	32.8	23.3
S	7.6	6.6	9.3	14.0	11.4	8.6	12.9	14.4	10.6
LL	37.4	30.7	34.9	34.1	22.6	21.1	19.1	27.6	28.4
ML	14.3	21.0	16.6	14.9	12.9	13.0	23.0	17.0	16.6
SL	8.5	1.4	4.5	6.3	4.9	13.4	9.2	7.4	7.0
Mean	16.2	13.6	17.3	21.3	12.0	12.9	17.8	22.0	16.7

[1]Standard error of difference values: between any 2 individual treatment combinations—16.1 g; between any 2 pot-type means—5.7 g; between any 2 soil mix means—6.6 g.

while all but 2 percent of those grown from Randolph County seed possessed the single heavy taproot typical of most black walnut seedlings. These differences were not apparent at the time of transplanting. It may be that seedlings with multiple taproots are better adapted to growing in potting media with relatively high sand content.

Pot type and soil mix influenced seedling height and weight, jointly as well as separately. The trend toward larger plants in larger pots was obvious, except in the large tarpaper (L) pots (table 2). This deviation was not anticipated, because in a previous study (Funk 1971) mean weights of black walnut seedlings were nearly the same for plants grown in L and LL pots in soil mixes B and C (mixes A and D were not tested). The tarpaper pots (L) used in the earlier study were not lined with polyethylene, and we hypothesize that in this study growth was much poorer in the soil mixes with greater sand content because aeration was insufficient (Long 1932). A similar pattern of heavier seedlings associated with greater peat content is apparent for all 3 sizes of conventionally shaped pots but potting media had no influence on weights of plants in the cylindrical containers (fig. 2).

Occasional small seedlings had unusually high shoot/root ratios and, when these ratios were averaged for treatment means, some extreme values appeared. Thus, it was more realistic to sum the shoot and root weights for the seedlings in the 3 replications of each treatment and then calculate ratios based on these sums; the 2 seedling families were also pooled (table 3) because there was little difference between their ratios. These ratios of sums are no longer additive and the suitability of analysis of variance is thus limited.

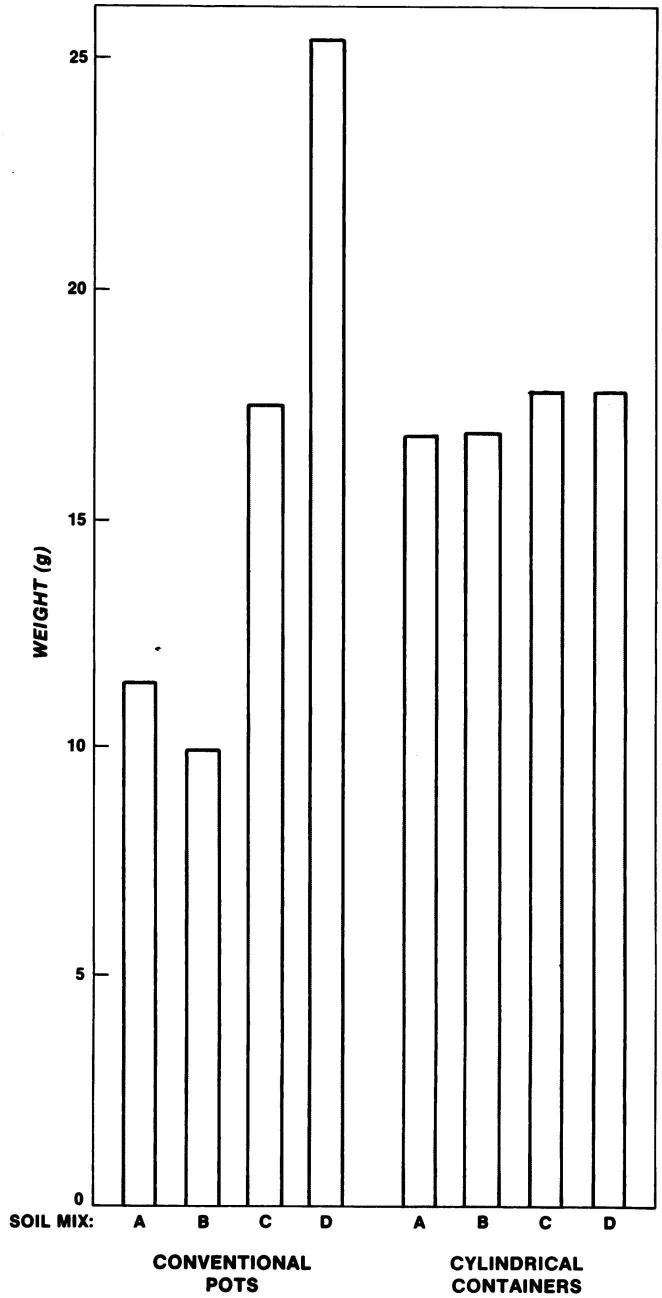

Figure 2.—*Weight of black walnut seedlings in relation to soil mix and container shape (3 container sizes and 2 genotypes pooled).*

DISCUSSION

Heavier seedlings generally had lower shoot/root ratios (tables 2 and 3); the correlation between shoot/root ratio and total weight was –.69. Other workers have suggested that the shoot/root ratio varies with plant weight, although not necessarily in the same fashion for herbs, conifers, and broad-leaved trees (Jones 1968, Ledig and Perry 1966). Farmer

Table 3.—*Shoot/root ratio (dry weight basis) of black walnut seedlings grown in different containers and media*

Container type	Soil mix A	B	C	D	Mean[1]
L	0.251	0.250	0.163	0.127	0.155
M	.158	.137	.184	.150	.157
S	.245	.246	.172	.175	.202
LL	.145	.148	.108	.112	.128
ML	.150	.137	.128	.117	.132
SL	.297	.227	.324	.165	.248
Mean	.175	.163	.156	.135	.154

[1]Mean ratios were calculated from shoot and root sums for each treatment, not by averaging ratios in the body of the table.

(1970), studying larger plants of eastern cottonwood (*Populus deltoides* Bartr.) grown in loam with 2 soil moisture regimes, found that shoot/root ratio was related to plant weight. In a favorable soil moisture situation the correlation between plant weight and shoot/root ratio was negative while in a stressful situation the correlation was positive.

In an earlier pot study with black walnut seedlings, Funk (1971) proposed that changes in shoot/root ratio are not necessarily related to total plant weight, so we looked for sets of treatments in which total plant weight was relatively constant to see if any ratio differences were evident. Apparently total weight of walnut seedlings is not much affected by soil mix in cylindrical containers (fig. 2). Considering the 2 genotypes together, weight is especially stable in vent-pipe containers (LL and ML) (table 2). But shoot/root ratio of seedlings grown in soil mix D in vent pipes is about 29 percent lower than for those grown in the soil mix A (table 3). Acknowledging that analysis of variance of these ratios is not completely appropriate, we made such an analysis based on the 4 soil mixes, 2 sizes of vent pipes, and 2 seedling families. The effect of soil mix on shoot/root ratio was significant; a subsequent covariance analysis determined that the effect was not related to differences in total weight.

In the vent-pipe containers the proportions of peat and sand in the potting media influences shoot/root ratio of seedlings, and this effect was independent of weight. But we doubt that any of these soil mixes (except perhaps mix A, 100 percent sand) constituted "drastic treatments" (Ledig and Perry 1966) although Farmer (1970) suggests that the stress regime that led to a positive correlation between shoot/root ratio and weight of cottonwood seedlings could be considered as drastic.

Soil mix D produced relatively heavy and well balanced seedlings for most pot-type and genotype combinations, but it is also relatively expensive because of its high proportion of peat. It is not commonly used for growing container stock, but has excellent aeration and moisture-holding properties and has been suggested for pots and beds (Matkin and Chandler 1957). Our results suggest that media containing high proportions of peat or perhaps other organic materials (Klett *et al.* 1972) are desirable for growing walnut seedling in conventional pots and should be considered for producing planting stock in nursery beds. Peat-sand proportions of potting media should be less important when seedlings are grown in tall, narrow containers, unless field studies indicate that differences in shoot/root ratio are related to plantation performance.

LITERATURE CITED

Boden, R. W., A. L. Higgs, and P. J. Setchell. 1969. Raising large Eucalypt seedlings in containers. Aust. For. Res. 4(1):21-28.

Celmer, Charles Kenneth. 1970. Effects of container size and shape and soil mix on growth and survival of greenhouse grown black walnut (*Juglans nigra* L.) seedlings. 48 p. M.S. thesis on file at Southern Illinois University, Department of Forestry, Carbondale, IL.

Farmer, R. E., Jr. 1970. Variation and inheritance of eastern cottonwood growth and wood properties under two soil moisture regimes. Silvae Genet. 19:5-8.

Funk, David T. 1971. Pot size, pot shape, and soil mix all influence black walnut seedling growth. The Plant Propagator 17(1):10-14.

Harris, Richard W. 1968. Factors influencing root development of container-grown trees. Int. Shade Tree Conf. Proc. 43:304-314.

Jones, E. W. 1968. A note on the dimensions of shoots and roots of planting stock. Forestry 41(2):199-206.

Klett, J. E., J. B. Gartner, and T. D. Hughes. 1972. Utilization of hardwood bark in media for growing woody ornamental plants in containers. J. Am. Soc. Hort. Sci. 97(4):448-450.

Ledig, F. Thomas, and Thomas O. Perry. 1966. Physiological genetics of the shoot-root ratio. Soc. Am. For. Natl. Conv. Proc. 1965:39-43.

Long, J. C. 1932. The influence of rooting media on the character of roots produced by cuttings. Am. Soc. Hort. Sci. Proc. 29:352-355.

Matkin, O. Z., and Philip A. Chandler. 1957. The U.C.-type soil mixes. *In* The U.C. System for Producing Healthy Container-Grown Plants. Kenneth F. Baker, ed. p. 68-85.

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