PERFORMANCE OF TUBED SEEDLINGS IN ONTARIO 1/

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Abstract .--Despite early difficulties and a currently reduced program, container planting is considered a biologically viable regeneration technique for use in Ontario. It is seen as a supplement, not an alternative, to bare-root planting, primarily for extending the planting season into the summer months. Studies of tubed seedling growth and survival have demonstrated the importance of size at planting as a determinant of subsequent performance, and have shown that there is a mid-August limit to the season when containerized seedlings can be successfully planted. The spectrum of sites suitable for containerized planting is narrower than for bare-root stock, and excludes the moist more fertile sites.

INTRODUCTION

Until relatively recently the container planting program in Ontario has been based exclusively upon the 9/16- x 3-inch (1.4- x 7.5-cm) plastic "Ontario" tube. Although I shall confine my remarks specifically to the performance of such tubed seedlings, it should be borne in mind that many of our early difficulties were related not so much to the technique, per se, of growing seedlings in containers, as to the more fundamental questions raised by the production and planting of very young seedlings.

From its inception, the container technique has been regarded as a supplement, rather than an alternative, to planting methods utilizing conventional bare-root nursery stock. Thus, in Ontario, arguments in favor of container planting relate primarily to the opportunities for extending the planting season into the summer months and for equalizing seasonal labor requirements by reducing the peak spring work load.

Any discussion of tubed seedling performance in Ontario must take into account the rapidity with which the container planting program was developed. The results of early experimental-scale plantings had been encouraging, and coincided with the realization that there was a need for a major expansion of the reforestation program. Thus, from a modest planting of 135,000 seedlings in 1965, container planting was suddenly elevated, in 1966 to a fully operational program with a first year production target of 20 million tubed seedlings. To date, some 93 million tubelings -- principally black and white spruce (Picea mariana (Mill.) B.S.P. P. glauca (Moench) Voss) and jack pine (Pinus banksiana Lamb.) -- have been planted.

Obviously, enormous problems were encountered in launching a program of this magnitude at relatively short notice; not surprisingly, both the quality of container planting stock and its field performance were extremely variable. A few growers were able to produce sturdy, healthy stock from the beginning, and this is evident both in a steady improvement in planting stock quality and in the relative success of their seedlings under plantation conditions. However, such instances were rather the exception, and it must be acknowledged that early failures considerably dampened the enthusiasm with which tubed seedlings were first introduced. This has resulted, in recent years, in a reduced program of container planting being increasingly concentrated around the better growers. Today, as a matter of deliberate policy, the program is virtually dormant, giving us the opportunity to re-evaluate past techniques and performance and to plan future directions.

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It would be wrong to infer from the recent history of container planting in Ontario that the program was a failure. Ontario helped to pioneer the technique of planting small, young seedlings grown in low-volume containers and, despite early difficulties, has made substantial progress in translating the concept into a biologically viable regeneration method. Much expertise and knowledge have been accumulated over the past decade, and this provides an invaluable basis for rebuilding the Ontario container planting program.

PLANTATION PERFORMANCE

Despite the large numbers of tubed seedlings planted on an operational basis in Ontario, meaningful performance data are rather meagre. In retrospect, we now know that the seedlings planted in the early years were far too small; not only was mortality very high, but the performance of the survivors is no longer relevant to the results which might be expected from present-day methods. Better production techniques have led to improvements both in the quality and size of planting stock and in its field performance but, unfortunately, few of the later plantations are sufficiently mature that we can make a valid assessment of their establishment success.

A standard of performance has been arbitrarily set requiring that containerized seedlings have at least the same impact, in terms of survival and growth, 3 years after planting as conventional planting stock. This may be an overly optimistic goal, particularly for white spruce, but it does indicate the level of performance we are now looking for. How does it relate to past experience?

For bare-root nursery stock planted in northern Ontario3/ during the period 1966-1971, the only years for which tubed seedling data are currently available, average survival 2 and 5 years after planting amounted to 68% and 60%, respectively (spruce and pine combined). By contrast, tubed seedling survival in the early years of the container program (1966-1968) was generally poor, a situation we now attribute primarily to the very small size o f seedlings at time of planting. Latterly, however we have seen a fairly consistent increase in the second-year survival of tubed seedlings, associated with the use of larger, better-quality seedlings (reflecting improved cultural techniques and a trend to overwintering). By 1971, containerized planting stock was being produced with a survival impact comparable to that of bare-root stock (fig. 1).

3/ For present purposes, defined as comprising those forest districts north of 46°N.

The only growth data presently available from operational plantings of tubed seedlings refer to material planted in 1967; as such, they severely underestimate the performance we might expect from the type of planting stock produced today. They are presented here (table 1) to provide a link with the research results discussed in the next section.

Table 1.--Comparative height growth of bare-root stock and tubed seedlings 5 years after planting: percentage distribution by height classes (average for northern Ontario)

	Height class			
	60in (<152cm)	40-59in (102-150cm)	20-39in (51-99cm)	19in (>48cm)
		White spruce		
Bare-root[1/]	3.2	13.1	51.1	32.5
Tubes	-	2.2	9.9	87.9
		Black spruce		
Bare-root	2.7	21.2	55.7	20.4
Tubes	-	-	19.7	80.3
		Jack pine		
Bare-root	6.0	25.1	53.0	15.9
Tubes	0.8	9.3	50.4	39.5

1/ Averages based on 2 years of planting (1966-1967) for bare-root stock, 1 year (1966) for tubed seedlings

RESEARCH RESULTS

In 1967-1968, stimulated by the disappointing results of the early operational container plantings, the Canadian Forestry Service began a series of studies in central northern Ontario to evaluate the importance of some of the factors influencing tubed seedling survival and establishment. The effects of seedling size and planting date upon subsequent field performance were primary objectives of the initial studies; these have formed the basis of subsequent research aimed at improved cultural high survival and growth potential.

In relation to the results which follow, it should be noted that all seedlings were raised in accordance with the then current prescriptions set down for operational use 4/. The only

4/ Anon. 1967. Provisional instructions for growing and planting seedlings in tubes. Ont. Dep. Lands For., Toronto. Manual for restricted distribution.

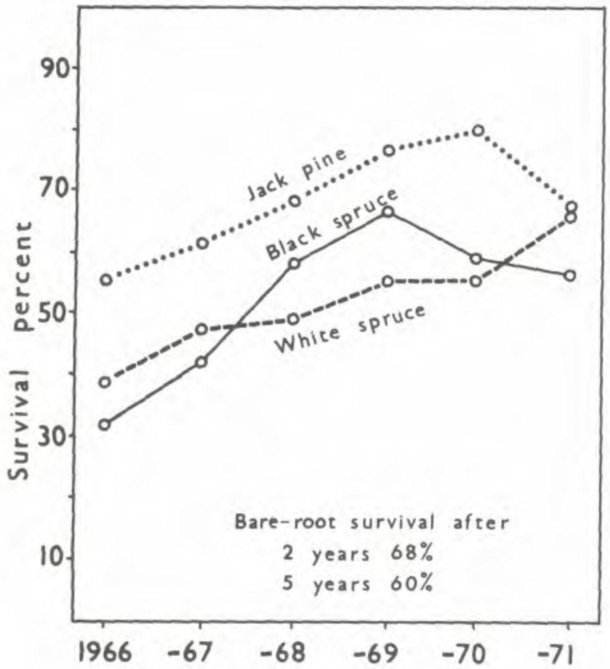

Figure 1.--Average survival of tubed seedlings in northern Ontario for the years 1966 to 1971.

deviation from operational practice was in the age of seedlings used for planting (the average age of seedlings in provincial operations at this time was 42 days).

Planting Stock Size

The relationship between planting stock size, here represented by age at planting5/, and the subsequent survival of tubed seedlings is clearly illustrated by the data for spruce in figure 2. By increasing seedling age at planting from 6 to 12 weeks, an average increase in gross survival amounting to 22% for both species was achieved 4 years after planting. Although the higher survival capacity of older, larger seedlings was already evident by the end of the first growing season, differences in fourth-year survival were not due to any single period of high mortality. Rather, differences between age-classes resulted from a consistently higher rate of mortality in 6-week-old seedlings throughout the 4-year trial period (table 2).

By contrast with the spruces, jack pine survival remained at a high level on all sites, with no significant differences in gross survival between the 2 age-classes at the end of 4 growing seasons.

Table 2.--Course of seedling mortality over 4 growing seasons (seedling age averaged over planting date for Site 2)

Age-class	Period1/ 1	2	3	4	5	6	Cumulative mortality
	(%)						(%)
			White spruce				
6 weeks	5.0	9.4	10.0	6.8	7.4	3.4	37.0
8 weeks	1.0	2.0	8.4	3.0	6.8	2.2	22.4
10 weeks	0.4	0.8	6.0	2.0	3.8	2.0	14.6
12 weeks	0.6	0.8	5.0	2.2	5.4	3.2	16.6
			Black spruce				
6 weeks	4.8	10.6	11.6	4.2	5.2	2.4	33.0
8 weeks	2.0	2.6	7.8	1.8	3.4	1.0	16.6
10 weeks	0.6	1.0	7.0	1.4	2.8	1.2	14.4
12 weeks	0.6	1.0	4.8	3.0	1.8	1.6	12.2

1/ 1 - One month after planting
2 - Fall of first growing season (cumulative)
3 - First winter (fall to spring)
4 - Second growing season (spring to fall)
5 - Third growing season (spring to fall)
6 - Fourth growing season (spring to fall)

Although gross survival is the most commonly used parameter of initial plantation performance, it is a poor standard by which to judge success or failure. By ignoring differences in seedling condition, assessments based on gross survival may lead to an unrealistically optimistic view of seedling performance. Thus, if we segregate surviving seedlings into 4 simple condition classes6/ a totally different picture

5/ Heights at planting of seedling age-classes used in age/planting date study (mean for all planting dates):

	White spruce	Black spruce	Jack pine
	(mm)	(mm)	(mm)
6 weeks	27	24	56
8 weeks	36	34	62
10 weeks	43	46	69
12 weeks	48	57	74

6/ Condition ratings:
1+2 - Healthy seedlings of at least moderate vigor; only minor abnormalities.
3 - Seedlings lacking in vigor, or with abnormalities in color or form.
4 - Very poor or moribund seedlings.

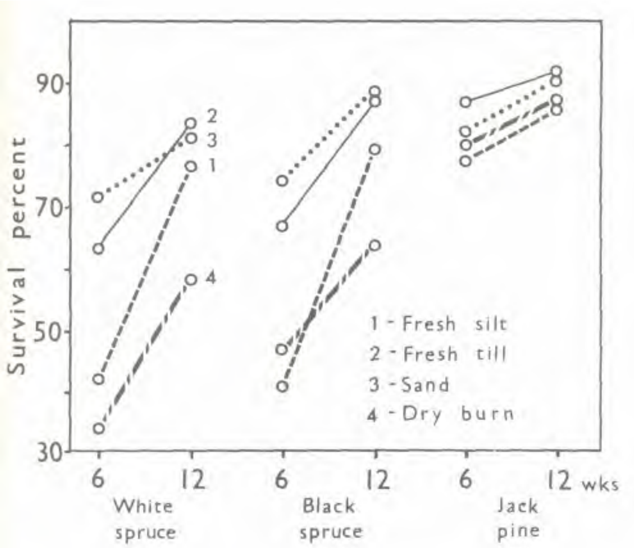

Figure 2.--Survival, 4 years after planting, of 6- and 12-week-old tubed seedlings planted on 4 sites (averaged over seedling age).

of seedling performance may emerge. This is illustrated in figure 3, taking the data from Site 2 (see fig. 2) as a typical example.

The most striking feature is the large discrepancy between gross survival and the number of seedlings falling into the class 1 and 2 categories -- those seedlings which we considered capable of producing an established plant of reasonable size and quality within 5 years of planting. Although this gives a rather pessimistic view of seedling performance, a more distinct correlation with age at planting emerges for all species. This is most apparent for jack pine, where consideration of class 1 and 2 seedlings serves to demonstrate a relationship between seedling age and subsequent performance not indicated by gross survival figures. In general, therefore, we see that the use of older, larger seedlings resulted not only in a higher level of survival, but also in an average quality of surviving seedlings significantly superior to that of b- and 8-week-old planting stock. The lower proportion of poor quality, class 4 seedlings in the older age-classes is consistent with this view.

Plantation success depends not only on a high survival rate but, also, on a reasonable growth rate coupled with unchecked and vigorous growth following outplanting. This is particularly true for containerized seedlings, which have generally been much smaller at planting than bare-root nursery stock. From a practical viewpoint, height growth is usually of greatest concern since any deficiencies in this respect prolong exposure to destructive agents, particularly the risk of suppression by weed competition.

The relationship between seedling age at planting and height growth after 4 growing seasons (fig. 4) clearly demonstrates the importance of planting stock size as one determinant of growth performance during the establishment phase of a young plantation. The parallel with the pattern of survival, particularly class 1 and 2 survival, in relation to age at planting is evident from a comparison with figure 3, and emphasises the general inferiority of 6- and 8-week-old seedlings compared with older planting stock. Although the 3 species performed somewhat differently under other site conditions, the relative response to age/size at planting was in all cases similar. On sites suited to jack pine, 10- and 12-week-old seedlings appeared to provide a satisfactory standard of planting stock in terms of their subsequent performance. However, in the spruces, despite the superior growth and survival of 12-week-old seedlings, it was evident that an older, larger seedling was desirable for planting most spruce sites. This was especially true of white spruce which, even in the 2 oldest (10- and 12-week) age classes, demonstrated significantly poorer quality and growth performance than black spruce.

Planting Season

An extended planting season is often cited as one of the major benefits to be gained from container planting. The capacity for extending planting into the summer months is undoubtedly of prime interest in many situations, yet there is a need to define the seasonal limits within which the technique can be used effectively. From the data presented here it is clear that a late-summer limit to container planting is advisable in Ontario; containerized seedlings, while they may facilitate summer planting on many sites, do not provide a vehicle for successful planting throughout the frost-free period.

Although the data relating planting date to gross survival after 4 growing seasons present a rather inconsistent picture, nevertheless all species showed a general decline in survival for the last 2 planting dates (fig. 5). However, the strongest evidence weighing against late-season planting comes from a consideration of seedling quality (fig. 3) and height growth (fig. 4) data. Clearly, the September planting was very largely a failure for all species; despite relatively good survival, the average quality of surviving seedlings was very poor, paralleling the marked decline in their growth performance when compared with earlier

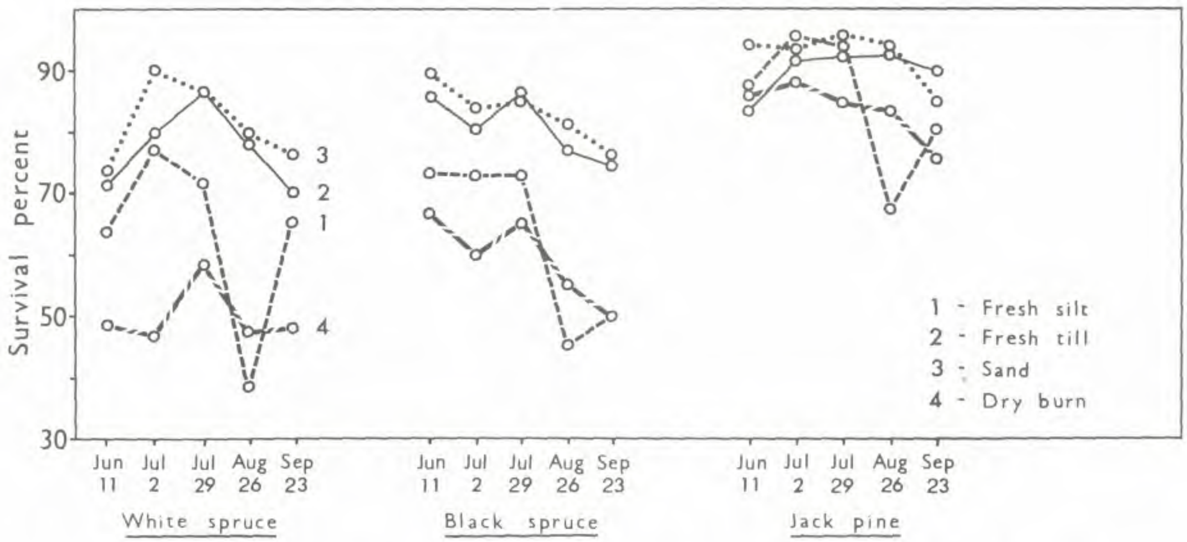

Figure 3.--Tubed seedling survival and condition after 4 growing seasons: A - Effect of planting date (average for all age-classes): B - Effect of seedling age at planting (average for all planting dates). (Data for Site 2).

plantings. Seedlings planted in late-August showed some improvement in quality and height growth, but they were still significantly inferior to summer planted seedlings.

The fact that the adverse effects of late planting persisted right up to the end of the fourth growing season precludes, from a practical viewpoint, any serious consideration of the possibility that seedlings might eventually recover from the setback. With the possible exception of jack pine, it is obvious that, on most sites in northern Ontario, these slow-growing seedlings would soon be overtaken by weed competition. Furthermore, no evidence was found to indicate that the use of older, larger seedlings might compensate for late planting. The 4 age-classes showed a similar decline in performance as a result of late planting, irrespective of site conditions.

On the basis of the evidence summarized above, a mid-August cutoff date is recommended for container planting in northern Ontario. In most areas this allows a planting season of about 12 weeks duration, depending on how early site conditions permit a start to spring planting. Within this period, seedling performance is likely to be determined by planting stock quality and local site conditions, rather than by planting date per se. Spring planting may favor more rapid initial establishment, but it also exposes seedlings to destructive influences for a longer period during the critical first year. This is illustrated by the poorer survival and quality of spring-planted seedlings in the example selected (fig. 3 and 5). However, with the trend t2 overwintering for late-produced seedlings, early spring planting is obviously essential to take advantage of the spring root surge.

Seedling Mortality

An analysis of the apparent reasons for seedling mortality revealed no evidence of any predominating factors to which containerized seedlings are especially susceptible. This is in line with findings from operational container plantings which indicate that the many factors contributing to seedling mortality change in relative importance from site to site and from season to season.

On all sites tested the period of heaviest mortality was the first winter after planting. Thus, on Site 2, first winter losses of all species accounted for 40% of the total mortality recorded to the end of the fourth growing season. In many instances no specific cause of mortality was evident, although frost damage, smothering and burial by eroded soil materials were identifiable causes. While subsequent mortality continued to be heaviest in the youngest age classes (table 2) and for late plantings, all age/planting date treatments suffered a gradual depletion in numbers over the period studied.

Apart from such specific instances as frost-heave or the destruction by grasshoppers of succulent 6-week-old spruce seedlings, it is note-

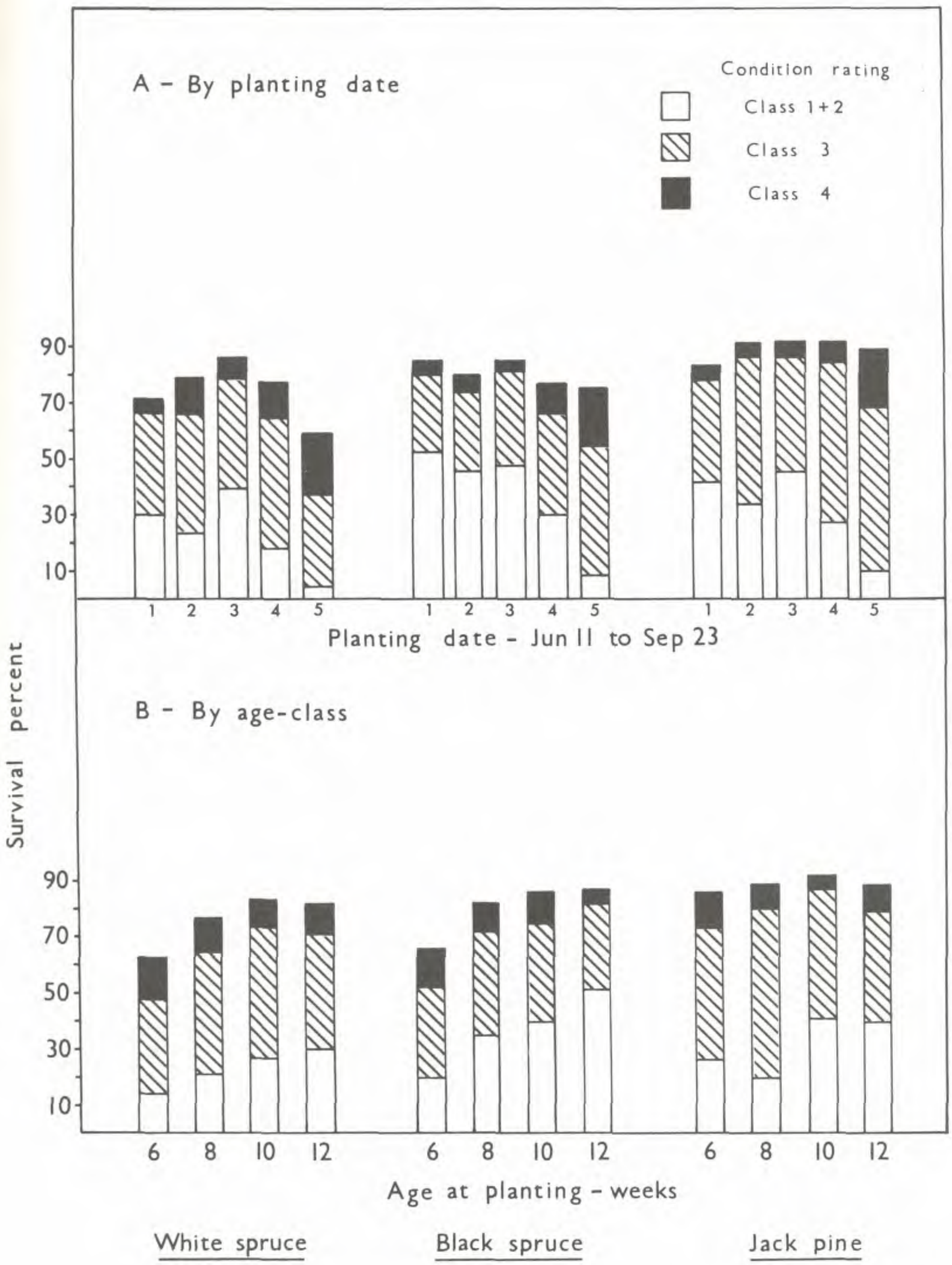

Figure 4.--Height of tubed seedlings after 4 growing seasons: Effect of planting date and seedling age at planting (Data for site 2).

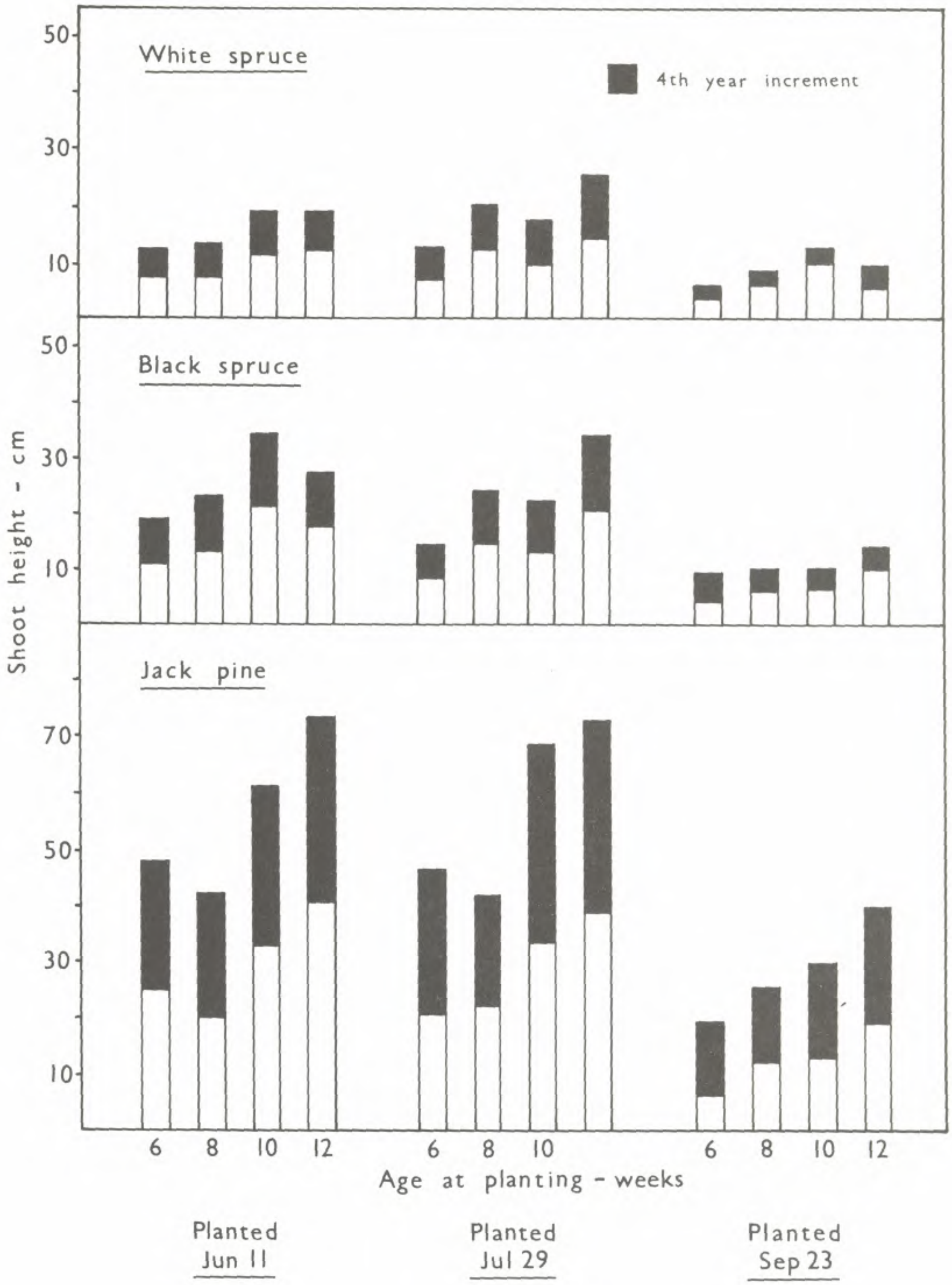

Figure 5.--Survival, 4 years after planting, of tubed seedlings planted at monthly intervals on 4 sites (averaged over planting date).

worthy that much of the mortality recorded was due, not so much to any catastrophic destruction of healthy, vigorous seedlings, as to the progressive debilitation of poor quality plants. In many instances, individual seedling histories reveal that seedlings given poor-quality ratings in early assessments underwent a gradual decline in condition during subsequent seasons, often culminating in their death. This point is illustrated by the data of table 3, which compare the movement of seedlings between condition classes over a 2-year period. Since it is based on data from 4 very different sites, this table suggests a more general deterioration of class 1 and 2 seedlings than was observed on the better sites. However, the picture of a net decline in seedling quality is a valid one, with the greatest mortality being experienced by class 4 seedlings. Some upward recruitment into the better condition classes occurred, especially in the spruces. However, this was not on a scale sufficient to alter the judgment that early plantation performance is a valid, if optimistic, indicator of its ultimate establishment potential.

Site

Results of the widespread planting of tubed seedlings in Ontario provide clear evidence that the spectrum of sites suitable for containerized seedlings is considerably narrower than that for bare-root stock. It may be speculated that the use of older, larger seedlings might reduce the gap somewhat, but obviously greater attention to site selection is an essential step in any efforts to improve the success of container planting.

On the basis of experience to date, we must acknowledge that container planting appears suited primarily to the easier, drier sites, supporting light-to-moderate vegetation of low competitive vigor. By inference, these will also be sites of lower productivity which, incidentally, may be more readily plantable by machine than are many richer sites. On droughty sites containerized seedlings may constitute the only viable choice of stock for summer planting, particularly the summer planting of pines.

Although container planting is contr-indicated on cold, wet soils, and on sites with thick duff or heavy grass potential, one of the most important considerations in site selection is the risk of suppression by competing woody vegetation. The latter excludes many of the more fertile upland sites in northern Ontario, and, consequently, calls into question the suitability of white spruce for container planting unless there is much wider acceptance of the need for early post-planting release.

Table 3.--Changes in the condition assessment of tubed seedlings over 2 growing seasons: percentage redistribution of seedlings from an original condition class (averaged over age at planting and planting date, for 4 sites).

Condition rating at end of second growing season	Condition rating at end of fourth growing season				Sample size
	1+2	3	4	Dead	
		(%)			
		White spruce			
1+2	29.9	52.1	5.8	12.1	3608
3	11.6	48.5	13.6	26.2	1452
4	1.2	24.6	19.9	54.3	418
		Black spruce			
1+2	45.5	43.2	4.2	7.1	3695
3	16.1	57.8	11.3	14.7	1129
4	3.5	27.9	27.6	40.9	398
		Jack pine			
1+2	28.4	64.4	4.7	2.4	5747
3	4.4	61.3	25.8	8.5	434
4	1.8	13.8	37.1	47.2	108

Scarification, to destroy vegetation and break up surface accumulations of litter, is practised in most areas, although its timing in relation to planting is particularly critical where container planting is being considered. Ideally, it should be carried out in the summer before planting, to allow the ground to settle and to avoid problems associated with soil movement2/. However, any delay in planting inevitably curtails the weed-free period and, on many sites, reduces the chances of seedlings becoming established before competition sets in. Even on some of our drier sites vegetation may close in again after about 3 years, while on the richer sites (least suited to container planting) the weed-free period may be no more than a single year.

Some light shade may favor early survival in the spruces, but even sq can cause a significant depression in seedling growth and sturdiness within a relatively short period (table 4). On sites liable to heavy competition or rapid recolonization, the ability of seedlings to keep abreast of vegetation is therefore an important consideration in the choice of planting stock. We have still not reached the point where the growth impact of containerized seedlings is equal to that of bare-root stock and, for the spruces at least, we must at present accept a lag in growth performance equivalent to at least one growing season. Unless this lag can be overcome, container planting will continue to be restricted to the less productive sites.

Table 4.--Effect of light shade on growth of white spruce seedlings1/ after three growing seasons.

	Dry-weight shoot	Root-collar diameter	Shoot height
	(g)	(mm)	(cm)
Light shade2/	1.84	2.8	20.7
Fully exposed3/	4.35	4.3	18.4

1/ 12 weeks old at planting

2/ Natural shade: light slash and raspberry (*Rubus* spp.)

3/ Hand-weeded

7/ Haig, R.A. 1972. Assessment of factors affecting the survival of tubed seedlings, Cupa Lake, Ontario, 1967-1970. Can. For. Serv., Sault Ste. Marie, Ont. Int. Rep. 0-35: 20 p.

The Container

The use of plastic tubes has often been assailed on the grounds of their non-biodegradability. This, it is claimed, inhibits rapid root egress and the early development of a natural root system, thereby reducing initial growth rates. While the general validity of these arguments has long been recognized in Ontario, the effects appear to be mainly of a short-term nature; adverse long-term effects have yet to be demonstrated. This is not to discredit the potential importance of the short-term effects, but rather to suggest that it may have been overstated in relation to other factors.

There can be little doubt that the poor results achieved by tubed seedlings in operational situations were largely attributable to the poor quality and small size of planting stock used, rather than to the use of solid-walled containers per se. Good quality stock raised in 9/16-inch (1.4-cm) diameter tubes has performed well after outplanting and, jack pine especially, has experienced no difficulties in shedding the container. Even in white spruce, vigorously growing seedlings soon develop a normal rooting habit outside the container, despite the fact that most roots may originate from the bottom of the tube (Scarratt 1972a).

One of the most critical faults of the original "Ontario" tube lay in its small rooting volume. This became apparent when the need for larger planting stock and longer production cycles was first realized. Subsequent studies have demonstrated that the 9/16-inch (1.4-cm) diameter tube places a severe restriction on seedling growth from a very early age, significantly depressing the size of seedling which can be produced within a given period (Scarratt 1972b, 1973). For white spruce and jack pine seedlings grown on a 16-week production cycle no significant benefit was achieved by increasing container diameter to 3/4-inch (1.9 cm). However, large and significant increases in seedling height and dry weight were obtained through the use of 1 1/4- and 2-inch (3.2- and 5.1-cm) diameter tubes, viz:

	Shoot height (cm)	Dry weight (g)
White spruce		
9/16-inch tube	7.0	0.11
3/4-inch tube	7.5	0.17
1 1/4-inch tube	10.1	0.26
2-inch tube	11.3	0.33
Jack pine		
9/16-inch tube	10.5	0.12
3/4-inch tube	9.9	0.17
1 1/4-inch tube	13.3	0.34
2-inch tube	19.4	0.64

While biological considerations might favor the use of a large container, there are obvious practical and economic restrictions -- utilization of greenhouse and nursery space, transportation and handling costs -- which govern the size of container that is operationally desirable. For the size of planting stock currently specified, the best compromise appears to be a container of the same depth (3 in. or 7.6 cm) as the 'standard' tube with a diameter of approximately 1 1/4 inches (3.2 cm).

Although the biological constraints associated with solid-walled containers may be a reasonable compromise in return for having a rigid, easily-handled container, the possibility of adverse long-term effects and considerations imposed by the need to increase container size are now leading us to evaluate alternative container systems. The principal requirements for any new system are that the container should be easy to handle, amenable to mechanized production operations, relatively cheap and biologically acceptable. Furthermore, some form of enveloping package, preferably biodegradable, is considered essential for the spruces to give support to the seedling and its rooting medium during handling and planting. However, irrespective of the system finally selected, it is clear that the ultimate success of container planting depends on our ability to produce seedlings of a size and quality consistent with maximum field performance. Other considerations are secondary.

SUMMARY AND CONCLUSIONS

Although the results of early tubed seedling plantings in Ontario were variable and often disappointing, improved cultural methods and a greater awareness of the needs and limitations of container planting have brought about a substantial improvement in the performance of operational plantings in recent years. Despite the rather doubtful future of plastic tubes, container planting per se is considered a biologically viable regeneration concept, and its future application to Ontario conditions, in one form or another, is viewed with optimism. However, for the immediate future the technique is regarded as a supplement, rather than an alternative, to bare-root planting, primarily as a vehicle for summer planting.

The variable results experienced with tubed seedlings can be attributed to a number of factors. The small size of seedling used in the early plantings was unquestionably a major factor contributing to their poor survival, but planting too late in the season, poor choice of microsite and off-site planting have all adversely affected seedling performance.

Past experience has shown that the spectrum of sites suitable for container planting is considerably narrower than that for bare-root stock. The risk of suppression by competing woody vegetation is the prime limiting factor, excluding the use of containerized seedlings from many of the more fertile upland sites. Consequently, container planting appears suited mainly to sites of lower productivity -- the easier, drier sites, with little duff accumulation, and supporting only light to moderate vegetation.

The size and quality of planting stock is undoubtedly one of the most important factors determining the performance of containerized seedlings during the establishment phase. Thus, small seedlings not only suffer higher mortality, but also produce seedlings of lower average quality with poorer growth rates. Moreover, the adverse effects upon growth persist for a number of years.

The optimum dimensions for containerized planting stock are presently open to conjecture. It is obviously desirable that seedlings become fairly well established before vegetation competition sets in, and this enables us to place broad limits on the level of acceptable performance. Thus, since it reflects the average life of a scarification job, an arbitrary performance standard has been set requiring that containerized seedlings have at least the same survival and growth impact, 3 years after planting, as bare-root stock. Based partly on the results of age-at-planting studies, the following tentative specifications for containerized planting stock are therefore suggested as an interim production goal aimed at meeting these performance criteria:-

	Age at planting (weeks)	Shoot height (cm)
White spruce	14-16	15
Black spruce	12-14	15
Jack pine	10-12	10

These are best guesses based on the rather limited evidence available; much more work is obviously needed to determine the optimum size of planting stock for use under various site conditions.

Notwithstanding the above, we must recognize that it may be over-optimistic to expect the same initial field performance from containerized stock as from bare-root plants. With the possible exception of jack pine, it may be more realistic to anticipate a growth lag equivalent to at least 1 growing season for most species. This clearly implies an even greater limitation on the range of sites that might be planted with containerized seedlings or, alternatively, a greater commitment to early plantation release.

Although the role of container planting is presently seen mainly as a summer supplement to the use of conventional nursery stock, this does not preclude planting at other times of the year, particularly if efficient mechanized planting systems become a reality. Consequently, there is practical significance to the conclusion that containerized seedlings do not provide a vehicle for successful planting throughout the entire frost-free period. Planting date studies have demonstrated a substantial deterioration in seedling performance as a result of late-summer planting, with no evidence to indicate that this might be compensated for by the use of older, larger seedlings. Because the adverse effects of late planting persist for a number of years, it is therefore recommended that the planting of containerized seedlings in northern Ontario be terminated by mid-August.

The novelty of container planting has unfortunately resulted in far greater importance being attached to the type of container used than is warranted on biological grounds. Thus, the failure of Ontario's tubed seedling program to achieve immediate success has often been attributed, by inference or otherwise, to the use of a non-biodegradable plastic container. Without denying the biological constraints imposed by such a container, there can be little doubt that the poor performance of early tubed seedling plantations was largely due to the use of small, low quality seedlings, and not directly to the use of plastic tubes. Although it is now apparent that the rooting volume of the original 9/16-inch (1.4-cm) diameter tube was totally inadequate, there is ample evidence to indicate that good field performance could be achieved, even in this small container, through the use of high-quality seedlings.

While biological considerations and the cost of increasing tube size place the future of plastic containers in serious doubt, the search for alternative containers is a secondary consideration. Our prime concern must be to develop the expertise necessary for producing vigorous planting stock of maximum survival and growth potential. This, rather than the type of container used, is the key to container planting success.

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