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# Effects of Age and Size of Sugar Maple Planting Stock on Early Survival and Growth

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*Age and size had little effect on the survival and height growth of bare-root seedlings and transplants. Survival and growth of containerized seedlings were significantly lower than those of bare-root stock.*

Sugar maple (*Acer saccharum* Marsh.) is planted only sparingly because most attempts to establish plantations have been unsuccessful (*1, 2, 6, 8*). However, recent experiments have shown that sugar maple can be planted successfully as long as the physiological requirements of the species are met (*3, 4, 5, 9*). To determine the effects of age and size of planting stock on survival and height growth during the first critical years after planting, sugar maple seedlings and transplants were planted in 1976, 1977, and 1978. This paper reports the 6-, 5-, and 4-year results of these studies.

### Methods

All plantings were made on abandoned agricultural land in southwestern Ontario. The fields were plowed and disked in the summer prior to spring planting. All seedlings and transplants were raised in the Ontario Ministry of Natural Resources tree nursery at St. Williams, Ontario. Each experiment was laid out in a randomized block design with 16 seedlings or transplants per treatment. Each treatment was replicated 10 times for a total planting of 160 seedlings or transplants per age and size class. Spacing was 3 meters between rows and 1.5 meters within rows. During the first 3 years after planting, weed control was maintained by rototilling between the rows and spraying the unwanted vegetation within the rows with 2.1 kilograms per hectare of active glyphosate in 400 liters of water. In the fourth and fifth years, 4.5 kilograms per hectare of active simazine were broadcast over the total plantation area. Survival and height were recorded at the end of each growing season. Survival data were subjected to chi-square tests and height data to analyses of variance and Tukey's tests.

***Study 1.*** In April 1976, 2 +0, 3 +0, and 4 +0 seedlings and 2 + 1 and 2 +3 transplants were planted in a well-drained gravelly loam. All seedlings and the 2+1 transplants were machine planted, whereas the 2 + 3 transplants were planted in auger holes 30 centimeters in diameter.

***Study 2.*** In the autumn of 1976, 2+0, 3+0, and 4+0 seedlings and 2 + 1 and 2 + 2 transplants were lifted from nurserybeds, graded into size classes by root collar diameters, and coldstored over winter in polyethylene-lined Kraft bags at 1.0° C. Seedlings in paperpots (size 408) were grown for 12 weeks in a greenhouse and 4 weeks under shade frames and then overwintered in cold storage at 1° C. In April 1977, all seedlings and transplants were machine planted in a loam soil, while the containerized seedlings were planted by hand.

***Study 3.*** In the autumn of 1972, 2+0 and 3+0 seedlings and 2+2 transplants were lifted from nurserybeds, graded into size classes, and coldstored over winter at 1.0° C. Seedlings in paperpots were grown and overwintered by the same method outlined in study 2. In April 1978, all seedlings and transplants were machine planted, while the containerized seedlings were planted by hand. All trees in this study were planted in the same field as the trees in study 2.

### Results

Average survival of nursery-grown stock was 84 percent or better in all three studies (tables 1 through 3). Survival of containerized seedlings was significantly lower than that of the nursery-grown stock (tables 2 and 3).

In study 1, 6-year height growth of 2+3 transplants was significantly higher than that of 2 + 1 transplants and all seedlings (table 1).

In study 2, 5-year height growth of the large 3+0 seedlings was significantly higher than that of containerized, 2+0 , and all 4+0 seedlings (table 2).

In study 3, 4-year height growth of the 2+2 transplants was significantly higher than that of containerized and 2+0 seedlings (table 3).

Within age classes, trees with large shoot collar diameters always

**Table 1.**—*Sugar maple planting stock size at time of planting and survival, height growth, and total height 6 years after planting (study 1)*

| Stock age | Root collar diameter | Stem length | Oven-dry stem weight | Oven-dry root weight | Shoot: root ratio | Survival[1] | Height growth[1] | Total height |
|---|---|---|---|---|---|---|---|---|
| | *Mm* | *Cm* | *G* | *G* | | *%* | *Cm* | *Cm* |
| 2+0 | 5.6 | 44 | 3.4 | 3.9 | 0.87 | 95a | 278x | 322 |
| 3+0 | 8.4 | 60 | 9.7 | 10.3 | .94 | 95a | 284x | 344 |
| 4+0 | 9.7 | 64 | 13.7 | 18.3 | .75 | 97a | 295x | 359 |
| 2+1 | 6.2 | 42 | 4.4 | 7.6 | .58 | 96a | 291x | 333 |
| 2+3 | 19.5 | 109 | 108.0 | 97.0 | 1.11 | 96a | 352w | 461 |

[1]Common letters denote treatments without significant differences (P=0.05) in survival and height growth.

**Table 2.**—*Sugar maple planting stock size at time of planting and survival, height growth, and total height 5 years after planting (study 2)*

| Stock age | Root collar diameter | Stem length | Oven-dry stem weight | Oven-dry root weight | Shoot:root ratio | Survival[1] | Height growth[1] | Total height |
|---|---|---|---|---|---|---|---|---|
| | *Mm* | *Cm* | *G* | *G* | | *%* | *Cm* | *Cm* |
| Paperpots | _2 | 10 | — | — | — | 67c | 135yz | 145 |
| 2+0 | 4.5 | 28 | 2.3 | 5.1 | 0.45 | 97a | 149xyz | 177 |
| 3+0 small | 5.4 | 31 | 3.5 | 7.8 | .45 | 92ab | 169wx | 200 |
| 3+0 large | 10.3 | 63 | 18.7 | 27.1 | .69 | 87b | 182w | 245 |
| 4+0 small | 7.8 | 85 | 12.9 | 11.0 | 1.17 | 94a | 129z | 214 |
| 4+0 medium | 11.2 | 102 | 27.6 | 19.2 | 1.44 | 94a | 147xyz | 249 |
| 4+0 large | 12.7 | 103 | 35.6 | 30.3 | 1.18 | 96a | 151xyz | 254 |
| 2+1 small | 5.7 | 36 | 4.3 | 9.6 | .44 | 90ab | 165wx | 201 |
| 2+1 large | 8.8 | 48 | 11.4 | 22.0 | .52 | 84b | 173wx | 221 |
| 2+2 small | 8.0 | 55 | 11.3 | 23.9 | .47 | 90ab | 160wxy | 215 |
| 2+2 large | 11.0 | 71 | 21.3 | 35.5 | .60 | 92ab | 174wx | 245 |

[1]Common letters denote treatments without significant differences (P = 0.05) in survival and height growth.
[2]– = not applicable or not available.

**Table 3.**—*Sugar maple planting stock size at time of planting and survival, height growth, and total height 4 years after planting (study 3)*

| Stock age | Root collar diameter | Stem length | Oven-dry stem weight | Oven-dry root weight | Shoot:root ratio | Survival[1] | Height growth[1] | Total height |
|---|---|---|---|---|---|---|---|---|
| | *Mm* | *Cm* | *G* | *G* | | *%* | *Cm* | *Cm* |
| Paperpots | — | 10 | — | — | — | 12b | 36z | 46 |
| 2+0 small | 4.9 | 36 | 1.9 | 2.3 | 0.83 | 91a | 89y | 125 |
| 2+0 large | 8.2 | 52 | 6.5 | 8.1 | .80 | 94a | 119y | 171 |
| 3+0 | 6.5 | 39 | 3.4 | 5.9 | .58 | 97a | 120xy | 159 |
| 2+2 small | 14.0 | 85 | 30.3 | 35.6 | .85 | 96a | 138x | 223 |
| 2+2 large | 20.6 | 121 | 89.4 | 83.4 | 1.07 | 99a | 149x | 270 |

[1] Common letters denote treatments without significant differences (P = 0.05) in survival and height growth.
[2]– = not applicable or not available.

grew taller than trees with smaller diameters. However, none of these differences were statistically significant (tables 2 and 3).

## Discussion and Conclusions

Survival of all nursery-grown planting stock ranged from 84 to 99 percent, with neither age nor size having much effect. The significantly lower survival of the containerized seedlings was probably the combined result of the fact that the seedlings were small, that they were grown in unsuitable containers, and that improper production methods were used. Improved growing methods may overcome the problem (7); but until seedling quality has been improved, it is recommended that only bare-root seedlings or transplants be planted.

With few exceptions, little difference was found in height growth between seedlings and transplants. In study 1, the superior growth of the 2+3 transplants was probably greatly influenced by their being planted in auger holes. This allowed the planting of large root balls, while machine planting required severe root pruning to shape the roots to fit into the relatively narrow planting slit. In study 2, the significantly poorer growth of the small 4+0 seedlings was no doubt the result of the weakest 4+0 seedlings being represented in this size class. In study 3, the 2+2 transplants grew significantly better than the 2+0 seedlings, probably because they had much larger root collar diameters.

Within age classes, root collar diameter was a reliable indicator of relative growth potential. Trees with large root collar diameters always grew taller than trees with smaller root collar diameters. However, these differences were not statistically significant and this trend held true only for trees belonging to the same age class. For example, the large 3+0 seedlings planted in study 2 had an average root collar diameter of 10.3 millimeters and grew 182 centimeters in 5 years, while the large 4+0 seedlings with a root collar diameter of 12.7 millimeters grew 151 centimeters (table 2).

Other studies have shown that intensive weed control was one of the prerequisites of successful sugar maple establishment (*3, 5, 9*). Therefore, the excellent weed control maintained in these experiments no doubt contributed greatly to the good survival and growth of the nursery-grown stock.

The small number of sugar maple seedlings and transplants produced in the provincial nurseries makes it impossible to establish reliable production costs for the different age classes of stock. However, the average cost of production of 2+0 hardwood seedlings in the St. Williams nursery is $85 per thousand.[1] The additional seedbed costs to produce 3- and 4-year-old seedlings are rather minor, but lifting and shipping costs increase with seedling size. The production costs for transplants are estimated to be several times higher than those for seedlings because of transplanting, lifting, root pruning, and shipping of the larger trees with bulkier root systems. The cost of machine planting is very similar for all ages of stock, but spade and especially auger planting are much more expensive.

For the establishment of most plantations, machine planting of sturdy 2 or 3-year-old seedlings is recommended. For special plantations in which total height is of major importance, the planting of large transplants in auger holes may justify the higher establishment costs.

[1]Laupert, R. E. Superintendent, St. Williams Nursery, Ontario Ministry of Natural Resources. Personal communication.

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