United States
Department of
Agriculture

Forest
Service

North Central
Forest Experiment
Station

Research
Paper NC-204

1981

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Paul S. Johnson

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1981. Early results of planting English oak in an Ozark clearcut. U.S. Department of Agriculture Forest Service, Research Paper NC-204, 6 p. U.S. Department of Agriculture Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota.

Shoot growth and survival of container-grown and 1-0 bare-root English oak (*Quercus robur* L.) seedlings are reported for a 3-year period after planting in a clearcut. Effects of mulching with black polyethylene are also reported.

KEY WORDS: *Quercus robur* L., shoot growth, polyethylene mulch, container-grown seedlings.

North Central Forest Experiment Station
Forest Service—U.S. Department of Agriculture
1992 Folwell Avenue
St. Paul, Minnesota 55108

Manuscript approved for publication October 17, 1980
1981

EARLY RESULTS OF PLANTING ENGLISH OAK IN AN OZARK CLEARCUT

Paul S. Johnson, *Principal Silviculturist, Columbia, Missouri*

English oak (*Quercus robur* L.) belongs to the white oak group and is indigenous to Europe, Asia Minor, and northern Africa. In Europe, it occupies relatively moist and fertile sites and is grown for high quality timber on rotations of up to 400 years. Although English oak has been primarily planted as an ornamental in the United States, in southern Michigan forest plantations of it grew more than twice as fast in diameter as native white oak (*Quercus alba* L.) during the first 13 years (Wright *et al.* 1973). Thus, English oak may be of interest to North American silviculturists because of its rapid juvenile growth compared to the relatively slow growth of most North American oaks (Russell 1971).

The results of numerous oak planting trials on forest sites in the Oak-Hickory Region have generally shown that planted oaks survive well, but that their slow growth soon results in their suppression by more vigorous natural vegetation. Thus, there is a need for developing nursery and planting techniques that will produce seedlings that grow rapidly under forest conditions (Johnson 1979). This paper reports on the growth and survival of container-grown and bare-root English oak during the first three years after planting in a Missouri Ozark clearcut. Black polyethylene mulching placed around planted trees was also tested to evaluate its effectiveness in reducing competition and increasing planted tree growth.

METHODS

English oak acorns were collected in October 1975 from about six fastigiate-form trees on the University of Missouri campus at Columbia. The acorns were then stored in 0.1 mm thick plastic bags at 2 to 4° C until late January 1976, when about 500 acorns were removed from cold storage and germinated between layers of wet paper towels at greenhouse temperatures of 21 to 24° C. After one week, 404 acorns with radicles ½ to 3 cm long were potted in 294 cc (20 cm deep) Spencer Lemaire "Rootrainers"[1] with grooved side-walls and open bottoms. The open bottoms cause "air-pruning" of roots, which in turn, produces a fibrous root system. Containers were filled with a 1:1 mixture of peat and coarse vermiculite.

These 404 seedlings were grown in the greenhouse until early May when they were moved outdoors under 43 percent shade fabric. In both environments, seedlings were grown at a density of 330 trees per square meter during the 9 month propagation period. Container propagation methods were modified after Tinus (1974) and Matthews (1971). In late October, all container-grown seedlings less than 30 cm tall were rogued. The remaining seedlings (approximately 200) were kept under the outdoor shade frame in an apparently dormant state until planting time in November.

Bare-root stock was grown in a conventional nursery bed at the George O. White State Forest Nursery at Licking, Missouri, from about 1,500 acorns sown in early April 1976. Seedlings were grown at an average density of 36 trees per square meter. These seedlings were lifted on October 25, and "healed-in" in the nursery. On November 3, the seedlings were sorted and those with tops less than 30 cm long were discarded. Roots of the remaining trees were then pruned 25 cm below the root collar and packed in plastic bags with moist peat moss. In contrast to the container-grown seedlings, bare-root seedlings had few lateral roots.

On November 4, 384 seedlings were planted in a 0.4-hectare (1-acre) clearcut on the Sinkin Experimental Forest in southern Missouri. The clearcut occupied a 30 percent north-facing slope where the site index for black oak was 21.3 m (70 feet). Before planting, stumps of all overstory stems 4.1 cm (1.6 in.) d.b.h. and larger were treated with 2,4,5-T to

[1]*Mention of trade names does not constitute endorsement of the products by the USDA Forest Service.*

prevent sprouting. Trees were planted in 12 blocks in a randomized block design. Each block contained two 8-tree rows of container-grown seedlings and two 8-tree rows of bare-root seedlings. Planting was done with mattocks at a 2.4- by 2.4-m (8- by 8-foot) spacing; soils were moist at time of planting. Container-grown seedlings were removed from containers with soil "plugs" intact and then planted.

After planting, two rows of each seedling-type per block were mulched with sheets of 0.1 mm thick black polyethylene film 91 by 91 cm. The polyethylene was held in place by U-shaped pins made of number 9 galvanized wire about 15 cm long that were pushed through the film and into the soil at the four corners of each sheet. Each corner was reinforced with nylon filament tape to prevent the film from tearing at the pinning points.

At the time of planting, measurements were made of seedling diameters (2 cm above the root collar) and seedling heights. On the average, stem diameters for bare-root seedlings were about 3 mm larger than for container-grown seedlings (table 1). Mean heights of planted trees by treatments ranged from 51.5 to 56.8 cm at time of planting. Measurements of total live heights of seedlings were also made at the end of each growing season; shoot dieback was measured after the first growing season. Also, on April 20 of the first growing season after planting, seedlings that had initiated shoot elongation were counted and flush lengths were measured. Net shoot elongation was calculated as the difference in live seedling height between two years. All heights and shoot lengths were measured to the nearest centimeter, and all stem diameters to the nearest millimeter.

RESULTS

Flushing was observed on some of the planted English oaks on April 20 of the first field growing season—several days before indigenous oaks at the planting site initiated flushing. By this date, 94 percent of the container-grown seedlings had initiated shoot elongation (90 unmulched and 91 mulched trees); the new shoots averaged 5 cm in length with the longest new shoot measuring 18 cm. Because of terminal shoot dieback, however, only 21 percent of those trees which had flushed by this date produced shoots that originated from the terminal bud cluster. In contrast to the high percent of flushing by the container-grown seedlings, only one of the 192 bare-root seedlings had initiated flushing by this date. This earlier initiation of growth by the container-grown seedlings may have been due to shading in the propagation bed the previous year—an effect similar to that of overstory canopy shading on northern red oak (*Quercus rubra* L.) seedlings as noted by McGee (1976).

During the first winter in the field there was much shoot dieback, and mean net shoot elongation for the first growing season was negative for all treatments. However, there was significantly more shoot dieback of bare-root seedlings than of container-grown seedlings, and significantly more dieback on mulched than on unmulched seedlings. Mean dieback was thus greatest for mulched bare-root trees (37.7 cm) and least for unmulched container-grown trees (13.7 cm) (table 2). By the end of the first year, container-grown trees were significantly taller than bare-root trees and unmulched trees were significantly taller than mulched trees. Live heights of unmulched container-grown trees were within 1 cm of their planted heights, and mulched bare-root seedlings were about 16 cm shorter than when they were planted. First-year survival averaged 89 percent, but was significantly higher for unmulched (99 percent) than mulched seedlings (82 percent). The difference in survival between types of nursery stock was not significant.

Table 1.—*Initial size of English oak nursery stock by treatments*

Treatment	Shoot diameter[1]			Height when planted		
	Mean	Standard deviation	Range	Mean	Standard deviation	Range
	mm			cm		
Bare root, unmulched	8.2	1.4	6-11	53.7	12.2	30-81
Bare root, mulched	8.3	1.5	5-12	51.5	12.6	30-80
Container-grown, unmulched	5.3	1.4	3-9	54.8	14.0	31-104
Container-grown, mulched	5.2	1.3	3-10	56.8	14.4	30-96

[1]Measured 2 cm above the root collar (nearest mm).

Table 2.—*Mean survival, shoot growth, shoot dieback, and significance level of treatment differences for planted English oaks*

Treatment	Survival	Shoot dieback	Net shoot elongation				Mean tree height after		
	Three-year	First year	First year	Second year	Third year	Three-year	First year	Second year	Third year
	Percent	*cm*[1]							
Bare root, unmulched	91	33.4	−7.9[2]	24.3	21.1	38.8	45.8	71.1	92.0
Bare root, mulched	75	37.7	−15.2	25.9	22.4	34.8	35.8	64.1	86.5
Container-grown, unmulched	97	13.7	−1.2	14.5	16.4	29.8	53.7	68.3	85.0
Container-grown, mulched	78	21.8	−8.5	15.0	16.3	24.3	48.9	65.5	81.8
	Significance Level of Treatment Differences[3]								
Comparison for a Given Response Variable									
Bare root vs. container-grown (S)	ns	.01	.01	.01	.05	ns	.01	ns	ns
Mulched vs. unmulched (M)	.01	.01	.05	ns	ns	ns	.01	ns	ns
S × M interaction	—	ns	ns	ns	ns	ns	ns	ns	ns
Replication	—	ns	ns	.05	.05	ns	ns	ns	.05

[1]Means are for survivors at the end of the year (field growing season) indicated.
[2] Negative values indicate that shoot dieback exceeded shoot elongation by the amount shown.
[3] ns = nonsignificant; for survival, significance is based on chi-square; for all other variables, significance is based on analysis of variance.

During the second growing season, mean net shoot elongation was positive for all treatments, and ranged from 14.5 to 25.9 cm. Net shoot elongation was significantly greater for bare-root than container-grown seedlings, despite the larger amount of shoot dieback of bare-root seedlings the first year. The second-year difference in net shoot elongation between mulching treatments was not significant nor did mean tree heights differ significantly among treatments. Frost in early May of the second year caused much dieback of new shoots; however, affected trees initiated new shoots shortly thereafter. During the first two growing seasons, most planted seedlings were subordinate to a cover of fireweed (*Erechtites hieracifolia* (L.) (Faf.)) of variable density but averaging about 2m in height. Thus, mulching was not very effective in reducing lateral shading of planted trees by competitors, although direct overhead shading was usually reduced.

During the third growing season, bare-root seedlings maintained their superiority over containerized seedlings in net shoot elongation. However, mulching effects were not significant the third year. Total live heights at the end of the third growing season did not significantly differ among treatments. Three-year survival by treatments ranged from 75 (mulched bare-root trees) to 97 percent (unmulched container-grown trees); 79 percent of total 3-year mortality occurred during the first growing season. Briars (*Rubus* spp.) and other woody plants emerged as the dominant vegetation during the third year and overtopped many planted trees. Even though the polyethylene film remained intact after three years, woody competitors were beginning to fill in the canopy "holes" created by mulching wherever planted trees did not already occupy a position of dominance or codominance.

Variability in net shoot elongation was high during the 3-year growth period. Although seedlings averaged 33 cm of net shoot elongation over the three growing seasons, about 20 percent of planted trees equaled or exceeded twice that amount. Among treatments, significant differences occurred in the percentage of trees that attained at least 40 cm of net shoot elongation (i.e., a minimum net shoot elongation of 40 cm); at or above 50 cm, minimum net shoot elongation percentages by treatments were not significantly different (fig. 1). Thus, 45 percent of unmulched bare-root trees attained at least 40 cm of net shoot elongation, while only 24 percent of mulched container-grown seedlings increased that much or more in height during the same 3-year period.

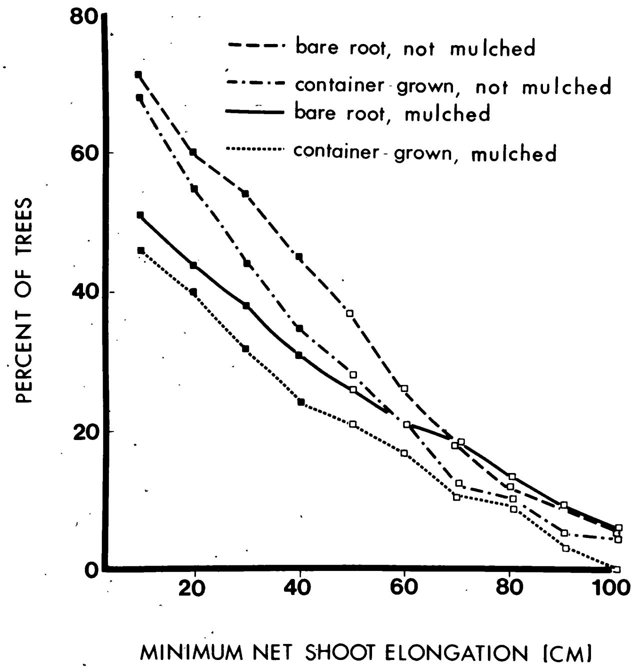

Figure 1.—*Percent of planted English oaks attaining a given minimum net shoot elongation after three field growing seasons by treatments. (Significance is based on chi-square; solid squares (■) indicate that significant differences ($p<.05$) occurred among treatments for a given minimum net shoot elongation.)*

Because average initial shoot diameters were smaller for container-grown than for bare-root seedlings, treatment effects were potentially confounded with seedling size effects. To overcome this problem, initial seedling cross-sectional area (2 cm above the root collar) was used together with minimum net shoot elongation percentages (fig. 1) as a predictor of the probability of net shoot elongation equaling or exceeding a given value. Based on these estimated probabilities for 3-year and 3rd year minimum net shoot elongation, combined effects of mulching and containerization in comparison to the "control" treatment (i.e., unmulched bare-root seedlings) were negative until an initial shoot diameter of a least 8 mm was reached (fig. 2, table 3).

Probability estimates indicated that above 8 mm shoot diameter, net shoot elongation of mulched container-grown trees may be superior to unmulched bare-root trees. However, the number of container-grown trees in the study that were above 8 mm in diameter was too small to reliably establish this relationship. The intersection of the two response surfaces for 3rd-year growth at about 8 mm (fig. 2) nevertheless suggests that net shoot elongation potentials for mulched-containerized trees 8 mm in diameter are about equal to those for unmulched bare-root seedlings; below 8 mm, combined effects of mulching and containerization are negative in comparison to the control treatment.

Based on the same regression models, comparison of probability response surfaces for mulched and unmulched container-grown seedlings (not shown) similarly indicated that mulching large diameter seedlings has a positive effect but that mulching small diameter seedlings has a negative effect on shoot growth. Comparison of response surfaces for unmulched and mulched bare-root seedlings (also not shown) indicated that mulching is likewise detrimental to small diameter trees but is not effective in increasing shoot growth of large diameter trees. Thus, the model indicates that only relatively large-diameter container-grown seedlings respond positively to mulching.

DISCUSSION AND CONCLUSIONS

Under greenhouse conditions, potential root growth of container-grown oaks has been shown to be superior to that of bare-root seedlings per unit of leaf area (Johnson 1979). In part, this may be due to the fibrous root systems of container-grown seedlings that provide relatively large numbers of sites for new root regeneration; in contrast, bare-root seedlings possess few lateral roots and the sites for root regeneration are confined primarily to the area around the root-pruning point. Nevertheless, figure 2 suggests that the possible advantages of containerization of English oak do not occur under field conditions until a minimum seedling diameter of 8 mm is attained. The slow growth of smaller plants may be related to the high density of seedlings in the container propagation bed which produced seedlings with spindly stems and small buds. Thus, wider container-bed spacing may be required to produce seedlings with large diameter stems, buds, and subsequent leaf areas that, in turn, will sustain a more efficient root and shoot feedback system (Borchert 1975).

First-year shoots died back primarily between time of planting and the onset of spring growth. Winter dessication of seedlings caused by limited root absorption is implicated as the primary cause of winter dieback of bare-root seedlings. In contrast, the relatively small amount of dieback of container-grown seedlings may have been attributable to the better root—soil contact provided by the container seedlings' intact root "plug". Despite more first-year

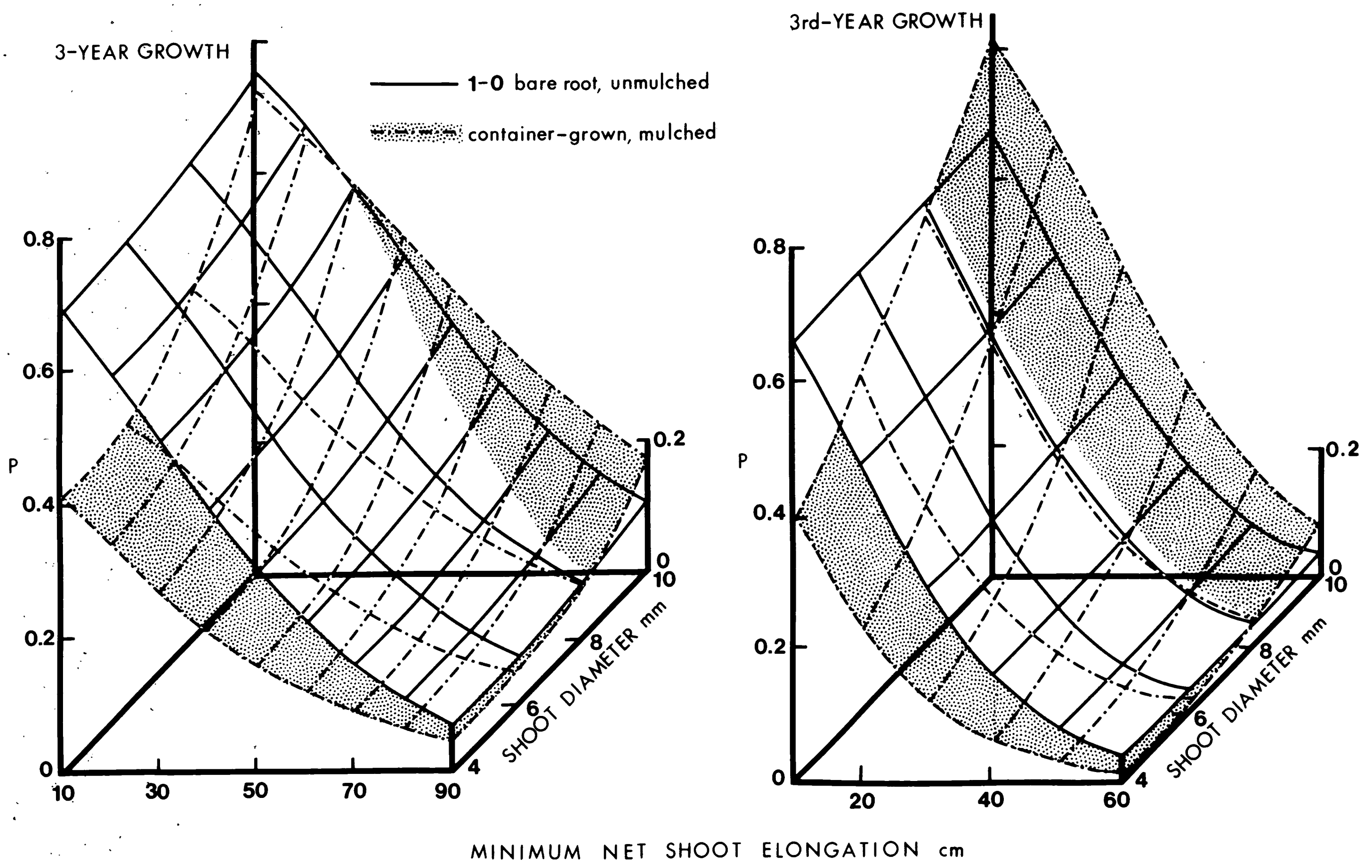

Figure 2.—*Response surfaces for estimated probabilities (P) of attaining at least the amount of net shoot elongation given on the horizontal axis in relation to initial shoot diameter 2 cm above the root collar. (Note that in both graphs, the response surface for container-grown, mulched (stipuled) intersects the other response surface at or above 8 mm shoot diameter. Regression equations and goodness-of-fit statistics are given in table 3.)*

shoot dieback, bare-root seedlings with stems less than 8 mm in diameter nevertheless tended to outgrow container-grown seedlings of equal diameter over the 3-year study period.

The reason for the negative effects from mulching on growth is unclear, but may be related to inadequate soil moisture recharge under the polyethylene mulch by light rainfalls during droughty periods as observed by Bowersox and Ward (1970). This may be particularly injurious to small planted seedlings with little potential for root growth and may explain the reduction in shoot elongation probabilities associated with mulching for trees of small diameter. However, for large seedlings with high root growth potentials, possible benefits from mulching might result from increased light over the mulch (due to a reduction in overhead shading from competitors) despite reduced soil moisture under the mulch. The early soil-warming effects of black polyethylene (Stephens 1965) apparently were nullified on the present study site by shading from competitors and a north aspect.

Average net 3-year shoot elongation of English oaks in the present study was about 2 to 2-½ times that of planted white oak, northern red oak, and black oak (*Quercus velutina* Lam.) measured in previous studies in the same area and under similar competition and site conditions.[2] In one comparison, 3-year minimum net shoot elongation percentages for English oak were approximately equal to 5-year percentages for northern red oak. Moreover, based on the reported growth of English oaks in southern Michigan (Wright *et al.* 1973), growth differences between English oak and native oaks might be expected to widen with tree age. Improvements in seedling production methods and seed source selection plus more intensive weed control might provide further gains. Given this potential, English oak

[2]*Unpublished data on file, North Central Forest Experiment Station, Columbia, Missouri.*

should be further studied and evaluated for planting in the oak-hickory region.

LITERATURE CITED

Borchert, Rolf. 1975. Endogenous shoot growth rhythms and indeterminate shoot growth in oak. Physiologia Plantarum 35:152-157.

Bowersox, T. W., and W. W. Ward. 1970. Black polyethyene mulch— an alternative to mechanical cultivation for establishing hybrid poplars. Tree Planters' Notes 21(1):21-24.

Hamilton, David, A., Jr. 1974. Event probabilities estimated by regression. United States Department of Agriculture, Forest Service, Research Paper INT-152, 18 p. U.S. Department of Agriculture Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah.

Johnson, Paul S. 1979. Growth potential and field performance of planted oak. *In* Regenerating Oaks in Upland Hardwood Forests, J. S. Wright Forestry Conference Proceedings (H. A. Holt and B. C. Fischer, eds.), p. 113-119. Purdue University, West Lafayette, Indiana.

McGee, Charles E. 1976. Differences in budbreak between shade-grown and open-grown oak seedlings. Forest Science 22(4):484-486.

Matthews, R. G. 1971. Container seedling production: a provisional manual. Canadian Forestry Service, Pacific Forest Research Centre Information Report BC-X-58, 57 p. Pacific Forest Research Centre, Victoria, British Columbia.

Russell, T. E. 1971. Seeding and planting upland oaks. *In* Oak Symposium Proceedings, p. 49-54. United States Department of Agriculture, Forest Service, Northeastern Forest Experiment Station, Broomall, Pennsylvania.

Stephens, George R., Jr. 1965. Yellow-poplar seedlings respond to soil temperature. Journal of Forestry 63(9):701-703.

Tinus, Richard W. 1974. Large trees for the Rockies and plains. *In* North American Containerized Forest Tree Seedling Symposium Proceedings (R. W. Tinus, W. I. Stein, and W. E. Balmer, eds.), p. 112-118. Great Plains Agricultural Council Publication 68.

Wright, J. W., W. A. Lemmien, J. N. Bright, and G. W. Parmelee. 1973. English oak— a versatile tree. Natural Resources Research Report 207, 6 p. Michigan State University Agricultural Experiment Station, East Lansing.

Table 3.—*Regression coefficients (B) for probability (P) equations represented by figure 2*[1]

	Model	
	3-year growth[2]	3rd-year growth
B_0	$4.7250 \times 10^{-1**}$	$4.7055 \times 10^{-1**}$
Independent variables[3] (B)		
X_1	$-3.6097 \times 10^{-1**}$	$-7.7735 \times 10^{-2**}$
X_2	$6.3441 \times 10^{-1**}$	$7.3485 \times 10^{-1**}$
X_3		1.4722^{**}
X_4	$1.3532 \times 10^{-2**}$	
X_5	$1.2254 \times 10^{-1*}$	$2.3800 \times 10^{-1**}$
X_6		-1.3799^{**}
X_7	$-8.2990 \times 10^{-3**}$	
X_8	$-4.7780 \times 10^{-3**}$	
Number of observations	3,456	2,304

[1]Equations are of the form: $P = \{1 + \exp[-(B_0 + B_1X_1 + \ldots B_nX_n)]\}^{-1}$ where P is the probability that net shoot elongation of a planted seedling equals or exceeds the amount set by the observed value of X_1.

[2]Significance levels are based on "t" tests (H_0: B = 0) and are: * = 0.05, ** = 0.01; $p<0.01$ for both regression F tests. Goodness-of-fit was also tested by chi-square for differences between observed and predicted numbers of seedlings with net shoot elongation equaling or exceeding the observed value of X_1 among probability intervals of width 0.05; both chi-square values were nonsignificant at the 0.05 level. This test was used because the customary measure of goodness-of-fit, the error mean square, is not appropriate when the dependent variable is dichotomous (Hamilton 1974).

[3] X_1 = the value of net shoot elongation (cm) that must be equaled or exceeded to yield an observed P of 1; smaller values of net shoot elongation yield observed P's of 0. For the 3-year growth model, values of P were observed for X_1 values of 10, 20, 30,...90; for the third-year model, values of 10, 20, 30,...60 were observed. X_2 = the orthogonally coded vector that compares mulched (–1) with unmulched seedlings (+1). X_3 = the cross sectional area of the seedlings stem at time of planting, measured 2 cm above the root collar (cm^2). $X_4 = (X_3)^2$. $X_5 = (X_2) \times$ (the orthogonally coded vector that compares bare-root (+1) with container-grown (–1) seedlings). $X_6 = (X_2) \times (X_3)$. $X_7 = (X_2) \times (X_4)$. $X_8 = (X_1) \times (X_2)$.

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