CONTAINER STOCK SPECIFICATIONS FOR NORTHERN ONTARIO

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Abstract.--The size of containerized seedling currently produced for use in northern Ontario generally confines container planting to the easier site conditions with a minimum of competing vegetation. Studies initiated in 1978 compare the performance of various sizes and grades of paperpot and bare-root planting stock over a range of sites, and attempt to define desirable container stock specifications for a broader range of site conditions. Third-year growth data from the first plantings of black spruce *(Picea mariana* [Mill.] B.S.P.) and jack pine *(Pinus banksiana* Lamb.) are presented and discussed.

Résumé.--En raison de la dimension des semis en mottes emballées qui sont couramment utilisés dans le nord de l'Ontario, ces derniers sont généralement plantés dans des stations assez favorables où la concurrence de la végétation est la moins forte. Les études entreprises en 1978 comparent les résultats obtenus dans différentes stations avec des plants de dimensions et de qualité diverses, à racines nues et en récipients de papier, et essaient de définir les caractéristiques souhaitables d'un matériel de reproduction en récipients à planter dans une gamme plus large de conditions stationnelles. On présente les résultats obtenus trois ans après la plantation ainsi qu'une discussion sur le sujet.

INTRODUCTION

It has been estimated that production of containerized planting stock in Ontario will reach 25 million seedlings by 1983 (Heeney 1982), at which time container planting will account for 27% of all planting in the province. In view of the importance of container planting to the overall regeneration program, and in order to justify the substantial capital investments in seedling production facilities, it is clearly essential that containerized planting stock be of such size and quality that it can become fully established and free to grow within a reasonably short time (3-5 years) after outplanting. Unfortunately, current operational experience shows that, while containerized jack pine *(Pinus banksiana* Lamb.) generally performs well in Ontario, field performance of container-grown spruces is frequently less than satisfactory, and is rarely comparable to that of bare-root stock.

Although numerous factors besides planting stock influence plantation success, there can be little doubt that, with current planting stock specifications, container planting in Ontario is still suited primarily to the easier, drier sites, supporting light to moderate vegetation of low competitive vigor. While this has not been particularly restrictive for the planting of jack pine, it means that the risk of suppression by competing vegetation excludes use of the spruces from the more fertile, upland sites. Consequently, for these species, the spectrum of sites currently suitable for container planting is considerably narrower than that for bare-root stock. Clearly, this situation must change if the burgeoning government and industry container planting programs are to

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be made more universally applicable, in terms of range of sites to be reforested, while still retaining operational flexibility.

Many of the disappointing results of the past can be attributed to the use of excessively small stock and/or planting on too difficult sites. Small seedlings not only suffer higher mortality, but also produce trees of lower average quality and poorer growth rates (Scarratt 1974). Several writers have pointed to the importance of seedling size at planting in determining subsequent plantation performance (Dobbs 1976, Roller 1977, Walker and Johnson 1980, Walker and Ball 1981), although little attention has been given to the optimization of stock size for different site conditions.

Container stock specifications suggested by Scarratt and Reese (1976) were an early attempt to relate stock grade to preliminary standards for field performance, and were based on the need to achieve free to grow status within three years of planting on easier sites. However, in many instances containerized seedlings continue to be planted on sites to which they are morphologically unsuited. Obviously, this is neither biologically nor economically acceptable. In order to increase the overall effectiveness of container planting and extend its use to more fertile, upland sites larger stock and specific site treatments are needed if the spruces especially are to perform adequately and reliably under the more difficult conditions that such sites present. To be realistic, two or three grades of stock may be needed to match sites of differing severity.

Studies aimed at the development of seedling specifications and associated growing schedules necessary to extend the effective application of container planting to a broader range of site conditions were initiated in 1978. The work described here is concerned with the preliminary testing and screening of an extended range of container stock grades on a limited number of sites. It attempts to identify a small number of promising seedling grades, with performance comparable to that of bare-root stock, for more extensive testing over a wider range of sites subjected to different pre- and post-planting treatments. Third-year results of the first year's planting of black spruce *(Picea mariana* [Mill.] B.S.P.) and jack pine are reported. All container stock was grown in the Japanese paperpot, the principal container currently used in northern Ontario.

STUDY DESCRIPTION

Planting Stock

This series of studies is concerned primarily with comparing the growth performance of various grades of bare-root and paperpot planting stock. However, in 1978 jack pine tubelings (T) grown in the 1.9 x 7.6 cm Ontario split-plastic tube and direct sowing treatments (SD) of jack pine were included on a limited basis because these were the principal options being considered for operationally regenerating some of the sites concerned.

Bare-root stock was supplied by the Ontario Ministry of Natural Resources' Swastika nursery, adjacent to the study sites. All stock was fresh-lifted on 2 May and was cool-stored (1.6 - 4.4 °C) at the nursery for 2-4 weeks until time of planting. Only one grade (2-0) of jack pine bare-root stock was planted, whereas small (3-0), medium (1.5-1.5) and large (1.5-2.5) grades of black spruce were used.

Paperpot seedlings were grown in the greenhouses of the Great Lakes Forest Research Centre in Sault Ste. Marie. In order to produce the required range in grade of planting stock, crops were started at three different times, viz: 28 May 1976, 14 February 1977, and 27 May 1977. Four sizes of paperpot were used, depending on the crop, to accommodate the different grades of seedling and to avoid inter-rooting between containers of seedlings on the longer growing schedules. Specific crop codes identify the resulting seven crop date/container size treatment combinations:

Crop code	Stock description	
	Date sown	Container size
76-2-5	28 May 1976	FH 508
76-2-6	"	FH 608
77-1-4	14 Feb 1977	FH 408
77-1-5	"	FH 508
77-1-6	"	FH 608
77-2-3	27 May 1977	FH 308
77-2-4	"	FH 408

Each crop was overwintered at least once, and presumably all stock was in a comparable physiological condition at time of planting in the spring of 1978.

Seed for the paperpot stock, supplied by the Ontario Ministry of Natural Resources, was of the same site region provenance (3200) as the bare-root stock, but not from the same seedlot. Although the different crop start dates necessitated minor variations in growing regime, cultural methods were essentially the same for each crop. Water-soluble fertilizers were applied two or three times per week, depending on the stage of seedling development, and, during the main growing period, consisted principally of 20-20-20 at 200-300 ppm N applied through the irrigation water. For two weeks at the beginning and end of the growing period in the greenhouse 10-52-10 at 100-150 ppm N was used. Seedlings remained in the greenhouse for about 12 weeks (jack pine) or 16 weeks (black spruce) of their total growing period; all seedlings were overwintered in Sault Ste. Marie under good snow cover, but were moved north to the Swastika nursery in early spring of the year of planting to avoid premature budbreak. The jack pine tubelings (T) were supplied by the Swastika nursery; they had been sown in early July 1977, and were consequently quite small at time of planting. Morphological characteristics of all planting stock at time of planting are given in Table 1.

Study Area

The 1978 plantings were established in the Englehart Management Unit (EMU) approximately 30 km east of Kirkland Lake, Ontario, within the Missinaibi-Cahonga section (B.7) of the boreal forest region (Rowe 1972). The five planting sites (Table 2) are situated in the townships of Gross and Bompas, all within a few kilometres of the Swastika nursery (48°02'N, 80°22'W).

The EMU is characterized by flat to gently undulating topography, and the elevation of the experimental sites ranges from 300 to 450 m above sea level. Most soils of the area are developed either from glacial till deposits on the upland sites or from outwash, deltaic sands, silts and windblown sands over silt or silt loam on the lower, flatter areas. They are mostly podsolized with a thick, poorly developed LFH layer and well developed Ae and Bf horizons where not disturbed by logging or scarification.

Table 1. Morphological characteristics of black spruce and jack pine planting stock (n = 50).

Stock type/ grade	Shoot height (cm)		Root-collar diam (mm)		Height/ diam ratio		Total dry weight (g)		Shoot/ root ratio		Root area index[a] $(cm)^2$	
	bS	jP[b]	bS	jP	bS	jP	bS	jP	bS	jP	bS	jP
Paperpots												
76-2-5	25.7	29.6	3.9	4.4	6.6	6.8	3.30	3.54	2.2	2.1	48.3	49.7
76-2-6	22.0	36.1	4.3	5.3	5.1	6.8	3.94	5.42	2.2	2.2	69.2	67.5
77-1-4	15.1	9.8	2.9	2.4	5.0	4.0	1.42	1.61	1.4	2.0	33.4	34.4
77-1-5	18.2	22.3	3.7	3.4	4.7	6.7	2.29	2.64	2.3	2.1	37.9	45.6
77-1-6	15.5	15.6	3.6	5.1	4.1	3.1	1.63	4.22	1.7	1.9	37.4	63.1
77-2-3	8.1	12.8	1.0	1.2	8.1	10.5	0.33	0.32	1.2	1.7	2.8	4.8
77-2-4	9.4	14.8	1.0	1.5	9.4	9.7	0.38	0.53	1.4	1.5	2.5	9.5
Tubelings												
T	-	7.8	-	1.5	-	5.2	-	0.15	-	2.0	-	5.8
Bare-root												
2-0	-	18.5	-	4.1	-	4.6	-	3.98	-	4.3	-	44.5
3-0	24.2	-	3.5	-	7.0	-	2.55	-	3.3	-	23.6	-
1.5-1.5	28.0	-	4.7	-	6.1	-	5.15	-	2.3	-	62.3	-
1.5-2.5	25.6	-	6.9	-	3.8	-	8.38	-	2.3	-	68.8	-

[a]Morrison and Armson (1968)

[b]bS/jP = black spruce/jack pine

Table 2. Description of experimental planting sites, Engelhart Management Unit, 1978.

Site number	Township	Description
1	Gross	Terrain flat; deep, fresh, well drained, fine silty sand. Original stand jack pine and trembling aspen; logged in 1974; site prepared with Marttiini plow in 1975. Jack pine tubelings planted in 1976; failed. High competition potential; aspen regrowth cut by hand in October 1977. Planted with black spruce and jack pine 10 May 1978.
2	Gross	Terrain rolling; deep, excessively drained, windblown sand. Site prepared with barrels in 1975. Other details as for site 1. Low competition potential. Planted with jack pine only on 17 May, 1978.
3	Bompas	Lower slope on rolling terrain beside Bompas Lake; deep, fresh, well drained sandy loam till with silt and boulders. Original mixed stand of black spruce, white spruce, trembling aspen and white birch with some jack pine. Logged in 1977 leaving heavy slash and residual birch; site prepared with Young's teeth in October 1977. Heavy competition potential (especially aspen). Planted with black spruce and jack pine 2 June 1978.
4	Bompas	Ridge top on rolling terrain; soil similar to that of site 3, but more shallow with some exposed bedrock. Smaller birch component in original stand, hence less residual slash. Heavy competition potential. Other details as for site 3. Planted with black spruce and jack pine 26 May 1978.
5	Bompas	Upper slope on rolling terrain; shallow, excessively drained sandy loam till over shattered, and frequently exposed, bedrock. Original stand jack pine and black spruce with some birch and poplar. Logged and site prepared as site 3. Low competition potential. Planted with jack pine only on 30 May 1978.

The area has a modified continental climate (Chapman and Thomas 1968), characterized by low winter and high summer precipitation, a wide annual temperature range, and large variation in daily temperature. Average annual precipitation for Kirkland Lake during the period 1951-1980 was 86.6 cm of which 34.0 cm (39%) fell between May and August (Anon. 1982). The mean annual growing season (5.5°C base) is 162 days, and the average length of frost-free period 80 days (Chapman and Thomas 1968).

Experimental Method

At each site an experiment was laid out in a randomized block design with six replications. Each block consisted of one row of 25 trees from each of the planting stock treatments. Black spruce and jack pine, when planted on the same site, were located in separate plots.

Planting was carried out during the latter part of May and early June (Table 2). Bare-root stock was slit-planted with a shovel. Paperpot seedlings were planted either with a Pottiputki (FH 308 and FH 408) or with a tool that removed a plug of soil (FH 508 and FH 608). A dibble was used to plant the tubelings. On site 1 trees were planted along the shoulder of the furrow made by the Marttiini plow; elsewhere they were planted in rows approximately 1.8 m apart parallel to the direction of scarification. Where a direct sowing treatment (SD) of jack pine was included, seedspots of minimum diameter 0.3 m were made with a Sandvik hoe and about 10 seeds were sown per spot. The resulting seedlings were thinned to one per spot at the end of the second growing season. All stock on sites 1, 3 and 4 was hand-released in 1979.

All experiments were assessed for survival, seedling condition and shoot growth at the end of the first, second and third (1980) growing seasons. Only the results of the latter assessment are reported here. The data were subjected to analysis of variance and significant treatment effects identified by Tukey's multiple range test.

RESULTS AND DISCUSSION

Survival

The weather at time of planting was good, with adequate rainfall, and even after three growing seasons all types and grades of planting stock showed exceptionally good survival on all sites (Table 3). However, total survival figures, by ignoring differences in seedling condition, may give an unrealistically optimistic view of seedling condition (Scarratt 1974). The fact that a seedling is able to survive does not necessarily mean that it will grow well.

If we consider the proportion of seedlings with a class 1 or class 2 condition rating[2] (Table 3) treatment differences are revealed that are not evident from the data for total survival. Over all stock types and grades, a higher proportion of jack pine seedlings (67% and 84% on sites 1 and 3, respectively) fell into the combined class 1+2 category than was the case with black spruce (15% and 42% on sites 1 and 3), reflecting the more aggressive growth habit of the pine. However, none of the differences between stock types or grades were significant in 1980, even though, in spruce particularly, a substantially larger proportion of poorer quality seedlings had been enumerated in the smaller grades of planting stock at earlier assessments. This apparent discrepancy may derive from the fact that by the end of the third growing season all seedlings had settled into a similar pattern of development unrelated to stock treatment. This situation will be discussed later in relation to height growth. By contrast, the distinct differences between sites in proportion of class 1+2 surviving seedlings would seem to reflect real differences in site quality. It may be noted that black spruce planted on site 1 has suffered recurrent damage from spring frosts, accounting for the lower quality assessment of spruce at this site in comparison with sites 3 and 4.

[2]Classes 1 and 2: seedlings of at least moderate vigor, healthy, and with only minor morphological abnormalities (Scarratt 1974).

Height Growth

Provided that the stocking of healthy, vigorous trees is adequate, growth rates are the primary expression of plantation success. From a practical viewpoint, height growth is usually of greatest concern in young plantations because of the risk of suppression by competing vegetation. Seedlings which are able to keep ahead of weed growth during the first few years after outplanting are more likely to become firmly established and form part of the final crop. Therefore height growth performance only is discussed here.

In comparing the performance of containerized and bare-root planting stock, it is

Table 3. Survival (%) of black spruce and jack pine planting stock after three growing seasons (1978-1980).

	Black spruce						Jack pine					
	Site 1		Site 3		Site 4		Site 1		Site 2		Site 3	
Stock type/ grade	Total surv- ival	Class 1+2	Total surv- ival	Class 1+2	Total surv- ival	Class 1+2	Total surv- ival	Class 1+2	Total surv- ival	Class 1+2	Total surv- ival	Class 1+2
76-2-5	98	10	99	33	99	30	99	73	98	49	98	82
76-2-6	99	12	100	50	100	39	99	68	100	58	100	85
77-1-4	100	16	91	44	100	35	97	65	98	62	-	-
77-1-5	94	16	94	45	98	26	97	59	100	66	98	88
77-1-6	96	19	95	39	96	29	99	70	100	67	100	89
77-2-3	90	21	94	35	97	36	93	70	94	48	96	87
77-2-4	-	-	88	46	96	30	98	71	100	63	100	79
T	-	-	-	-	-	-	89	68	90	50	99	81
2-0	-	-	-	-	-	-	91	56	92	59	99	82
3-0	90	10	95	46	98	28	-	-	-	-	-	-
1.5-1.5	95	13	97	40	99	41	-	-	-	-	-	-
1.5-2.5	92	21	96	39	93	41	-	-	-	-	-	-

clear that the latter, being considerably older, usually has a substantial advantage in terms of both initial height and mass at time of planting (Table 1). For this reason, performance comparisons between the two stock types are sometimes criticized for comparing "apples and oranges". However, from the practical viewpoint of regenerating a given site such comparisons are fully justified by the fact that we are concerned with the relative performance impact of different planting options over a given period of time irrespective of their age or origin.

Clearly, if containerized stock is to have the same performance impact as bare-root on a given site, it must first grow faster until height equivalence is achieved, and then continue to match the height growth of bare-root stock until it is free to grow. However, while superior initial growth rates have long been claimed for container-grown stock, operational experience has frequently shown a lag in total height equivalent to one or more years' growth in comparison with bareroot stock. Although such a growth lag may be acceptable on easier site conditions, it may mean the difference between success and failure on more difficult sites.

Data for shoot height, current (1980) height increment and current height increment percent (CHI%) (current height increment expressed as a percentage of 1979 total height -- i.e. rate of height increment) are illustrated in Figures 1 to 3 (black dots indicate equivalents to current operational paperpot grades).

Jack pine

In jack pine, both stock type/grade and site had a significant effect on height growth, although their interaction was significant only for CHI%. Clearly, the larger paperpot stock produced the largest trees over the three-year period, with several grades surpassing the performance of 2-0 bare-root stock, especially on the better sites 1, 3 and 4. However, Figures 2 and 3 suggest an overall levelling off in the effects of stock grade upon height increment, contrasting with the strong, continuing response to site. This parallels the situation with class 1+2 survival, and points to a progressive stabilization of growth rates at the five sites. Total height and height increment of all stock types were poorest on the drier sites 2 and 5.

In terms of total height, tubelings (T) and 77-2-3 paperpots still lagged considerably behind 2-0 bare-root stock after three growing seasons. The sturdier 77-2-4 paperpot stock, comparable with current operational grades, was a somewhat better choice, although the data indicate that larger container stock would be needed to reliably achieve height parity with bare-root stock. However, this would necessitate either the use of a larger container or a longer growing period in the FH 408 paperpot. Neither is a desirable choice; the larger container would drastically reduce greenhouse production capacities, while an extended growing period with the FH 408 paperpot could well lead to severe inter-rooting problems and a reduction in morphological seedling quality (e.g. tall, spindly seedlings).

While current height increments (Fig. 2) were still positively related to seedling size at planting, differences in rate of height increment (Fig. 3) were beginning to level off. This is confirmed by Figure 4, which demonstrates the extent to which rates of height increment of both stock types had evened out on site 4. A similar response was noted on other sites also. Stabilization of growth rates implies that the benefits of containerization had been outgrown by the end of the third growing season. Henceforth height growth may be expected to increase at a steady rate, irrespective of stock origin, in direct relation to individual tree size and site potential. It is now unlikely that the smaller grades of container stock will catch up to the bare-root stock.

The high relative rate of height increment in direct sown jack pine is noteworthy, for it typifies the early vigor of this species on good sites. However, most seedlings were still quite small (<20 cm) in 1980 (Fig. 1) and are likely to have increasing difficulty coping with the prolific vegetation of sites 3 and 4 unless they are released a second time. Consequently, it is concluded that direct sowing would not have been a satisfactory regeneration method for these sites, although it would have been a reasonable choice, given the difficulties experienced in planting seedlings, on the shallower and drier site 5. By comparison, it should be pointed out that, with the exception of tubelings on sites 3 and 4, all other stock types and grades had achieved free to grow status by 1980.

On balance, it appears that the current specifications for jack pine seedlings grown in FH 408 paperpots (12-14 weeks old, 10-15 cm shoot height, 500-700 mg dry weight) were generally adequate for the sites on which this species was planted. However, the data indicate a one-year lag in height growth compared with bare-root stock. For the majority

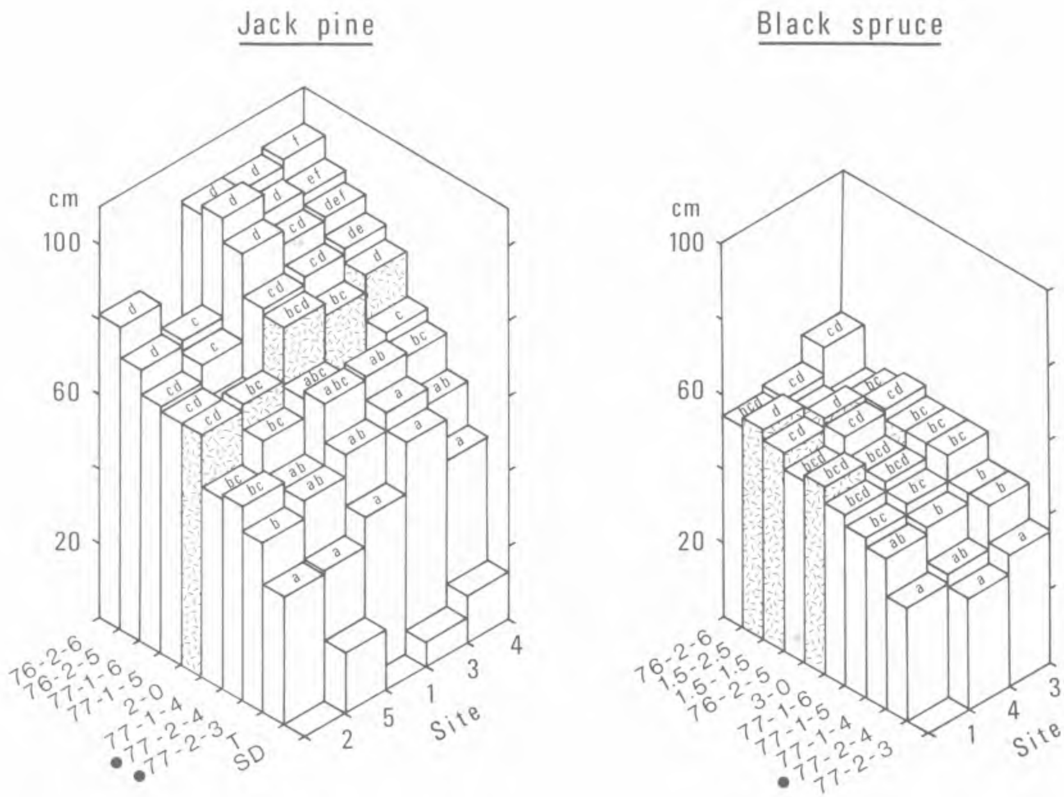

Figure 1. Total shoot height (1980) of bare-root and containerized planting stock grades. (Within sites, treatments with the same letter do not differ significantly: p = 0.05)

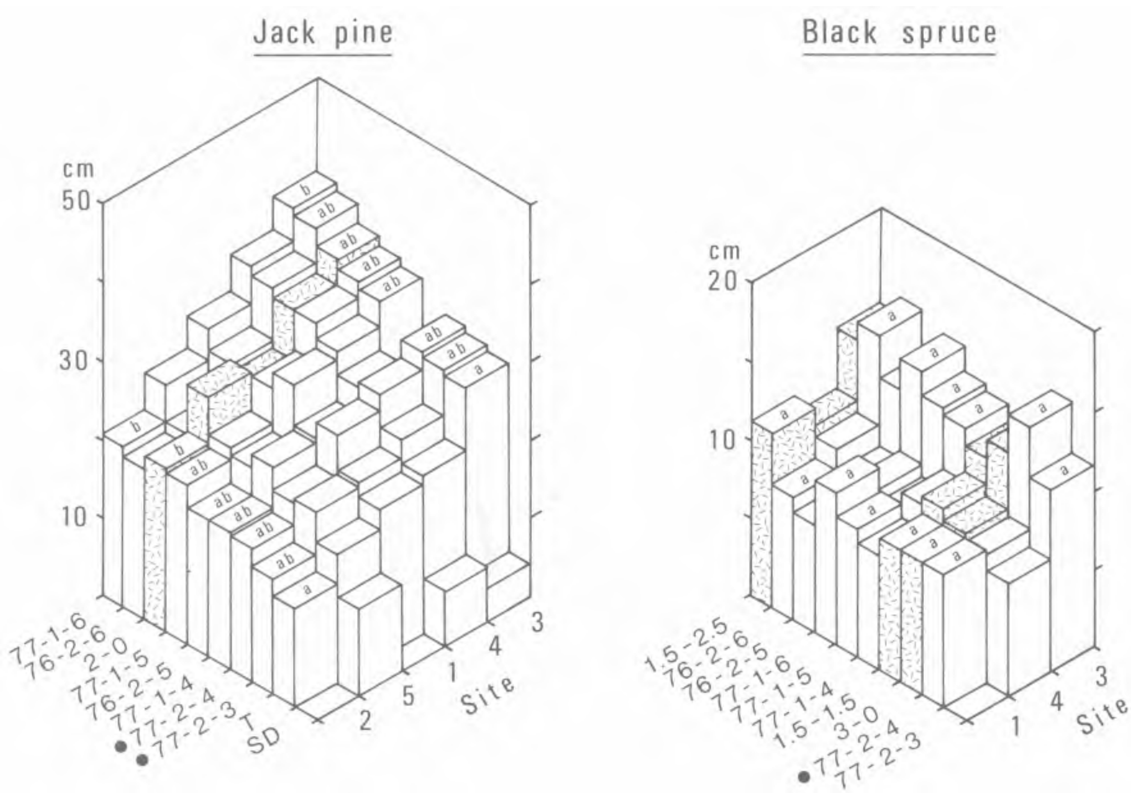

Figure 2. Current height increment (1980) of bare-root and containerized planting stock grades. (Within sites, treatments with the same letter do not differ significantly: p = 0.05)

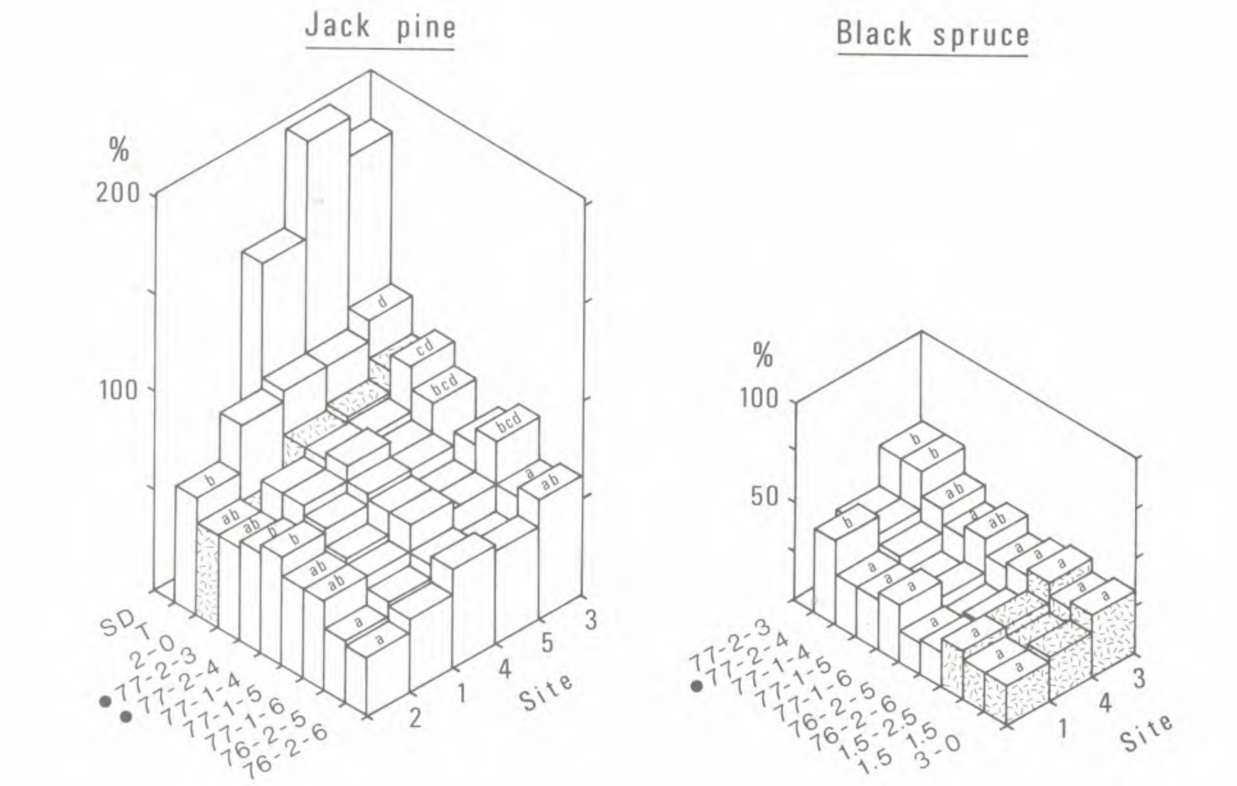

Figure 3. Current height increment % (1980) of bare-root and containerized planting stock grades. (Within sites, treatments with the same letter do not differ significantly: p = 0.05)

of sites, such as sites 2 and 5, on which jack pine is planted, a one-year growth lag with container stock would be of little consequence. But on sites with heavier vegetation competition, larger container stock, or at least the maximum of the specifications set out above may be desirable. This does not exclude the possibility that release from competition may also be required, for it will be recalled that sites 2, 3 and 4 were hand-released in 1979.

Black spruce

In black spruce, as in jack pine, both stock type/grade and site had significant effects upon all height growth parameters, although in this case only shoot height showed any significant interaction. The overall response of shoot height to site differences was not as pronounced as in pine, despite the lower proportion of class 1+2 seedlings that resulted on site 1 from the recurrent frost damage noted earlier. All stock grades had substantially greater current height increment on site 3 than on site 4. Since there was no corresponding difference between sites in total heights, and in view of the heavier weed competition (aspen especially) to which trees were subjected on site 3, it is not unreasonable to suppose that the greater height increment reflects a stronger response to the hand release carried out in 1979.

In relation to competing vegetation, none of the black spruce treatments, bare-root or container-grown, could be considered especially successful. On sites 3 and 4 even the larger stock grades (bare-root included) were barely adequate to keep ahead of the vegetation, emphasizing the need to include competition control as an essential element in regeneration prescriptions for spruce plantations.

If typical, the weak performance of bare-root stock on the moderately severe sites 3 and 4 suggests that comparability of growth with bare-root stock may be too conservative a criterion by which to judge the performance of container-grown stock, especially on more competitive sites. Clearly, if conventional grades of bare-root stock experience difficulty in achieving early, effective establishment of spruce on such sites, we should require better growth rates from both container-grown and bare-root stock in order to ensure reliable plantation

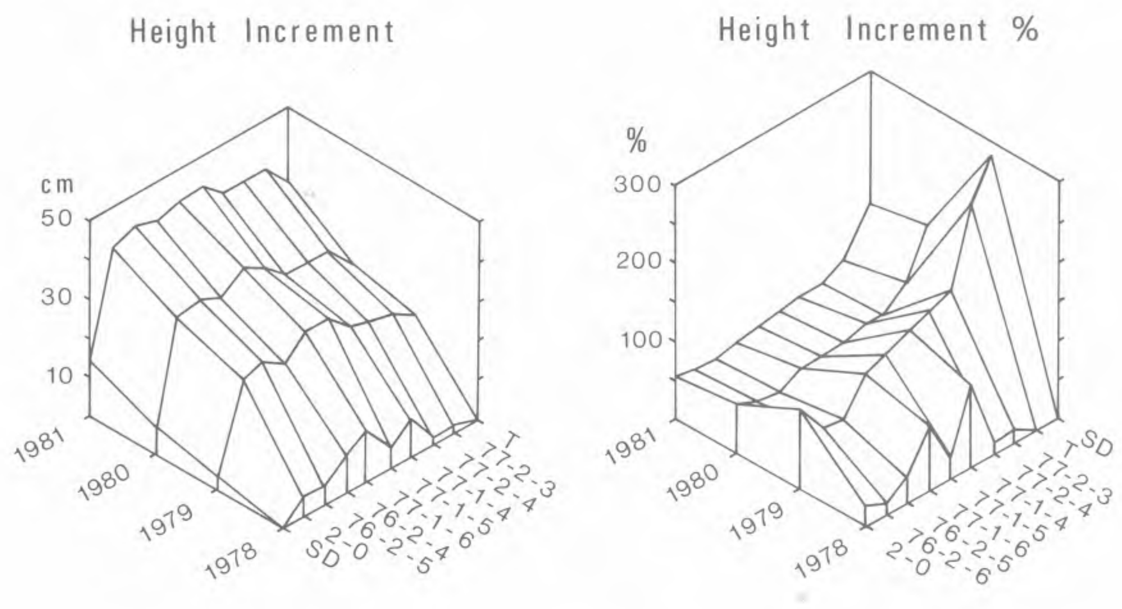

Figure 4. Comparative progression of jack pine height increment on site 4.

establishment. While it is too early to make a final judgment, the question should be borne in mind when considering the present results with containerized spruce.

Although, in general, the larger grades of planting stock grew best, on none of the sites was there any significant difference in height increment or shoot height between bare-root grades. This is somewhat surprising in view of the substantial differences in tree mass at time of planting, and contrasts with the long-term findings of Mullin (1980) regarding the relative performance of seedling and transplant stock. Height increment on site 4 is now (1981) practically identical for all three bare-root grades (Fig. 5), which indicates that the total height relationship is unlikely to change in the future.

Larger seedlings have clearly been of significant benefit in promoting shoot heights of container-grown stock to match those of bare-root material. It is equally evident that the growth performance of the current grade of black spruce paperpot stock (i.e., 77-2-4) was significantly poorer than that of other types and grades and failed to match even the growth of 3-0 bare-root stock. In fact, on sites 3 and 4 many of the 77-2-3 and 77-2-4 seedlings were already being suppressed by weed competition. In all grades of paperpot stock, differences in height increment had levelled off by 1980 and seedlings were now growing at the same relative rate as bare-root stock, indicating, as with jack pine, that the benefits of containerization had been outgrown. This stabilization of height relationships between stock types and grades means that the smaller grades of paperpot stock are not now likely to catch up, and may fall progressively further behind as they succumb to the competition.

Since the current grade of black spruce paperpot was inadequate even for the conditions presented by sites 3 and 4, what size of stock should be used for these and for more difficult site conditions? It is obviously too early in this study to provide definitive specifications. However, as a preliminary working recommendation, it appears that black spruce container stock should, at least, have a shoot height of 20 cm and a minimum dry weight of 1.0 g in order to match the height growth performance of 1.5-1.5 bare-root stock. Seedlings of these dimensions will require one season to grow, and might be sown in late March/early April, grown in a greenhouse for 14-16 weeks, and then grown on outdoors for overwintering and planting the following spring. (Other production schedules could be used to achieve the same results, but will not be discussed here.) Stock of these dimensions should be looked upon as the *minimum* requirement for sites with light to moderate competition potential. This assumes that, for most situations under which black spruce container stock is planted, a one or two year growth lag is unacceptable if the risk of suppression by competing vegetation and/or high re-

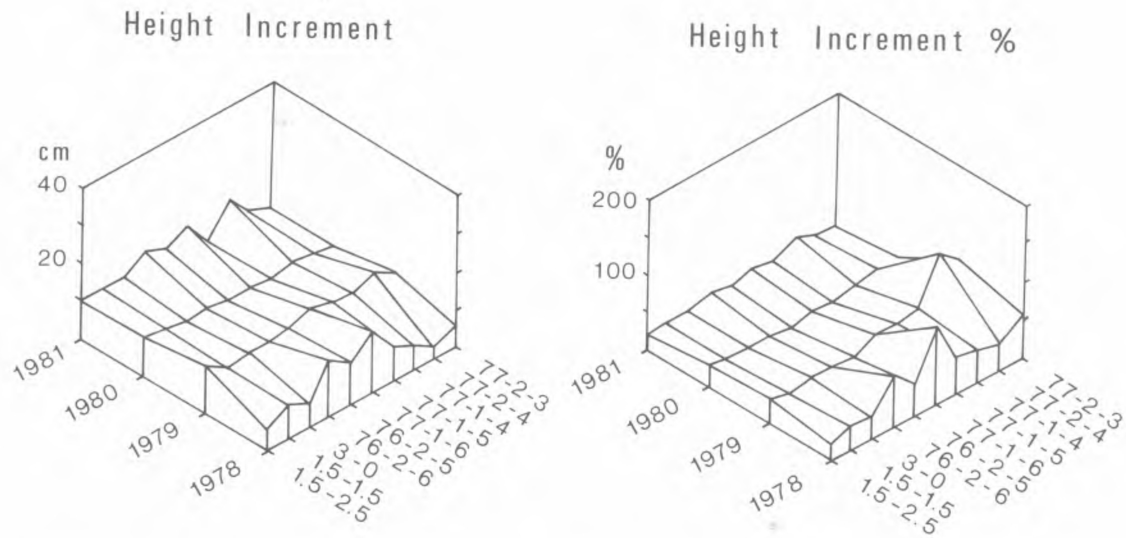

Figure 5. Comparative progression of black spruce height increment on site 4.

lease costs are to be avoided, and that seedlings must perform at least as well as 1.5-1.5 bare-root stock.

In view of the short period over which the growth benefits of containerization prevail, it is clear that, if container stock is to achieve parity of shoot height with bare-root stock, this must occur within three years of outplanting, and before vegetation dominates the site. For this reason, even larger, older stock (up to 1.5 years old and perhaps equivalent to the experimental grade 76-2-5) will undoubtedly be necessary in order to extend the application of container planting to more fertile, upland sites. Although considerably more testing is required to define the optimum grade of seedling for such sites, it is evident that we must also be prepared to apply routine vegetation control treatments in conjunction with these larger grades to ensure early and effective establishment.

While spruce can be grown in the FH 408 paperpot for up to one year without difficulty, seedlings of greater specifications than those set out above should preferably not be grown in this size of container, especially if they are to be grown on into the second growing season. Even with black spruce, some inter-rooting between pots will almost certainly occur after such seedlings have been overwintered. Furthermore, the combination of restricted aerial growing space and extended growing period will produce a seedling that is out of balance with its pot and of impaired morphological quality (e.g. tall, spindly seedlings with few side branches and low photosynthetic area), as well as increasing the risk of disease within the dense foliage. For periods longer than one growing season an FH 508 paperpot or other container of equivalent size is recommended; the data do not indicate that anything larger is necessary. Because these longer growing cycles would allow the development of a well-knit root mass, plug-type containers (e.g., multipot) become a viable alternative to the paperpot for producing larger containerized black spruce.

The production of larger container stock on longer growing cycles will obviously increase production costs, particularly if a larger container is also employed. Planting costs may also increase slightly because larger seedlings are often more difficult to handle. However, these additional costs must be looked at in relation to the total cost of plantation establishment up to the point when seedlings are free to grow, not, as is the case now, simply in terms of nursery production costs. Continued use of the small grade spruce paperpot stock currently produced in Ontario on a 16-18 week rotation vitiates the objective of establishing a new crop as quickly and as cheaply as possible, even on the easier site conditions. The use of larger containerized planting stock, though more expensive in terms of nursery production, shipping and perhaps planting costs, must be balanced against its better growth performance after outplanting, the greater probability of successful establishment, and the probable reduced need for competition release before a free to grow status is achieved. The additional investment may be more than justified by more rapid and reliable plantation establishment, as well as by the prospect of extending the effective use of container planting to more difficult sites.

SUMMARY AND CONCLUSIONS

1. The study reported here is concerned primarily with the screening of comparative growth in a range of bare-root and overwintered experimental paperpot stock grades. It attempts to identify promising grades of containerized seedling for more extensive testing, with the objective of increasing the reliability of container planting as a reforestation method, and extending its application to a broader, often more difficult range of site conditions.

2. The results indicate that, in both jack pine and black spruce, the benefits of containerization, in terms of increased survival and early growth, were outgrown by the end of the third growing season. Beyond this, height growth and seedling condition stabilized in relation to stock type and grade. Henceforth, height increases are likely to depend upon individual tree size and site quality rather than upon stock origin. Thus, if container stock is to match or improve upon the performance impact of bare-root stock on a given site, seedlings must be of sufficiently large grade that this status is achieved within two, or at most three years from planting. This period coincides with the average three-year establishment "window" that exists following site preparation before weed competition begins to dominate most planting sites (Scarratt and Reese 1976).

3. The current grade of jack pine paperpot stock is considered adequate for most planting situations, provided that a one-year lag in height growth in comparison with bare-root. stock is acceptable. Somewhat larger stock may be desirable for the most difficult sites on which jack pine is planted, although the need might be offset through the judicious use of herbicides.

4. In comparison with bare-root stock, the current grade of black spruce paperpot seedling, produced on a 16-18 week production cycle, suffered at least a two-year lag in height growth on sites with light to moderate competition growth, with many seedlings in imminent danger of suppression. This is an unacceptable level of performance. Substantially larger seedlings, grown for about one year in the FH 408 paperpot, are recommended as the minimum requirement for such sites to ensure at least parity of height growth with bare-root stock. However, even larger seedlings, preferably grown in an FH 508 paperpot or equivalent container for perhaps 1.5 years, are considered necessary in order to establish black spruce container stock successfully on the more fertile upland sites with heavy competition potential.

5. Planting stock is but one of a number of interacting factors which collectively constitute a regeneration prescription. While the preliminary results of this study indicate the need for two or more grades of black spruce container stock to match site conditions of differing severity, it is evident that their growth response will be conditioned by other factors besides site. Logging practices, the degree and method of site preparation, rate of competition ingrowth, time of planting, planting method, and especially the adequacy of post-planting tending may all substantially modify the response of planting stock grade on a given site. Ultimately, the interaction of all these factors must be taken into consideration when specifications for containerized planting stock are being defined.

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