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Use of Polyethylene-covered Greenhouses to Improve the Growth of *Quercus rubra* Seedlings for Reforestation

by

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Abstract

Seedlings of *Quercus rubra* were cultivated outdoors and in a polyethylene-covered greenhouse. Their development over the first growing season was monitored and compared, taking into consideration factors such as the time of sowing (fall or spring). Height, root-collar diameter, and oven-dry mass of tops and roots were significantly greater in greenhouse-cultivated seelings. However, the differences were reduced when the seedlings were sown later in the spring. Analysis of top-root ratios showed that the balance of seedlings was not affected by greenhouse cultivation. The results of this study and the rapid growth of the seedlings produced in the greenhouse lead us to reconsider our current production standards.

Key words: Grading criteria, greenhouse production, morphological quality, nursery stock, *Quercus rubra*, seedling production.

Résumé

Des plants de *Quercus rubra* ont été cultivés au champ et à l'intérieur d'un tunnel à couverture de polyéthylène. Leur développement, durant leur première saison de croissance, a été suivi de façon comparative en considérant notamment le moment (automne ou printemps) de la réalisation des semis. La hauteur, le diamètre au collet et les masses anhydres des tiges et des racines se sont révélés significativement supérieurs pour les plants cultivés sous tunnel. Les différences sont toutefois atténuées lorsque les semis sont effectués tardivement au printemps. L'analyse des rapports tige/racine a démontré que l'équilibre des plants n'est pas affecté par une culture sous tunnel. Les résultats obtenus et la rapidité de la croissance des plants produits sous tunnel nous conduisent à reconsidérer les normes de production jusqu'ici utilisées.

Mots clés: critère d'évaluation, culture en serre, qualité morphologique, pépinière, *Querum rubra*, production de plants.

Introduction

Generally, hardwood seedlings intended for reforestation in southern Quebec are produced outdoors in nurseries by conventional methods. New greenhouse production techniques were tested with a view to improving the growth and quality of seedlings for reforestation. The polyethylene-covered greenhouse (tunnel), more currently used in horticulture for such applications as early production of fruits and vegetables (Stanley and Toogood 1981), offers a number of significant benefits for growing tree seedlings. It is a low-cost means of maintaining higher temperatures, humidity levels, and CO_2 concentrations while protecting seedlings from winds or heavy rains (Tinus and McDonald 1979).

In this study, our goal was to determine the extent to which greenhouse cultivation could be beneficial to *Quercus rubra* seedlings by comparing their growth and productivity with those grown in the nursery field.

Methods

Growing conditions

The study was conducted in the nursery of the Montreal Botanical Garden, located at Terrebonne, some 25 km north of Montreal (45°41′ N, 74°40′ W). The site is on former agricultural land and has been used as a nursery since 1966.

The seedlings, in the greenhouse or outdoors, were grown in the same soil which was a well-drained sandy clay loam with a pH of 6.7. Details on the chemical characteristics of the soil are given in Table I.

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Table 1. Characteristics of the soil used to grow seedlings outdoors and in the greenhouse.

pH (in water)	:	6,7
Organic matter (%)	:	3,8
Available nutrients elements (ppm)		
Phosphorus	:	266
Potassium	:	162
Calcium	:	2 113
Magnesium	:	122

Table 2. Experimental design and breakdown of experimental blocks.

	Greenhouse	Field
Sown in fall (November 16, 1984)	Group 1 (6 blocks)	Group 2 (6 blocks)
Sown in spring (May 20, 1985)	Group 3 (6 blocks)	Group 4 (6 blocks)

Throughout the summer, all seedlings were grown under natural light conditions where photoperiod was 16 ± 2 h. Inside of the greenhouse no artificial light or heating was used and it was ventilated by opening large shutters on both sides. The polyethylene cover (CIL 440, 40-mil) was laid over the greenhouse structure at the beginning of May, soon after germination of seedlings, and removed in early August. Normal irrigation was provided to prevent water stress, and weeding was done by hand. No fertilizer was applied over the summer.

Experimental Design

Seeding was carried out in the fall of 1984 and the spring of 1985. A total of 24 blocks were sown, as indicated in Table 2. After germination, each block contained 50 to 60 seedlings (40 seedlings per square meter).

Growth Monitoring

Height and root-collar diameter of 30 seedlings (5 per block) were randomly measured at regular intervals and for each experimental group.

At the end of the summer, additional oven-dry mass measurements were made. For each group, 30 specimens were randomly chosen and carefully lifted and cleaned. Roots and tops (shoots with leaves) were separated and oven-dried at 100°C for 24 hours before weighing.

Statistical Analysis

Variance analysis was conducted to compare the height and root-collar diameter data. At the end of the season, multiple comparison tests (Student-Newman-Keuls) (Scherrer 1984) were used to compare the oven-dry masses of the roots and tops of the harvested specimens. The final growth measurements (height and root-collar diameter) were also treated in this manner.

Results

Growth Comparison

Although the growth patterns of seedlings in the four treatments were comparable, fall-sown greenhouse seedlings were the best performers. They produced three, sometimes four flushes during the summer, when seedlings of the other treatments yielded only two or rarely three flushes. The height (H) and root-collar diameter (D) measurements taken throughout the summer from the four experimental groups are presented in Figures 1 and 2 and Tables 3 and 4. In general, the values of H and D for greenhouse-cultivated seedlings were significantly greater than those produced in the field. However, near the end of the growing season, the measured deviations between seedlings of groups 3 and 4 (sown in the spring) were not significant (P = 0.05) and the values of H and D were comparable (Figure 2 and Table 4).

The results of the multiple comparison tests conducted for the means of the four variables considered (height, root-

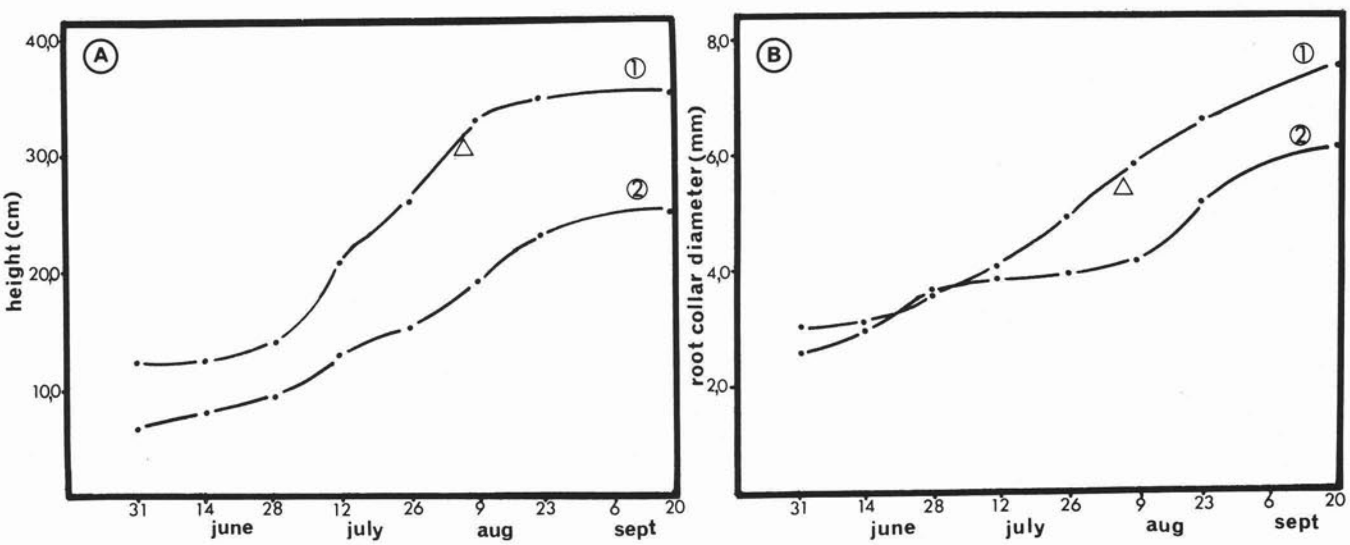

Figure 1. Comparison of growth of *Quercus rubra* seedlings sown in the fall of 1984 and cultivated for one season in greenhouse (group 1) and field (group 2). A. Height growth. B. Root-collar diameter growth.
Small triangle indicates time at which polyethylene cover was removed.

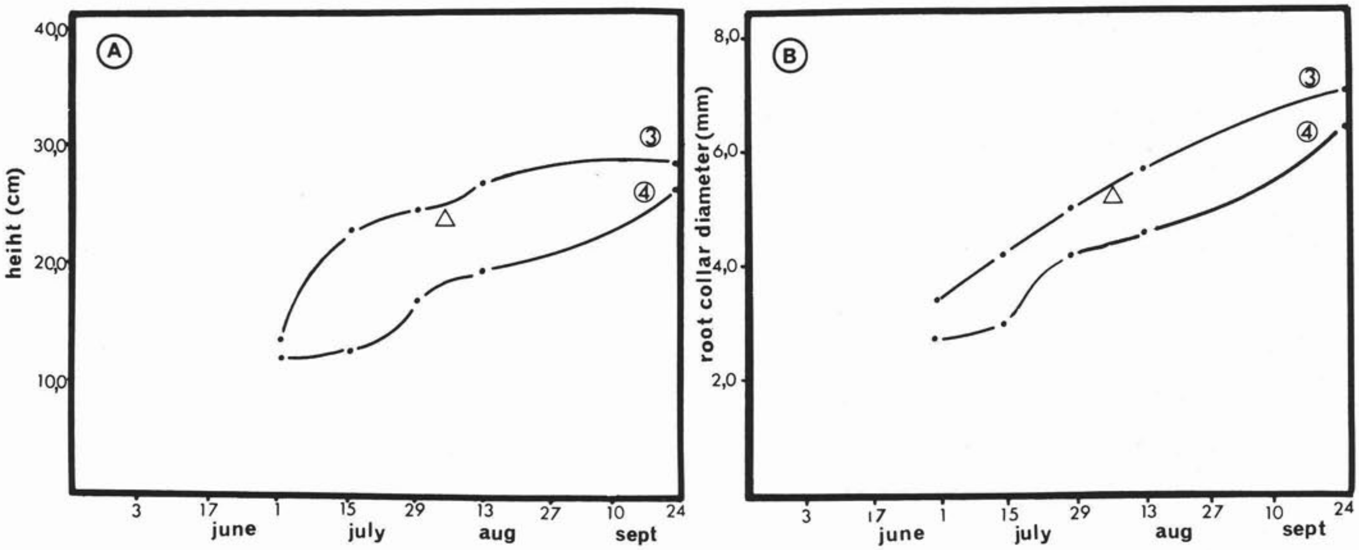

Figure 2. Comparison of growth of *Quercus rubra* seedlings sown in the spring of 1985 and cultivated for one season in greenhouse (group 3) and field (group 4). A. height growth. B. Root-collar diameter growth.
Small triangle indicates time at which polyethylene cover was removed.

collar diameter, tops oven-dry mass, and roots oven-dry mass) are presented in Table 5. The measured values for the fall-sown greenhouse seedlings were in general significantly greater than those for the other groups. By contrast, spring-sown greenhouse seedlings (group 3) produced lower values which were comparable to those of the field-cultivated seedlings (Figures 1 and 2, Tables 3 and 4). Sowing late in the spring (around May 20) thus had a major impact on seedling growth and was particularly unfavourable for greenhouse-cultivated seedlings (Table 4).

Table 5 shows the end of season top-root (T/R) ratios. The lowest ratio was obtained for the seedlings in group 1. However, no significant differences were found between the results for the groups, indicating that the balance between tops and roots was not affected by the use of one or the other production method.

Discussion

The results presented in Tables 3 and 4 and Figures 1 and 2 show that the growth of *Quercus rubra* seedlings was significantly improved under greenhouse growing conditions. The height, root-collar diameter, and oven-dry masses of roots and tops for greenhouse-cultivated seedlings (groups 1 and 3) were greater than for field-cultivated seedlings (groups 2 and 4). The differences would have been greater if the polyethylene cover had been left in place for a longer period. After removing it in early August (August 7), to promote cold hardening of the seedlings, we noted that the growth of seedlings in groups 1 and 3 (greenhouse-cultivated) dropped off fairly sharply while that of the field-cultivated seedlings (particularly in group 2) continued for a few weeks longer (Figure 1).

The greenhouse-cultivated seedlings reacted well to the end of the season by terminating shoot growth and showed signs of hardening by mid-August. Subsequent observations in early September revealed that most of the seedlings in groups 1 and 3 had formed a terminal bud, while this was less prevalent among field-cultivated seedlings. Moreover, Figures 1 and 2 show that root-collar diameter increased substantially during September for the greenhouse-cultivated seedlings but had almost ceased in groups 2 and 4.

The T/R ratios in Table 5 indicated that while stem height development of greenhouse-cultivated seedlings was enhanced, morphological balance was not affected. The polyethylene cover increased seedling height growth without detracting from quality or balance.

The growth curves also show that the positive effect of the greenhouse was present throughout the summer. Comparison of the two curves in Figures 1 and 2, for example,

Table 3. Comparison of height and root-collar diameter growth in greenhouse-cultivated and field-cultivated *Quercus rubra* seedlings sown in the fall.

Date	May 31	June 14	June 29	July 12	July 25	Aug 9	Aug 23	Sept 22
Height (cm)								
— Greenhouse (group 1)	12.37	12.70	14.05	20.97	26.18	33.22	34.84	35.72
— Field (group 2)	6.77	8.00	8.99	12.97	13.67	19.24	23.54	24.83
Root collar diameter (cm)								
— Greenhouse (group 1)	0.32	0.34	0.33*	0.41	0.48	0.59	0.66	0.74
— field (group 2)	0.26	0.29	0.35*	0.37	0.37	0.42	0.53	0.62

*These values are not significantly different at P = 0.05.

Table 4. Comparison of height and root-collar-diameter growth in greenhouse cultivated and field-cultivated *Quercus rubra* seedlings sown in the spring.

Date	July 2	July 15	July 29	Aug 13	Sept 25
Height (cm)					
— Greenhouse (group 3)	12.86	23.05	24.86	27.55	29.03*
— Field (group 4)	10.99	11.24	16.85	19.13	27.32*
Root-collar diameter (cm)					
— Greenhouse (group 3)	0.34	0.41	0.50	0.56	0.70
— Field (group 4)	0.26	0.30	0.41	0.44	0.63

*These values are not significantly different at P = 0.05.

Table 5. Comparison of measured height (H), root-collar diameter (D), tops oven-dry mass (TODM), and roots oven-dry mass (RODM) for *Quercus rubra* seedlings harvested at season end (groups 1 to 4).

	H (cm)	D (cm)	TODM (g)	RODM (g)	T/R
Sown in fall					
— Greenhouse	35.72 a	0.74 a	10.35 a	6.07 a	1.76 a
— Field	24.83 b	0.62 b	6.04 b	3.14 b	1.97 a
Sown in spring					
— Greenhouse	29.03 b	0.70 a	6.46 b	3.34 b	2.15 a
— Field	27.32 b	0.63 b	5.15 c	2.56 c	2.02 a

*Values in a single column that are followed by the same letter are not significantly different at P = 0.05.

Table 6. Comparison of production standards suggested by Von Althen (1969) and Stroempl (1985) for *Quercus rubra* with values obtainable using greenhouse cultivation.

	From Von Althen (1969) for (2 + 0) seedlings	From Stroempl (1985) for (2 + 0) seedlings (suggested minimum values)	Based on potential of greenhouse cultivation in a single season
Height (cm)	15,0 - 20,0	30,0 - 45,0	30,0 - 45,0
Root-collar diameter (cm)	0,5 - 0,6	0,45 - 0,65	0,7 - 0,8

shows that the distance separating the curves increases constantly over the growing season until early August when the covering was removed.

The rapidity with which seedlings can be produced and the size they can attain under this cultivation method lead us to reconsider the production standards suggested by Von Althen (1969) for southern Ontario and currently used in Quebec. Stroempl (1985) recently recommended the use of larger *Quercus rubra* (2 + 0) seedlings, and greenhouse cultivation offers the potential to produce in a single season seedlings of a size comparable to that suggested by Stroempl (1985) (Table 6). It should be remembered that age is a much less determinant criterion for assessing seedling quality than morphological characteristics (Chavasse 1977). Thus, ultization of good quality one-year-old (1 + 0) seedlings should not affect the success of plantations. Moreover, it is recognized that the largest seedlings are generally those that tend to develop best after planting (Chavasse 1980; Von Althen 1983).

Conclusion

Use of a polyethylene greenhouse has proved very effective in promoting the growth of red oak seedlings. In this way, it is possible to produce in a single season, seedlings that might normally take two or three years to reach a desirable size. The quality and balance of the seedlings produced by this method appear to be superior to those of field-cultivated seedlings. In view of the additional benefit of lower production costs (Tinus and McDonald 1979) associated with this technique, the polyethylene-covered greenhouse appears to be a highly effective tool in the production of seedlings for reforestation.

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