EFFECTS OF ROOT REGENERATION AND TIME OF PLANTING ON SUGAR MAPLE PLANTATION ESTABLISHMENT

F. W. von Althen and D. P. Webb
Research Scientists
Department of the Environment
Canadian Forestry Service
Great Lakes Forest Research Centre
Sault Ste. Marie, Ontario
Canada

ABSTRACT

Height growth of nursery-lifted and cold-stored sugar maple (*Acer saccharum* Marsh.) seedlings (2+0 and 3+0) planted in an open field in southern Ontario at two-week intervals between April and June were closely correlated to root regeneration capacity at time of planting. Cold-stored seedlings had high root regeneration capacity, high survival and good height growth on all planting dates. Nursery-lifted seedlings had high root regeneration capacity, high survival, and good height growth only for seedlings planted before the middle of May.

BACKGROUND

During the last decade interest in hardwood planting has increased greatly in Ontario. The main reasons are a greater appreciation of environmental and aesthetic values, a scarcity of high quality hardwood trees for lumber and veneer, and the loss of most elm trees (*Ulmus americana* L.) to Dutch elm disease. While silvicultural treatments have been developed for the successful establishment of several hardwood tree species in open field plantations (von Althen 1977a), attempts to establish sugar maple (*Acer saccharum* Marsh.) on these sites have generally been unsuccessful.

When planted in open fields, sugar maple often enters a state of reduced growth or 'check'. This growth stagnation is most severe on sites where seedlings have to compete with herbaceous vegetation. For example, Yawney and Carl (1970) found that the growth of sugar maple seedlings improved in relation to the degrees of weed control achieved by cultural treatments. The best growth was obtained in plots where the soil had been covered with black plastic film: this not only eliminated the competing vegetation during the first year after planting but also greatly retarded evaporation, thereby increasing the available soil moisture. Webb (1974) observed significant differences in micro-climate between areas with competing vegetation and areas where the vegetation had been removed manually. The decreased absorption of solar radiation, decreased maximum temperatures and absence of transpiring vegetation resulted in a significant increase in soil moisture in the non-competitive areas. In this study, soil moisture appeared to be the limiting factor of greatest importance to seedling survival. Von Althen (1977b) found that the growth of planted sugar maple seedlings improved significantly with the degree of weed control achieved by cultural treatments, while organic soil amendments and fertilizers, applied at time of planting, failed to improve seedling survival or growth significantly.

ROOT REGENERATION

While site preparation and weed control are essential for the successful establishment of sugar maple seedlings in open field plantations, these treatments alone do not always guarantee the establishment success of a plantation.

Recently attention has been drawn to the importance of the physiological state of seedlings at time of planting (Farmer 1975, Lavender and Hermann 1976, Webb 1976a). One measure of the physiological condition of a seedling is its root regeneration capacity, which measures the ability of a seedling to initiate and elongate new roots (Stone and Schubert 1959, Lee et al. 1974). With the aim of improving the establishment success of sugar maple plantations, Webb (1977) compared the root regeneration capacity of sugar maple seedlings during chilling to that of the more easily established silver maple (*Acer saccharinum* L.) and white ash (*Fraxinus americana* L.) seedlings. In all three species root regeneration was significantly correlated to the number of hours of chilling and all species showed a marked seasonal periodicity in root regeneration potential. Root regeneration was low from November to January and reached maximum levels for April. The increase in root regeneration beginning in mid-February was concomitant with the loss of physiological bud dormancy. The more easily established white ash and silver maple seedlings produced significantly higher numbers of new roots during April than did the more difficult to establish sugar maple seedlings (table 1). This difference was greatly increased with further chilling into the late spring months. It therefore appears possible that the decreased root regeneration capacity of sugar maple seedlings is responsible for some of the differences in ease of establishment.

TIME OF PLANTING

To determine the effect of time of planting on seedling survival and growth, studies were initiated in 1975 and 1976. In the spring of 1975, sugar maple seedlings (2+0 and 3+0) were lifted from nursery beds at two-week intervals from 16 April to 10 June and planted the same day in a fully cultivated field with a soil of well drained loam. In 1976 sugar maple seedlings (2+0 and 3+0 were either lifted from nursery beds or removed from cold storage where they had been stored over winter in large paper bags at 1.0°C. The seedlings were planted at two-week intervals from 7 April to 2 June in the same field as those planted in 1975. At the time of planting 12 seedlings from each treatment were planted in pots and root regeneration was measured after 30 days' growth in a greenhouse, according to the procedures outlined by Webb (1977).

In the 1975 study, survival of the 2+0 and 3+0 seedlings was near 100% for the first two and three planting dates, respectively (table 2). The poor survival of the seedlings planted on 26 May was the result of drought conditions which prevailed at time of planting. Although first-year survival of the seedlings planted on 10 June was still relatively high, many of the seedlings were weak and died during the second summer.

Table 1. Root regeneration of 2+0 hardwood seedlings.

Species	March	April	May
Acer saccharum	29.7±5.4[a]	69.4± 8.3	53.7± 3.1
Acer saccharinum	94.1±8.3	102.6± 9.9	109.7± 8.3
Fraxinus americana	56.5±3.6	143.7±11.1	149.4±11.2

[a] Mean number of new white roots per seedling ± standard error.

Table 2. Survival and height growth of sugar maple seedlings planted in the spring of 1975.[a]

Time after planting	2+0 Stock Planting date 16 Apr	28 Apr	14 May	26 May	10 June	3+0 Stock Planting date 16 Apr	28 Apr	14 May	26 May	10 June
					Survival (%)					
1st year	96	100	75	8	58	100	100	100	67	98
2nd year	96	100	65	8	48	98	100	100	56	77
3rd year	96	100	62	8	48	98	100	100	56	77
4th year	96	100	62	8	48	98	100	100	56	75
					Height growth (cm)					
1st year	3	3	2	8	8	4	4	3	6	10
2nd year	11	12	7	5	3	14	12	8	5	1
3rd year	26	26	21	20	12	33	27	24	16	10
4th year	50	50	42	47	32	59	50	47	39	26
Total height growth 4 years after planting	90	91	72	80	55	110	93	82	66	47

[a] All seedlings lifted from nursery beds shortly before planting.

In the 1976 planting, survival of cold-stored seedlings was excellent. Approximately 100% survival was recorded on all planting dates (table 3). In contrast, survival of the nursery-lifted stock, though comparable to that of the cold-stored stock on the 7 April and 21 April planting dates, dropped progressively on later planting dates until it reached 11% on 2 June.

Height growth of the nursery-lifted stock of both studies closely followed the trend in seedling survival, with highest growth recorded for seedlings planted in April or early May and lowest growth for seedlings planted in June. In contrast, height growth of the cold-stored stock remained relatively high for all planting dates.

Height growth of both 2+0 and 3+0 seedlings was strongly correlated with the ability of the seedlings to initiate and elongate new roots following planting (table 3, fig. 1). Nursery-lifted seedlings planted after the middle of May grew slowly during the first and second year, most likely as a direct result of poor root growth, which caused an impairment in the uptake of water and nutrients. Although the growth of all seedlings increased in the third year after planting, the cumulative third-year growth (1976 planting) or fourth-year growth (1975 planting) of the nursery-lifted seedlings, planted after the middle of May, was much lower than that of the seedlings planted or cold-stored earlier.

The results of these studies support previous work (Taylor and Dumbroff 1975, Dumbroff and Brown 1976, Webb 1976b, Dumbroff and Webb 1978) and suggest that root regeneration potential is an important factor in the successful establishment of sugar maple plantations in southern Ontario. Planting of seedlings in a physiological state conducive to rapid root growth following outplanting, brought about by either early spring planting or cold storage of autumn-lifted stock, overcame the early growth check common to sugar maple plantings.

SUMMARY

During the last decade silvicultural treatments have been developed for the successful establishment of a wide range of hardwood tree species on open field sites in southern Ontario. However, attempts to establish sugar maple on these sites have been less successful. Previous work in the phenology of root growth of sugar maple indicated that time of lifting and spring planting were important factors in successful establishment. The studies reported here have shown that height growth during the first two years after planting was strongly correlated to root regeneration capacity at time of planting.

Table 3. Survival and height growth of sugar maple seedlings planted in the spring of 1976

	2+0 Stock									
	Lifted from nursery beds shortly before planting					Lifted in November, stored at 1.0°C until planting				
	Planting date					Planting date				
	7 Apr	21 Apr	5 May	19 May	2 June	7 Apr	21 Apr	5 May	19 May	2 June
	Survival (%)									
1st year	97	100	92	97	11	97	100	100	100	100
2nd year	97	100	89	97	8	97	97	100	100	100
3rd year	97	100	89	97	8	94	97	100	100	100
	Height growth (cm)									
1st year	9	7	8	5	0	3	6	4	4	3
2nd year	24	22	22	4	0	21	21	28	23	28
3rd year	33	46	38	27	13	44	55	44	36	48
Cumulative height growth 3 years after planting	66	75	68	36	13	68	82	76	63	79
Root regeneration[a] capacity at time of planting	71	78	66	3	0	116	90	54	41	58

	3+0 Stock									
	Lifted from nursery beds shortly before planting					Lifted in November, stored at 1.0°C until planting				
	Planting date					Planting date				
	7 Apr	21 Apr	5 May	19 May	2 June	7 Apr	21 Apr	5 May	19 May	2 June
	Survival (%)									
1st year	100	100	100	75	11	100	100	100	100	100
2nd year	100	100	94	64	11	100	100	100	97	100
3rd year	100	100	94	64	8	100	100	100	97	100
	Height growth (cm)									
1st year	10	11	9	2	0	10	10	8	7	6
2nd year	39	47	37	14	0	51	49	40	37	42
3rd year	44	46	41	41	4	60	58	57	62	63
Cumulative height growth 3 years after planting	93	104	87	57	4	121	117	105	106	111
Root regeneration[a] capacity at time of planting	82	84	-	29	0	100	97	58	60	55

[a] Mean number of new white roots per seedling.

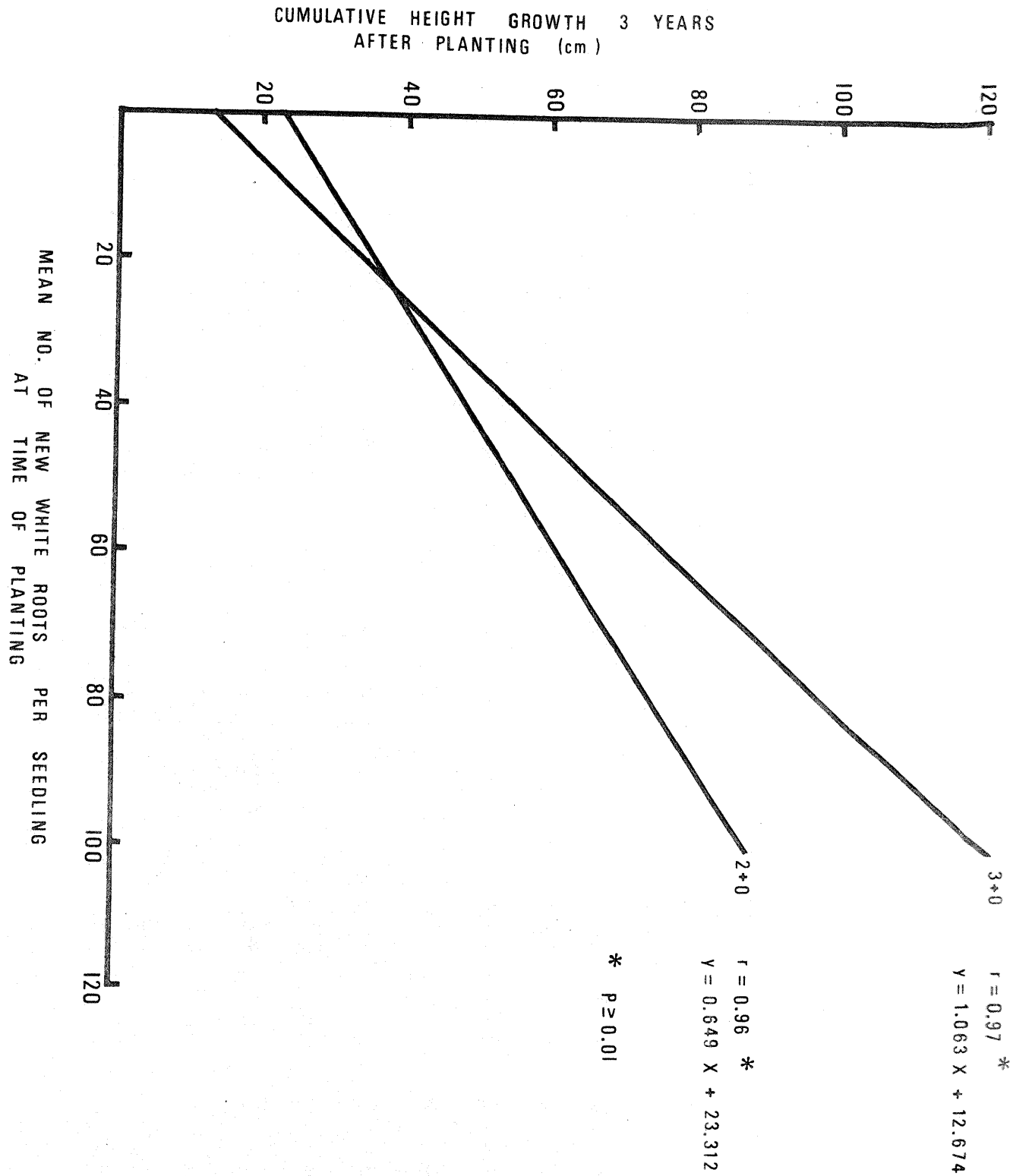

Fig. 1. Linear regression of total height growth of nursery-lifted seedlings 3 years after planting and seedling root regeneration capacity at time of planting.

Cold-stored seedlings showed high root regeneration capacity, approximately 100% survival, and good height growth for all planting dates. Nursery-lifted seedlings showed high root regeneration capacity, approximately 100% survival, and good height growth only for seedlings planted before the middle of May. In later plantings, root regeneration capacity, survival, and height growth declined greatly.

These studies indicate that root regeneration capacity is an important factor in the successful establishment of sugar maple nursery stock in open fields in southern Ontario. Cold storage of autumn-lifted nursery stock is essential for the successful establishment of sugar maple seedlings planted after the middle of May.

REFERENCES

Dumbroff, E. B. and D. C. W. Brown. 1976. CYTOKININ AND INHIBITOR ACTIVITY IN ROOTS AND STEMS OF SUGAR MAPLE SEEDLINGS THROUGH THE DORMANT SEASON. Can. J. Bot. 54: 191-197.

Dumbroff, E. B. and D. P. Webb. 1978. PHYSIOLOGICAL CHARACTERISTICS OF SUGAR MAPLE AND IMPLICATIONS FOR SUCCESSFUL PLANTING. For. Chron. 54: 92-95.

Farmer, R. E., Jr. 1975. DORMANCY AND ROOT REGENERATION OF NORTHERN RED OAK. Can. J. For. Res. 5: 176-185.

Lavender, D. P., and R. K. Hermann. 1976. ROLE OF FOREST TREE PHYSIOLOGY IN PRODUCING PLANTING STOCK AND ESTABLISHING PLANTATIONS. p. 34-45 *in* Proc. XVI IUFRO World Congress, Oslo, Norway.

Lee, C. I., B. C. Moser, and C. E. Hess. 1974. ROOT REGENERATION OF TRANSPLANTED PINE AND SCARLET OAK. New Horizons, Hort. Res. Inst., Washington, D. C. p. 10-13.

Stone, E. C. and G. H. Schubert. 1959. ROOT REGENERATION BY PONDEROSA PINE SEEDLINGS LIFTED AT DIFFERENT TIMES OF THE YEAR. For. Sci. 5: 322-332.

Taylor, J. S. and E. B. Dumbroff. 1975. BUD, ROOT, AND GROWTH REGULATOR ACTIVITY IN *ACER SACCHARUM* DURING THE DORMANT SEASON. Can. J. Bot. 53: 321-331.

Von Althen, F. W. 1977a. HARDWOOD PLANTING IN ONTARIO. For. Chron. 53: 1-6.

Von Althen, F. W. 1977b. PLANTING SUGAR MAPLE: FOURTH-YEAR RESULTS OF AN EXPERIMENT ON TWO SITES WITH EIGHT SOIL AMENDMENTS AND THREE WEED CONTROL TREATMENTS. Can. For. Serv., Sault Ste. Marie, Ont. Report O-X-257. 10 p.

Webb, D. P. 1974. EFFECTS OF COMPETITION ON MICROCLIMATE AND SURVIVAL OF PLANTED SUGAR MAPLE (*ACER SACCHARUM* MARSH.) SEEDLINGS IN SOUTHERN ONTARIO. Can. For. Serv., Sault Ste. Marie, Ont. Report O-X-209. 14 p.

Webb, D. P. 1976a. EFFECTS OF COLD STORAGE DURATION ON BUD DORMANCY AND ROOT REGENERATION OF WHITE ASH (*FRAXINUS AMERICANA* L.) SEEDLINGS. Hort. Sci. 11: 155-157.

Webb, D. P. 1976b. ROOT GROWTH IN *ACER SACCHARUM* MARSH. SEEDLINGS. EFFECTS OF LIGHT INTENSITY AND PHOTO PERIOD ON ROOT ELONGATION RATES. Bot. Gaz. 137: 211-217.

Webb, D. P. 1977. ROOT REGENERATION AND BUD DORMANCY OF SUGAR MAPLE, SILVER MAPLE, AND WHITE ASH SEEDLINGS: EFFECTS OF CHILLING. For. Sci. 23: 474-483.

Yawney, H. W., and C. M. Carl, Jr. 1970. A SUGAR MAPLE PLANTING STUDY IN VERMONT. USDA For. Serv., Northeast. For. Exp. Stn., Res. Pap. NE-175. 14 p.