SURVIVAL AND GROWTH OF HARDWOOD SEEDLINGS FOLLOWING PREPLANTING-ROOT TREATMENTS AND TREESHELTERS

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Abstract: The study evaluated the influence of root collar diameter, number of large lateral roots, preplanting-root treatments (biostimulant called Roots and a moisture loss retardant called supersorb) and tree shelters on 1-0 black walnut (*Juglans nigra* L.) and northern red oak (*Quercus rubra* L.) seedlings. Four years after outplanting, the survival of black walnut and northern red oak increased with the number of large lateral roots. The difference was significant ($p < 0.05$) for black walnut but not for northern red oak. Total seedling height was significantly affect by tree shelters. The height of black walnut and northern red oak was significantly better with tree shelters than without tree shelters. There were significant interactions between the number of large lateral roots and root treatments for height and diameter for both species and between root collar diameter and number of large lateral roots for the diameter of northern red oak.

INTRODUCTION

Regenerating many desirable hardwoods after harvesting continues to be a problem on many sites in the Central Hardwoods Region. Planting nursery stock on sites that lack adequate advance regeneration, is a possible solution (Johnson 1979). Planted hardwoods often have variable growth rates which can be attributed to properties of the root system (Farmer 1975, Kormanik 1988).

Foster and Farmer (1970) suggested that the use of larger planting stock would help solve the slow growth problem after plantation establishment. Later, Johnson (1976) reported that planting seedlings with stem caliper of 8 mm or greater also increased survival and early growth. In one study, lifted oak seedlings possessed the characteristics to potentially become high-yielding trees 5 years after planting (Johnson 1984). Stroempl (1985) graded 2-0 northern red oak nursery stock from Ontario nurseries for 6 years and found 40% of the seedlings to be of unacceptable quality.

Nurseries are improving seedling quality by increasing the number of large lateral roots, also called first order lateral roots (>1 mm (0.04 in.). The number of large lateral roots are a morphological root characteristic of 1-0 seedlings that remains stable over a range of fertility levels and strongly influences field performance (Kormanik 1985, Kormanik 1986). Johnson (1988) reported that red oak seedlings undercut in the nursery bed had more large lateral roots when lifted and these seedlings survived and grew better when outplanted.

The ability of bare-root seedlings to produce new roots after planting has also been shown to be a valuable index of seedling quality (Ritchie and Dunlap 1980, Stone 1955). The organic biostimulant, "Roots," has been shown to greatly increase root and shoot growth of plants, and to increase seedling resistance to stresses such as low soil water potential and low soil nutrient content (Berlyn and Beck 1980, Berlyn and Russo 1990). Several other products also appear to increase the ability of the soil to hold more water as a means to reduce or moderate moisture stress for planted seedlings. One of these products, SuperSorb-F (supersorb), distributed by Aquatrols Corporation of America in Pennsauken, NJ, was used in this study. Minimizing the stresses encountered by newly planted seedlings could maximize root development over a range of site conditions.

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Initial reports on the value of tree shelters in silviculture in the United States focused on their dramatic effect on height growth in some species (Lantagne 1991, Potter 1988). But more recently interest has also been directed at ways in which tree shelters can improve survival of planted trees (Marquis 1977, Ward and Stephens 1995). They provide protection and modify the microclimate inside the shelter (Tuley 1984). The use of biostimulants and tree shelters either separately or in combination may reduce the amount of shoot dieback during the early years of establishment, thereby increasing the growth and development of both roots and shoots of young hardwoods. The purpose of this study was to evaluate the impact of preplant root treatments and tree shelters on survival and growth of black walnut and northern red oak seedlings having different root collar diameters and numbers of large lateral roots.

METHODS

Black walnut and northern red oak were planted separately at the same location. The study was established in an old field in Cedar County, Missouri on a low stream terrace. The soils are in the Helper series (Udollic Ochraqualfs, fine-silty, mixed, thermic). Soils are deep, somewhat poorly drained, and silt loam in texture. Slopes range from 0 to 3%. The field had been in the Conservation Reserve Program for one year prior to planting. The site received no site preparation.

Seedlings for the study were from the George O. White State Nursery located at Licking, Missouri. Prior to planting, root collar diameters and the number of large (>1 mm (0.04 in) lateral roots were measured and recorded for the 1-year-old seedlings. Assigned lateral root groups were (1) 0-4, (2) 5-7, (3) 8-11, and (4) 12 or more. Assigned root collar diameter groups were (small) 9-10 mm, (medium) 11-12 mm, and (large) 13 mm or larger. Seedling roots were pruned to 20 cm in length to aid in planting and bundled in groups of five seedlings of the same species for each assigned lateral root group.

Seedlings were planted in a randomized design at a spacing of 1.5 X 1.8 m. Three replicates per species were planted. One replicate consisted of 4 root treatments X 3 root collar diameters X 2 tree shelter treatments X 4 large lateral root groups X 5 seedlings per bundle. The following root treatments were used: (1) seedling roots soaked in a mixture of supersorb and tap water (71g/18.9 L of water), (2) seedling roots soaked in a mixture of supersorb (71g/18.9 L of tap water) and Roots (0.5 L/9.5 L of tap water), (3) seedling roots soaked in Roots solution (0.5 L/9.5 L of tap water), and (4) seedlings soaked in tap water. Seedlings were allowed to soak for 5 minutes. Half of the original dosage of supersorb and Roots were added to soaking solutions when half of the seedlings for a replicate had been soaked and new solutions were prepared after planting each replicate.

Tree shelters, distributed by TREESSENTIAL of St. Paul, MN, (1.2 m tall and ranged from 7.6 to 10.2 cm in diameter) were placed around seedlings designated to receive them and installed according to distributor's guidelines. Glyphosate was sprayed at the recommended rate in 61-cm-wide strips on both sides of the row within 5 days after planting. Height and diameter measurements and weed control have been done annually. Study data were analyzed using analysis of variance and differences between treatments were tested using the Scheff'e test. Survival percentages were transformed with the arc sine procedure before analyzing.

RESULTS

Survival

Root collar diameters at planting ranged from 9.0 to 14.0 mm for black walnut and northern red oak. The survival of black walnut was significantly (p=0.05) affected by the number of large lateral root (Table 1). Survival ranged from 53% for seedlings with 0 to 5 large lateral roots up to 96% for seedlings with 12 or more large laterals. Survival of northern red oak seedlings also increased as the number of large laterals increased, but the affect was not significant. There were no significant interactions between treatments for survival for either species. Both rabbit and deer browsing were apparent for seedlings without shelters. However, the damage did not significantly affect survival after 4 years.

Table 1. Mean survival of black walnut and northern red oak in response to number of large lateral roots[1]

Large lateral roots Number	Black walnut %	Northern red oak %
0-4	53a	49a
5-7	75a	63a
8-11	81ab	60a
12 +	96b	68a

[1]Values in a column followed by the same letter are not significantly different at the 0.05 level according to Scheff'e Test.

Growth

Four years after outplanting, black walnut averaged 75.0 cm in height and 11.3 mm in diameter while northern red oak averaged 39.6 cm in height and 11.2 mm in diameter. The height of both black walnut and northern red oak seedlings was significantly affected by tree shelters (Table 2). Black walnut and northern red oak seedlings in shelters were 36 and 37% taller, respectively, than seedlings without shelters. The interactions of tree shelters with other treatments were not significant (Table 3).

Table 2. Height of black walnut and northern red oak with and without tree shelters[1]

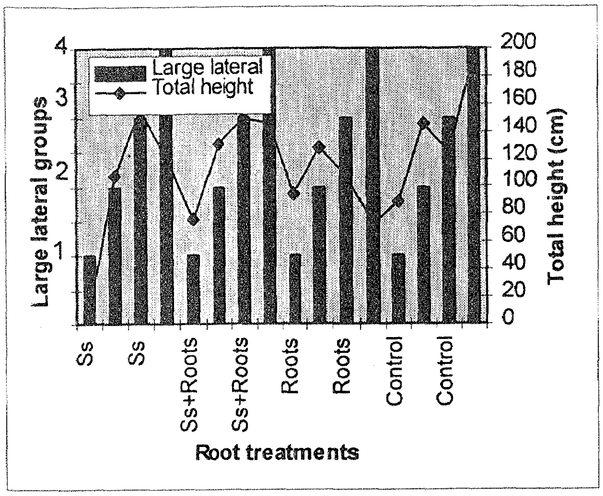
Tree shelter	Black Walnut cm	Northern red oak cm
Without	104.8a	61.3a
With	163.9b	97.5b

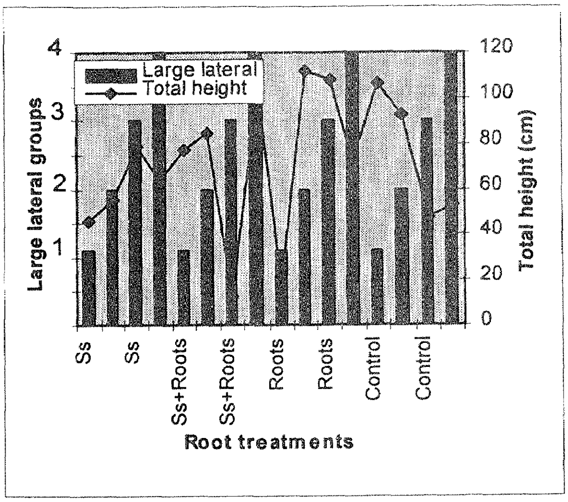
[1]Values in a column followed by the same letter are not significantly different at the 0.05 level according to Scheff'e Test.

Table 3. Treatments and their interactions with degrees of freedom, mean squares, and p-values for total height of black walnut and northern red oak seedlings 4 years after outplanting

Source	Degrees of freedom	Mean squares	P-values
		Black Walnut	
Tree shelter (T)	1	147,392	0.0001
Root (R)	3	7,146	0.0113
TXR	3	128	0.9762
Large lateral (L)	3	22,179	0.0001
TXL	3	2,816	0.2132
RXL	9	9,875	0.0001
TXRXL	9	2,307	0.2748
Caliper (C)	3	5,072	0.7466
TXC	3	540	0.8315
RXC	8	578	0.9604
TXRXC	4	2,631	0.2317
LXC	4	1,301	0.5923
TXLXC	2	2,381	0.2807
RXLXC	5	725	0.8540
		Northern red oak)	
Tree shelter (T)	1	26,435	0.0003
Root (R)	3	2,818	0.1737
TXR	3	862	0.6555
Large lateral (L)	3	4,485	0.0562
TXL	3	1,301	0.4924
RXL	9	5,331	0.0065
TXRXL	9	1,878	0.3417
Caliper (C)	3	4,215	0.0672
TXC	2	364	0.7956
RXC	6	1,504	0.4754
TXRXC	6	3,775	0.0751
LXC	6	2,150	0.2654
TXLXC	4	640	0.6708
RXLXC	6	3,718	0.0786

The effects of root treatment and number of large laterals and their interactions were significant for black walnut height, but only the interaction between these two treatments was significant for the height of northern red oak. For black walnut, except for Roots among root treatments, seedlings with up to 7 (group 1 and 2) large lateral roots, were shorter than seedlings with 8 or more (group 3 and 4) large lateral roots (Figure 1). The shortest walnut seedlings in the Roots treatment were with the highest number of large lateral roots. However, in the case of





BW NRO

Figure 1. The effect of root treatments and the number of large laterals on the height of black walnut (BW) and northern red oak (NRO) seedlings 4 years after outplanting.

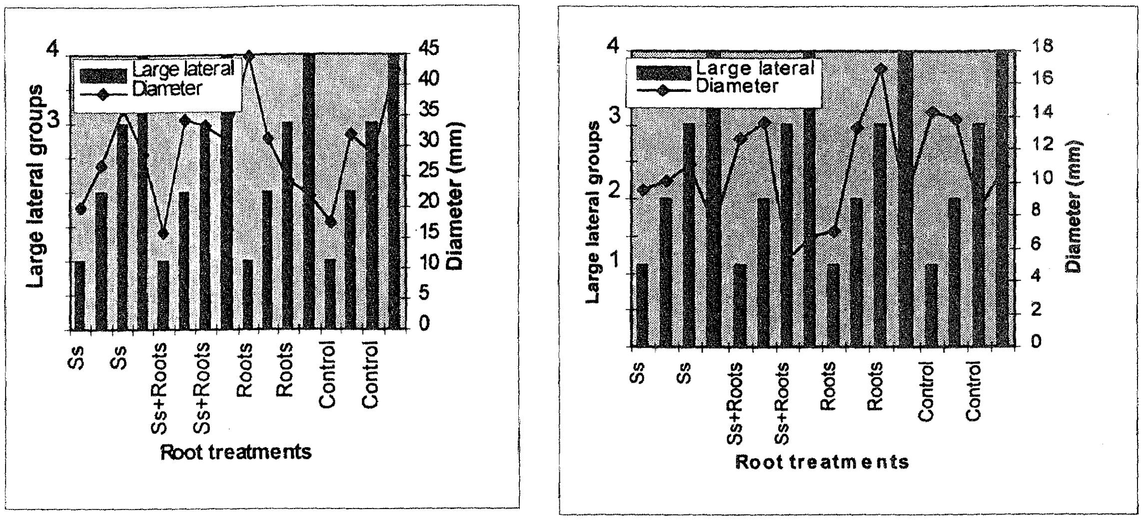
northern red oak, except for seedlings in the supersorb + Roots treatment, the taller seedlings were those with 0 to 7 (group 2 and 3) large laterals. The taller seedlings in the control treatment had 0 to 7 (group 1 and 2) large laterals.

The main effects and their interactions for diameter are shown in Table 4. The use of tree shelters with northern red oak was the only significant main effect for diameter. Northern red oak seedlings with tree shelters had a mean diameter of 10.4 mm compared to 12.4 mm for seedlings without tree shelters. The mean diameter of black walnut seedlings followed a similar trend for the two treatments, but the difference was not significant. Black walnut seedlings with tree shelters had a mean diameter of 27.8 mm compared to 31.8 mm for seedlings without shelters. The interactions for root treatment and number of large lateral roots were significant for both black walnut and northern red oak. Also, the interaction between the number of large lateral roots and root collar diameter was significant.

Table 4. Treatments and their interactions with degrees of freedom, mean squares, and p-values for diameter of black walnut and northern red oak seedlings 4 years after outplanting

Source	Degrees of freedom	Mean squares	P-values
		Black walnut	
Treeshelter (T)	1	687	0.1387
Root (R)	3	109	0.7868
TXR	3	137	0.7234
Large lateral (L)	3	366	0.3189
TXL	3	452	0.2285
RXL	9	891	0.0037
TXRXL	9	296	0.4807
Caliper (C)	3	69	0.8809
TXC	3	231	0.5305
RXC	8	171	0.8193
TXRXC	4	277	0.4741
LXC	4	422	0.2554
TXLXC	2	213	0.5072
RXLXC	5	649	0.0730
		Northern red oak	
Treeshelter (T)	1	100	0.0410
Root (R)	3	53	0.0873
TXR	3	34	0.2191
Large lateral (L)	3	39	0.1762
TXL	3	13	0.6219
RXL	9	53	0.0313
TXRXL	9	17	0.6250
Caliper (C)	3	215	0.9001
TXC	2	27	0.3029
RXC	6	45	0.0892
TXRXC	6	29	0.2638
LXC	6	63	0.0234
TXLXC	4	4	0.9448
RXLXC	6	50	0.0789

The diameter of black walnut seedlings decreased as the number of large lateral roots increased in the Roots treatment (Figure 2). The diameter of seedlings in the supersorb and supersorb + Roots treatments increased gradually as the number of lateral roots increased with a noticeable decline for seedlings with more than 12 lateral roots. However, for the control treatment, there was an overall increase in mean diameter as the number of large laterals increased. The diameter of northern red oak seedlings increased as the number of large lateral roots increased with a decline at twelve or more for Supersorb and Roots treatments. Northern red oak seedlings in the supersorb + Roots and the control treatments had larger diameters for seedlings with 7 or less large laterals than for seedlings with 8 or more large lateral roots.



BW NRO

Figure 2. The effect of root treatments and number of large lateral roots on the diameter of black walnut (BW) and northern red oak (NRO) seedlings 4 years after outplanting.

The interaction between the number of large lateral roots and root collar diameter for northern red oak diameter showed that for seedlings with up to 11 large lateral roots, diameter generally increased as root collar diameter increased, but declined for seedlings with 12 or more large laterals (Figure 3).

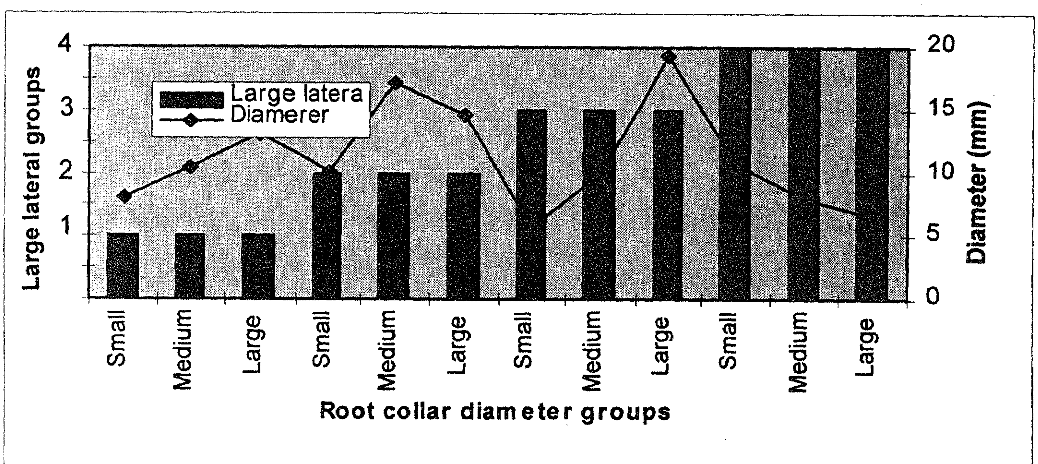


Figure 3. Interaction effect of root collar diameter and number of large lateral root on diameter of northern red oak seedlings 4 years after outplanting

DISCUSSION

Seedlings with more large lateral roots had better survival (Tables 1). Similar results were reported for seedlings from different mother trees (Ruehle and Kormanik 1986) and for seedlings that were undercut (Schultz and Thompson 1990). The results reported by Ruehle and Kormanik (1986) and Kormanik (1986) also demonstrated that the number of lateral roots on a seedling has a strong genetic relationship to the mother tree. The number of large later roots can be further increased by undercutting in the nursery and by radicle clipping (Barden and Bowersox 1989, Schultz and Thompson 1990). Undercutting in the nursery reduces shoot growth and improve the shoot:root ratio which makes the seedlings better competitors in their planted environment. Schultz and Thompson (1990) suggested that competitive black walnut seedlings should have large root systems with at least eight or more large laterals and that northern red oak should have at least five large lateral roots.

The significance of the interactions between root treatments and the number of large lateral roots for height and diameter indicates that there is a relationship between them that impact plant growth (Figures 1 and 2). Root absorptive area undoubtedly plays a big role in the response. Supersorb remains active in the soil for only 2 years and the activity of Roots last no more than one growing season. This may not be long enough for growth differences to occur for tree seedlings. Seedlings were excavated to determine if there were root system differences that may be attributed to root treatments.

The difference in height growth often associated with young trees in tree shelters was apparent for black walnut and northern red oak (Table 2). The diameter of seedlings with tree shelters was smaller than for seedlings without tree shelters. Conditions inside tree shelters are characterized by warm temperatures, high humidities (Tuley 1984), lack of air movement, and reduced light intensity; all of which seem to promote height growth.

In conclusion, these data on survival and growth in response to planting seedlings with different numbers of large lateral roots and root collar diameters offer further evidence of how field performance is improved when seedlings with both large root collar diameters and root systems with many permanent large lateral roots are planted. The advantage of using supersorb and Roots as preplanting root treatments for black walnut and northern red oak is not clear in this study. Other studies are in progress to further quantify the benefits of both root treatments and tree shelters on outplanted tree seedlings.

LITERATURE CITED

Barden, C.J. and T.W. Bowersox. 1989. The effect of root pruning treatments on red oak seedling root growth capacity. In Proc. Seventh Central Hardwood Forest Conf. USDA Forest Service Gen. Tech. Rep. NC-132. p. 115-118.

Berlyn, G.P. and R.C. Beck. 1980. Tissue culture as a techinique for studying meristematic activity. In (C.A. Little, ed.) Control of shoot growth in trees. Proceedings International Union Forest Research Organization. Fredericton, N.B. Canada, p. 305-324

Berlyn, G.P. and R.O. Russo. 1990. The use of organic biostimulants in nitrogen fixing trees. Nitrogen Fixing Tree Res. Rep. 8: 1-2.

Farmer, R.E. 1975. Dormancy and root regeneration of northern red oak. Can. J. For. Res. 5: 176-185.

Foster, A.A. and R.E. Farmer, Jr. 1970. Juvenile growth of planted northern red oak: effects of fertilization and size of planting stock. Tree Planters' Notes 21: 4-6.

Johnson, P.S. 1976. Eight-year performance of inter-planted hardwoods in southern Wisconsin oak clearcuts. USDA Forest Service. Res. Pap. NC-126. 9 p.

Johnson, P.S. 1979. Growth potential and field performance of planted oaks. In Proceedings 1979 John S. Wright forest conference, Regenerating oaks in upland hardwood forests. Purdue University, West Lafayette, IN. p. 113-119.

Johnson, P.S. 1984. Responses of planted northern red oak to three overstory treatments. Can J. For. Res. 14: 536-542.

Johnson, P.S. 1988. Undercutting alters root morphology and improves field performance of northern red oak. In Proceedings 10th North American Forest Biology Workshop., University British Columbia, Vancouver, p. 316-323.

Kormanik, P.P. 1985. Can lateral root characteristics be a major factor in assessing seedling quality? In (R.C. Schmidtling and M.M. Griggs, eds.) Proceedings 18th Southern forest tree improvment conference, Long Beach, MS. p. 290-297.

Kormanik, P.P. 1986. Lateral root morphology as an expression of sweetgum seedling quality. For. Sci. 32: 595-604.

Kormanik, P.P. 1988. Frequency distribution of first-order later roots in forest tree seedlings: silvicultural implications. In Proceedings 5th biennial southern silvicultural research conference, Memphis, TN, November 1-3, 1988. USDA Forest Service Gen. Tech. Rep. SO-74. p. 101-105.

Lantagne, D.O. 1991. Treeshelters increase heights of planted northern red oak. In Proceedings 8th central hardwood forest conference. USDA Forest Service Gen. Tech. Rep. NE-148. p. 291-298.

Marquis, D.A. 1977. Devices to protect seedlings from deer browsing. USDA Forest Service Res. Note NE-243. 7 p.

Potter, M.J. 1988. Treeshelters improve survival and increase early growth rates. J. For. 86: 39-41.

Ritchie, G.A. and J.R. Dunlap. 1980. Root growth potential: its potential and expression in forest tree seedlings. N. Z. For. Sci. 10: 218-248.

Ruehle, J.L. and P.P. Kormanik. 1986. Lateral root morphology: a potential indicator of seedling quality in northern red oak. USDA Forest Service Res. Note NE-344. 6 p.

Schultz, R.C. and J.R. Thompson. 1990. Nursery practices that improve hardwood seedling root morphology. Tree Planters' Notes 41: 21-32.

Stone, E.C. 1955. Poor survival and the physiological condition of planting stock. For. Sci. 1: 89-94.

Stroempl, G. 1985. Grading northern red oak planting stock. Tree Planters' Notes 36: 15-18.

Tuley, G. 1984. Treeshelters take the greenhouse to the tree. For. Brit. Timber 13: 17-22.

Ward, J.S. and G.R. Stephens. 1995. Protection of tree seedlings from deer browsing. In Proceedings 10th central hardwood forest conference, Morgantown, WV, March 5-8, 1995. USDA Forest Service Gen. Tech. Rep. NE-197. p. 507-514.