FIELD PERFORMANCE OF CONTAINER-GROWN NORWAY AND BLACK SPRUCE SEEDLINGS

by

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Cover Photos: Left; 42-month-old Norway spruce grown in Styroblock 8 container. Right; Norway spruce in 1975, seven years after seeding.

ABSTRACT

The field performance of 42-month-old seedlings produced in containers, Styroblock 8 and 2, R.C.A. peat sausage (with intact case, perforated case, and caseless), Swedish multipot, Jiffy 7 pellet, and round peat pot was investigated to determine their suitability for planting in cut-over areas in southwestern Nova Scotia. The effects of the containers on seedling survival and initial growth in the field are discussed. Norway spruce grown in Styroblock 8, and black spruce in Swedish multipot gave the best performance.

RESUME

On a étudié le comportement sur le terrain de semis de 42 mois produits dans des récipients Styroblock 8 et 2, des boudins de sphaigne R.C.A. (avec enrobage intact, enrobage perforé, puis, sans enrobage), dans des multipots suédois, des boulettes Jiffy 7, et dans des potets ronds de sphaigne, afin de déterminer leur efficacité dans les forêts coupées à blanc du sud-ouest de la Nouvelle-Ecosse. L'auteur met en relief l'influence des récipients sur la survie des semis et leur croissance initiale sur le terrain. Les meilleurs rendements furent obtenus par les Epinettes de Norvège dans les Styroblocks 8 et par les Epinettes noires en multipots suédois.

INTRODUCTION

A program for growing seedlings using Domtar cardboard, Ontario plastic tubes, Jiffy 7 pellets, peat pots, and biscuit containers was initiated by Nova Scotia Forest Industries in 1965. The seedlings did not grow well in the greenhouse and when field-planted they suffered high mortality from drought, frost heaving, wind damage, and rabbit browsing. In 1968, the Nova Scotia Department of Lands and Forests began producing containerized stock using 20-mm Ontario type tubes. According to Levy (1972), 'The results during the first year were not promising, only 14% of the seeds germinated and survived in the greenhouse.' However, improvements were made in the methods of production, and seedlings were later grown in 12-mm and 20-mm plastic tubes, Swedish multipots, and BC/CFS Styroblock containers. By 1972, survival was averaging 62%.

In 1973, the Nova Scotia Department of Lands and Forest, Scott Paper Co., and Nova Scotia Forest Industries Ltd. became involved in a large-scale reforestation program using containerized stock grown in 408 paper pots (Armson, 1973). The field performance of these seedlings varied greatly, probably because of differences in sites and in the condition of the seedlings when outplanted. However, all the factors responsible for their success or failure have not been fully determined.

In 1972, the Maritimes Forest Research Centre initiated a reforestation research project in southwestern Nova Scotia to determine the most suitable planting methods for the region. In the study reported here, seedlings of Norway and black spruce were grown in six different types of containers and subsequently were outplanted on a cut-over area considered typical of a substantial proportion of the productive forest sites in that part of Nova Scotia. Three years after outplanting, the effect of the different types of containers on seedling survival, height growth, and root development was measured and evaluated.

STUDY AREA

The 0.5-ha study area is located near Ten Mile Lake, 20 km west of Liverpool, Queens County, Nova Scotia (lat. 44°10' N, long. 64°50' W), within the Herring Cove Lake Experimental Forest owned by Bowaters Mersey Paper Co. Ltd.

The soil is a dark grayish-brown humic podzol, mottled, and sometimes indurated. It has a sandy-loam texture and a pH between 4 and 5. The underlying material is olive-gray sandy-loam till, firm, mottled, and stony. Internal drainage is moderately slow. The physical characteristics of the soil are uniform throughout the area except in a few places where the soil is shallow above bedrock. The topography is gently undulating with a slight slope towards the northeast.

The area has a humid temperate climate. Annual precipitation, approximately 150 cm, is well distributed throughout the year. The growing period is about 180 days and the frost free season ranges from 110 to 116 days. The minimum average temperature is -5°C in February (Liverpool climatic station, data recorded for 25 years).

The area was previously covered by a mixedwood stand of white spruce, black spruce, and aspen, together with a dense ground vegetation of lambkill, blueberry, and bracken. It was cut-over in 1971 and some cleaning of logging debris was carried out by bulldozer in the spring of 1972. The soil was not disturbed. The ground surface was largely free of slash at the time of planting.

CONTAINER TYPES

The containers used in the study are illustrated in Fig. 1; their dimensions are given in Table 1. Additional characteristics of each of the containers that may have affected the field performance of the seedlings are described.

Styroblock containers (Ste. 2 and Ste. 8) were first introduced by the Canadian Forestry Service in British Columbia in 1970, and have been modified several times. Two molded "runners" on the bottom support and elevate the block for drainage and air circulation. The top surface has a molded perimeter "fence" to prevent water runoff, and "dome" protrusions between the cavities to aid in directing soil and water into the cavities (Sjober, 1974). The inner wall of each individual plug is smooth and rigid so that roots cannot penetrate.

Swedish Multipot (Mp) contains peat plugs similar to those in the styroblock containers. The peat plugs are compact and shaped to fit the 'planting shoe' of the dibble bar which was designed specifically for this purpose. Use of this dibble bar ensures close contact between the peat plug and the surrounding soil after planting. An economic advantage of this container is its reusibility. Disadvantages are its small cavity size and the imperfect heat conductivity of the plastic tray; both features may retard root and stem development.

Jiffy 7 Pellet (JP) was developed in Norway and is used for growing vegetables, ornamental plants, and forest trees. The pellet is a flat disk (7.0 x 0.8 cm) composed of a mixture of peat moss and NPK fertilizer wrapped loosely in an elastic fine-mesh plastic net. Before seeding, the disk should be soaked in water for 5 or 10 minutes or until saturated. It will then expand and contain approximately 60-70 ml of water which is sufficient for the germination period under humid greenhouse conditions.

The Peat Pot (PP) container was also developed in Norway. The wall of the container is made of a mixture of peat, waste wood pulp (raw fiber), urea, and molybdenum. The urea is added to increase microorganism activity in the medium and in the surrounding soil. The wall is not firmly compressed and can be easily penetrated by seedling roots. Although the material of the pot is biodegradable it takes several years to completely decompose.

R.C.A. (sometimes call A.R.C.) peat sausage (AP) was developed by the Alberta Research Council. The containers were first used in the Maritimes in 1972 by the Maritimes Forest Research Centre. The exact composition of the filling medium is unknown: the only information

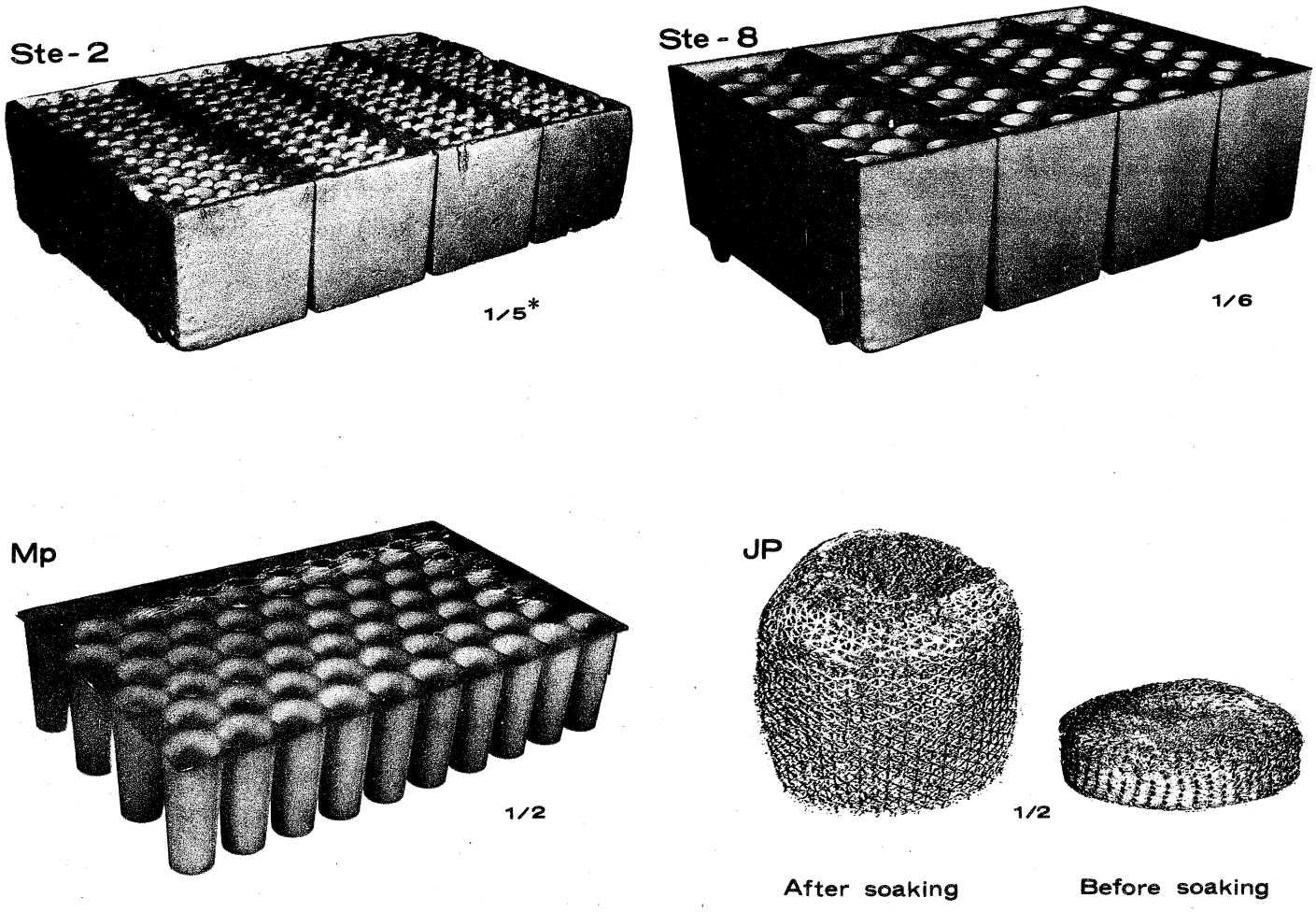

Fig. 1. Containers used in the trial at Ten Mile Lake. Fractions beside the individual figures indicate the ratio of the actual height of the container.

available is that the peat was forced through a die into the thin-walled tubular polyethylene case as a fluid paste, providing a denser medium than that in the other containers used in this study. The case is not biodegradable. According to Ferdinand *et al.* (1974), the compacted peat is supposed to give superior field survival and to ease dudding, reseeding, and handling. In this study, three forms of the peat sausage were used: plugs in intact case (Ap), plugs in perforated case (App), and plugs removed from the case at the time of planting (Awp).

Table 1. Dimensions of containers used in the experiment at Ten Mile Lake

Container type	Abbreviation	Top Diameter (cm)	Depth (cm)	Volume (cm^3)
Peat pot, round	PP	6.0	8.0	157
Jiffy 7 pellet	JP	4.5	4.5	72
R.C.A. peat sausage*		2.5	12.7	64
Swedish multipot	Mp	3.3	8.0	53
Styroblock 2, BC/CFS	Ste 2	2.5	11.4	40
Styroblock 8, BC/CFS	Ste 8	3.9	15.2	125

*R.C.A. peat sausage with intact case, Ap; perforated case, App; without case, Awp.

SEEDLING PRODUCTION

Seedlings used in this study were grown in 1972 in the greenhouse at the Maritimes Forest Research Centre, Fredericton. Seeds of Norway spruce were collected from a 45-year-old stand at Harmony, Queens County, Nova Scotia, 25 miles west of the study area. Black spruce seeds were from Lac La Ronge, northern Saskatchewan. All seeds were tested in 100% alcohol for viability and cleaned to obtain maximum germination, thus eliminating the necessity of reseeding. The R.C.A. peat sausage containers and the Jiffy pellets contained commercial growth media supplied by the manufacturers; the other containers were filled by hand with a mixture of sterilized moist peat moss and coarse vermiculate (3:1 by volume) and the surface was covered by a layer of sand. The medium was packed by shaking the trays up and down, then tamping with a brush.

Two or more seeds per cavity were sown during the week of 20 February. Germination of both species started on 28 February and within the next five days most seeds had germinated. After germination, the media were kept moist by watering with a fine spray for at least one hour per day, depending on the temperature and humidity in the greenhouse. After 3 or 4 weeks, when the stem and the first true needles appeared, a water soluble commercial fertilizer (RX-30), at a rate of 1 tablespoon to 4 litres of water, was used every 2 weeks until the middle of June. The seedlings were then moved to outdoor cold frames under partial shade at the field station in Caledonia, Queens County, N.S., for hardening prior to field planting. During the growing season in 1972, precipitation at Caledonia was adequate and the seedlings did not require additional water. Some seedlings were damaged before being outplanted in late August. Lepidoptera larvae infested the stems, mice chewed the needles and bark, and a species of Chironomidae fed on dropped needles. Some species of Chironomidae infest the roots and stems of small seedlings if the soil is very damp; this condition occurred several times while the seedlings were in the cold frame.

DESIGN AND SAMPLING

Containerized seedlings were planted in parallel rows, 100 per plot. A 'Pottiputki' planting tool was used to plant seedlings grown in Styroblock and R.C.A. peat sausage containers. This planting tool is 93 cm long, 50 mm diameter, and weighs 2.5 kg. The planting depth can be adjusted and the tool is easy to use without stooping. A dibble bar was used for Swedish Multipot containers; the other containers were planted with a spade.

Seedling survival and height growth were assessed immediately before planting. In September 1973, after one growing season in the field, survival and frost heaving were assessed. In August 1975, the seedlings were again assessed for survival, frost heaving, height increment, and root collar diameter. At the same time, 20 randomly-selected seedlings in each container type were dug up, the roots were

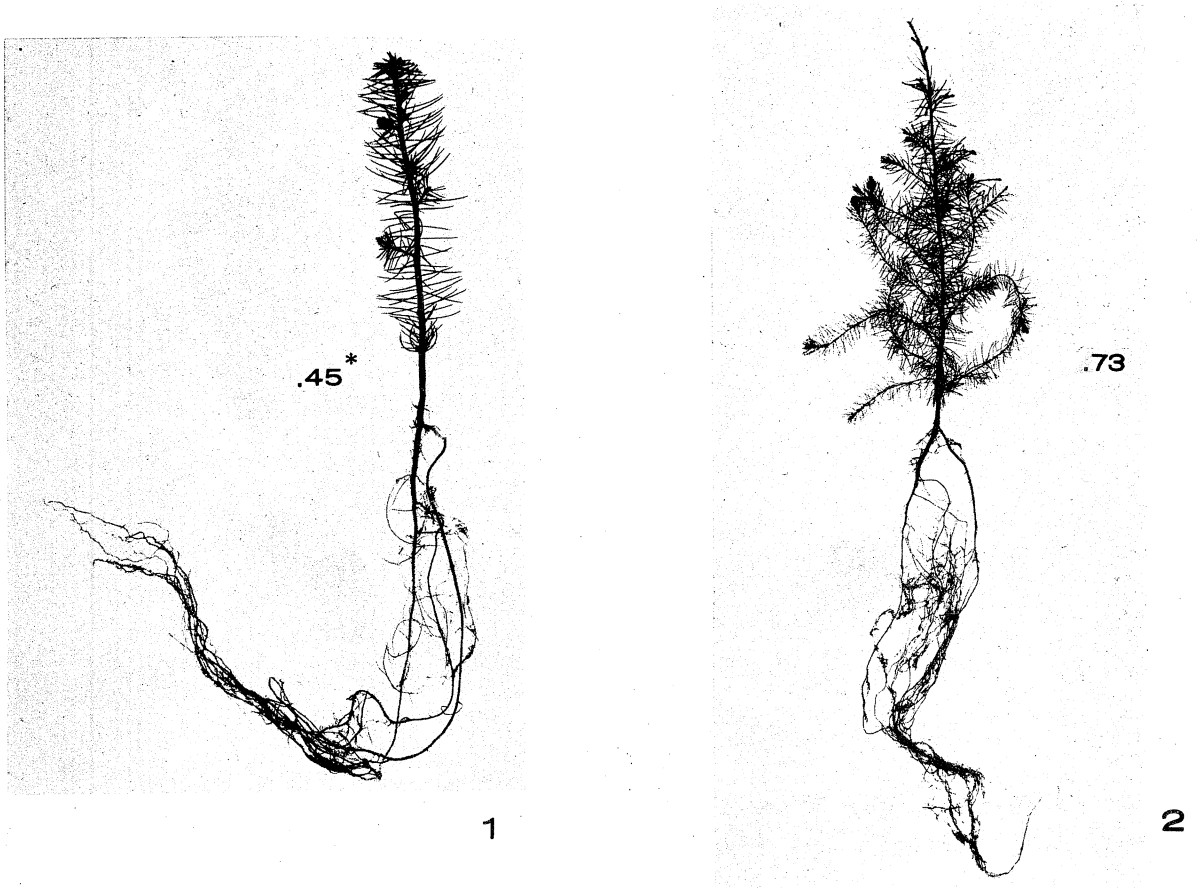

Fig. 2. Representative 6-month-old seedlings of Norway spruce (1) and black spruce (2) grown in Styroblock 8 containers. *Shoot/root ratio by length.

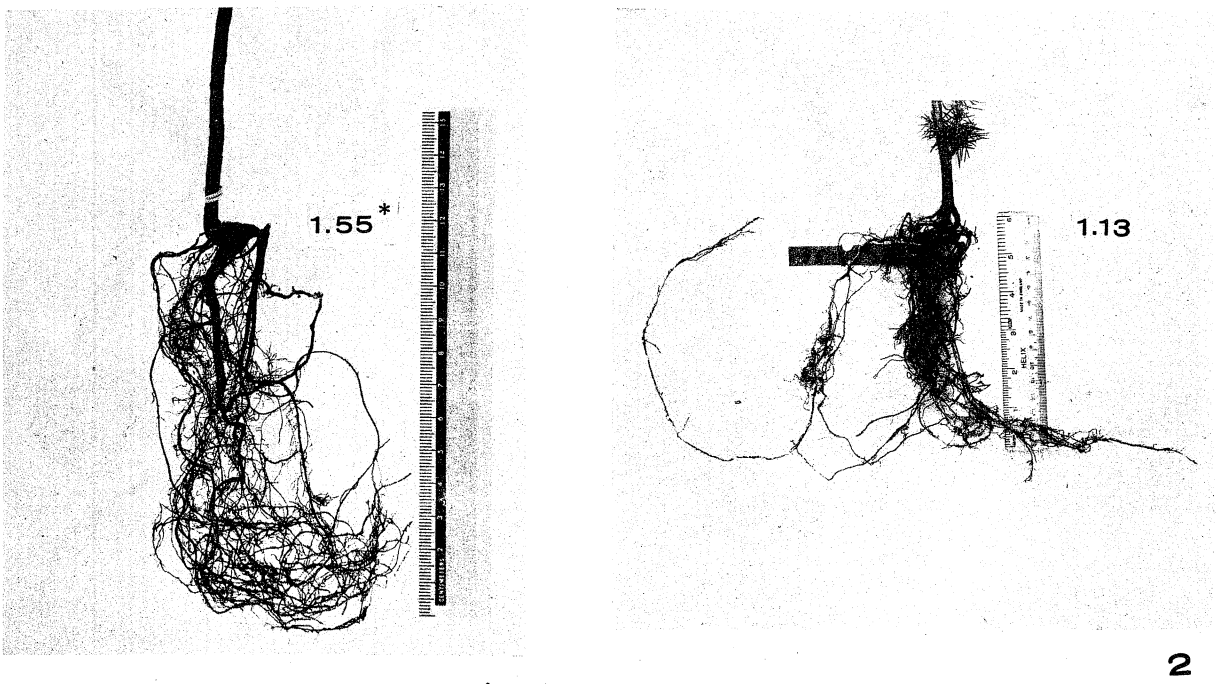

Fig. 3. Representative 42-month-old root systems of Norway spruce (1) and black spruce (2) grown in Styroblock 8 containers. *Shoot/root ratio by length.

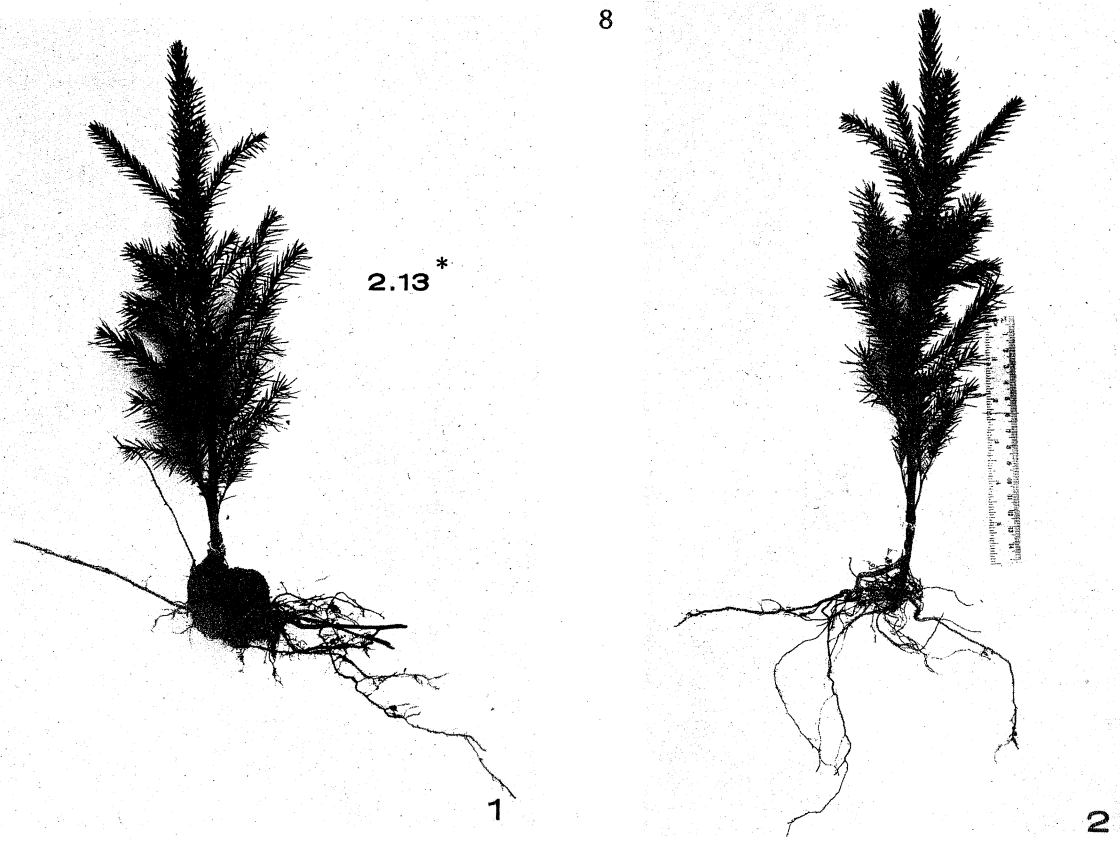

Fig. 4. Representative 42-month-old Norway spruce seedlings grown in Jiffy pellets; (1) in pellet, (2) pellet removed. *Shoot/root ratio by length.

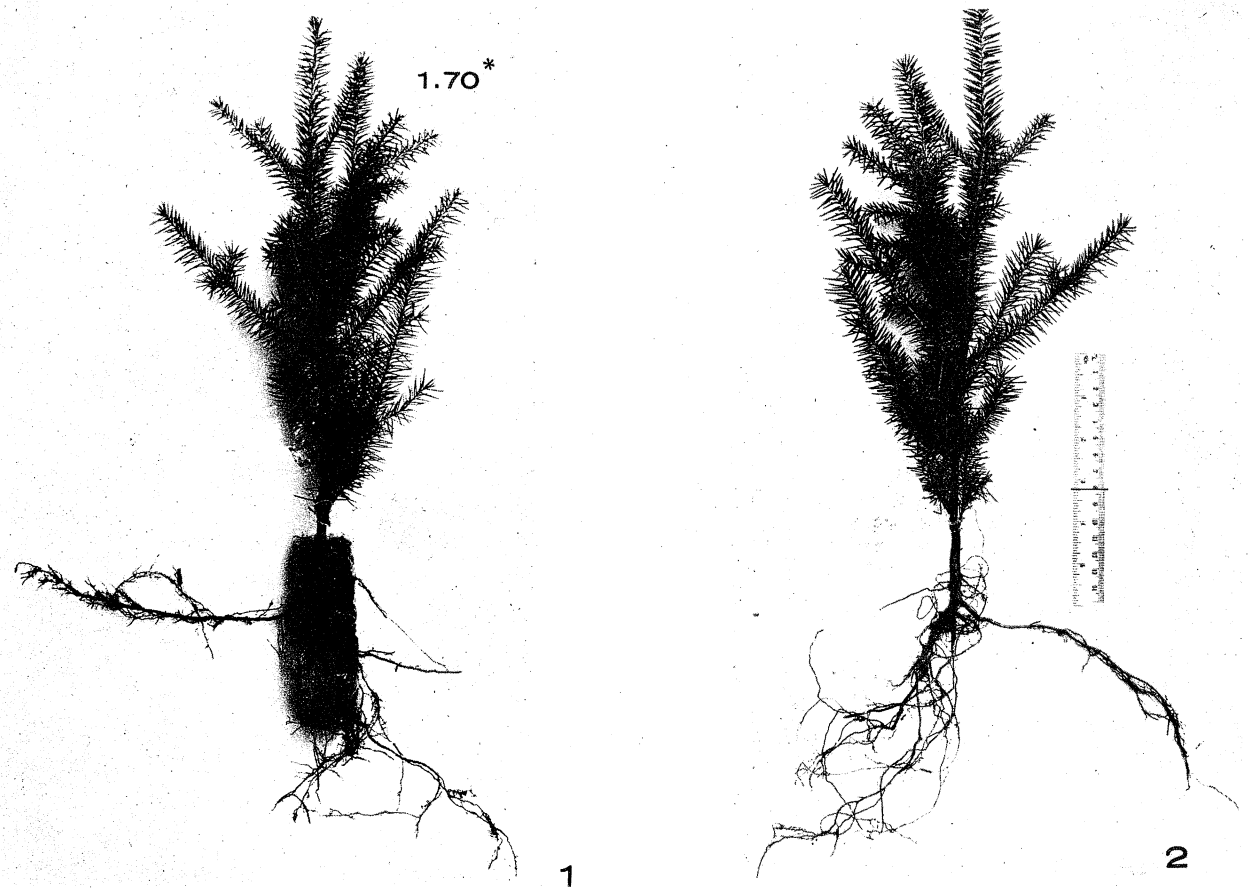

Fig. 5. Representative 42-month-old Norway spruce seedlings grown in R.C.A. peat sausage with perforated case; (1) in case, (2) removed from case. *Shoot/root ratio by length.

washed and the shoot and root lengths measured. They were then dried in an oven at approximately 85°C, and the stem and root were separated and weighed individually. Root development of each seedling was recorded and one or two seedlings from each container type were photographed (Figs. 2, 3, 4, 5).

RESULTS

Survival

Average survival of seedlings in the greenhouse was about 95%. During the hardening off period, from June until the end of August, 15% of the seedlings died from damage, as noted earlier.

Survival in 1973, 1 year after planting, exceeded 80% for both species in most containers (Table 2). The poorest survival for bS was in the R.C.A. peat sausage without case (75%), and for nS, in the round peat pot (also 75%).

Survival in 1975, 3 years after planting, was best (91%) for bS reared in multipots, but both sizes of Styroblocks, Jiffy 7 pellets, and the R.C.A. peat sausage with intact case gave survival rates in excess of 80% (Table 2). However, about 30% of the latter were frost heaved. Survival of nS was best (87%) in the R.C.A. peat sausage with perforated case, and exceeded 70% in both sizes of Styroblocks and the R.C.A. sausage without case.

Survival was poorest for bS in the R.C.A. peat sausage without case (69%), and for nS in the R.C.A. peat sausage with intact case (63%).

Frost heaving was worst (ca. 30%) for seedlings of both species grown in the R.C.A. peat sausage with intact case (Table 2). Most of the frost-heaved nS died in the first year, but many frost-heaved bS survived because their roots penetrated the soil through the bottom opening of the container and anchored the seedlings to the ground.

Containers with a smooth unperforated case were prone to frost heaving. Generally, survival was best where there was no case or where the case was well-perforated.

Table 2. Field performance of Norway and black spruce seedlings, germinated in February 1972 and planted at Ten Mile Lake in August 1972

Container	Number of seedlings planted		Top length at planting (cm)		Height increment in 3 years (Aug.'72-Aug.'75) (cm)		Number of seedlings frost-heaved up to Aug.'75		Survival in Sept. 1973 %		Survival in Aug. 1975 %	
	nS	bS	nS	bS	nS	bS	nS	bS	nS	bS	nS	bS
Ap	144	152	5.1	4.0	18.2	23.1	45	48	78	90	63	82
App	40		5.1		22.9		20		90		87	
Awp	159	192	5.1	4.0*	19.0	27.6	6	10	80	75	72	69
Jp	78	125	7.0	7.0	21.7	28.5	0	3	95	94	65	84
Mp	313	60	4.8	8.0	23.0	30.2	0	0	80	96	66	91
PP	23	173	5.0	5.0	16.0	27.7	0	6	75	81	70	77
Ste 2	464	120	5.6	7.0	22.5	23.5	6	3	80	92	73	84
Ste 8	180	141	8.3	8.0	23.1	26.5	0	4	95	90	79	86
Total	1424	1048					77	74				
Mean			6.0	6.50	20.8	26.7			84	88	72	82

*Initial top length of the seedlings reared in R.C.A. peat sausage was measured before removing the plug from the polyethylene film case.

Height and Diameter Growth

Data on height increment for the three years after planting and on total height attained during the study period of four years are presented in Tables 2 and 3. Height growth of bS was generally superior to that of nS in all container types. In terms of height, nS grew best in Styroblock 8, Jiffy pellets, and peat pots, while bS grew best in Multipots, Jiffy pellets, and Styroblock 8.

Norway spruce seedlings had the largest root collar diameters when grown in Styroblock 8, and the smallest in peat pots. Black spruce seedlings had the largest diameter in Swedish multipots and the smallest in peat sausage plug in intact case (Ap). There was little difference between the two species in terms of overall average root collar diameter growth.

Root Growth

Although characteristic root development was observed in each of the container types, differences did not become fully apparent until the time of outplanting. The conical cavity of most containers directed the roots toward the bottom-hole where root pruning was achieved in the air space. Fig. 2 shows 6-month-old seedlings of Norway and black spruce which were lifted from the containers at the end of the 6-7 month hardening off period. The main roots had extended from the container into the soil through the drainage hole. Fig. 2 shows that Norway spruce tended to develop a larger root system than black spruce.

Data on root development 42 months after seeding are presented in Table 3. Both species of seedlings produced the largest root systems in Styroblock 8 containers. Norway spruce grew the poorest roots in peat pots, and black spruce in intact R.C.A. peat sausage.

Shoot/root ratio

Table 4 summarizes the data on shoot/root ratio by length (cm) and by weight (mg) 42 months after seeding. Black spruce generally had a greater shoot/root ratio than Norway spruce. Both species showed their largest shoot/root ratios when grown in Jiffy pellets. Apparently, the NPK fertilizer used by the manufacturer in the Jiffy pellet media was responsible for the relatively greater shoot growth.

Table 3. Field performance of Norway and black spruce seedlings in August 1975, 42 months after seeding

Container Type	Norway Spruce					Black Spruce				
	Length (cm)		Weight (g)		Root Collar	Length (cm)		Weight (g)		Root Collar
	Top	Root	Top	Root	Diameter (mm)	Top	Root	Top	Root	Diameter (mm)
Ap	23.3	21.3	6.5	1.0	4.4	27.1	20.2	3.3	0.5	3.4
App	28.0	19.2	7.0	1.3	5.4					
Awp	24.1	19.7	6.5	1.2	5.0	31.6	18.8	7.5	1.0	4.8
JP	28.7	17.6	7.4	1.0	5.2	35.5	17.0	8.2	0.9	4.9
Mp	27.8	20.6	8.1	1.3	5.0	38.2	20.7	13.4	1.5	6.0
PP	21.0	16.5	3.2	0.7	3.6	32.7	20.4	7.8	1.9	4.9
Ste 2	28.1	21.0	5.8	1.3	5.3	30.5	19.5	7.5	1.4	4.8
Ste 8	31.3	27.2	12.2	2.8	6.5	34.5	25.8	11.1	2.2	5.8
Mean	26.5	20.4	7.1	1.3	5.1	32.9	20.3	8.4	1.3	4.9

Table 4. Shoot/root (S/R) ratio of seedlings, length and weight, 42 months after seeding

Container	Norway spruce		Black spruce	
	length	weight	length	weight
Ap	1.1	6.3	1.3	6.7
App	1.5	5.8	-	-
Awp	1.2	5.3	1.7	7.7
Jp	1.6	7.2	2.1	9.1
Mp	1.3	6.2	1.9	8.7
PP	1.3	4.9	1.6	4.0
Ste 2	1.4	4.3	1.6	5.6
Ste 8	1.2	4.4	1.3	5.0
Mean	1.3	5.5	1.7	6.7

DISCUSSION AND RECOMMENDATIONS

This study was initiated to determine the types of containers most suitable for producing seedlings for use on cut-over areas in southwestern Nova Scotia. Paper pot containers were excluded from the study because they were already being widely used in Nova Scotia when this study started and it appeared that sufficient data were available on their suitability.

Forty-two months after seeding, this study suggests that Styroblock 8 containers are best for growing Norway spruce, and Swedish multipots for black spruce. The containers are ranked in Table 5 according to the relative quality of the seedlings produced in them. Styroblock 8, Swedish multipot, and R.C.A. peat sausage in perforated case can be successfully used to establish Norway and black spruce plantations in humic-podzol soils on cutovers of southwestern Nova Scotia. In these three types of container, seedlings have a high rate of survival and early growth despite their small size (about 6 cm tall) when planted.

In the experimental area, all seedlings in all container types escaped planting check, which is very common in bare-root transplants during the first 3 to 5 years after planting. There was little competition from ground vegetation during the study period because the area had been

Table 5. Ranking of containers based on seedling performance

Criteria	Norway Spruce								Black Spruce						
	Ap	App	Awp	JP	Mp	PP	Ste2	Ste 8	Ap	Awp	Jp	Mp	PP	Ste 2	Ste 8
Height increment	2	5	1	7	4	8	6	3	7	4	2	1	3	6	5
Frost-heaving	4	3	2	1	1	1	2	1	6	5	2	1	4	2	3
Survival	8	1	4	7	6	5	3	2	4	6	3	1	5	3	2
Top-length	7	4	6	2	5	8	3	1	7	5	2	1	4	6	3
Root collar diam.	6	2	5	4	5	7	3	1	5	4	3	1	3	4	2
Shoot weight	5	4	5	3	2	7	6	1	6	5	3	1	4	5	2
Root weight	4	2	3	4	2	5	2	1	7	5	6	3	2	4	1
Overall Ranking	7	2	5	6	3=	8	3=	1	7	6	3	1	4	5	2

cleaned before planting. Seedling performance in the peat sausage was not satisfactory on sites where mineral soil was exposed by the bulldozer while cleaning the area. The high number of peat sausages that frost heaved (Table 2) strongly suggests that packed plugs, particularly those with unperforated cases, have little future for planting in clay and loamy clay soil. This type of plug absorbs a great deal of water during the fall and holds the moisture until heavy frost occurs, usually in early December. The freezing peat plug then swells and pushes out of the planting hole. Where an adequate surface humus layer covers the mineral soil, the moisture content of the humus will usually equal the moisture in the plug medium and frost heaving will be reduced.

Seedling parameters indicate that the two species responded in different ways to the various containers both before and after planting. Mean values for survival and height were higher for black spruce than for Norway spruce, suggesting that black spruce may be better adapted to container production. Especially good height growth was recorded for black spruce in Swedish multipots during the entire study period. However, the root system of black spruce tends to be more delicate than that of Norway spruce, resulting in smaller root weights and root collar diameters (Tables 2 and 3) and larger shoot/root ratios (Table 4). Norway spruce has a marked tendency to develop a strong tap root system; the typical pattern is illustrated in Figs. 2 and 3. The larger root system of the Norway spruce did not however, contribute to better growth after planting, because side roots did not tend to escape from the plug. In contrast, it was observed that spruce started to produce new fibrous roots soon after planting. Kramer (1960) stated that seeding development and survival depends principally on its ability to produce new roots immediately after planting.

Although the study was limited to one site, several other inferences of general relevance, can be drawn from the results:

1. Before planting container seedlings in cutover areas of humic podzol soils, it is more advantageous to remove the slash with a light bulldozer or to lightly scarify the area than to cultivate the soil with plows or other heavy equipment that scrapes off the forest floor. Heavy equipment tends to expose the mineral soil, which in turn results

in an increased incidence of frost heaving. Usually the removal of ground vegetation is necessary during the first three or four years after planting because the seedlings are not able to compete with ericaceous shrubs common in southwestern Nova Scotia.

2. It is usually more important to take advantage of microrelief while planting than to follow a strictly regular spacing. Old stumps, rocks, pieces of logs, creeping roots on the surface of the ground, etc., protect seedlings from solar radiation, frost exposure, wind, and other adverse biotic or abiotic factors. Also, the protected spaces accumulate well-aerated humus and hold moisture longer during dry spells. Seedlings planted in mineral soil will often frost heave, especially when planted in tightly packed plugs or in smooth-surfaced containers.

3. Special planting tools such as Pottiputki and Swedish planting bars should be used to set out containerized seedlings. These bars are the same size as the peat plugs, thus ensuring an optimum bond between the seedling and the soil and consequently the continuation of uninterrupted absorption of moisture from the soil. In addition, the appropriate planting bar controls the depth of the hole, so that it corresponds to the depth of the container plug. For black spruce, it is important to plant the plug the proper depth, not too deep, because black spruce has shallow fibrous roots that prefer to extend into well-aerated humus. Reese (1974) observed that typical containerized spruce seedlings have roots radiating in all directions from the root collar. The main benefit of removable containers or cases is that the seedlings, after outplanting in the field, will be able to develop a well-balanced root system, thereby maintaining an adequate water relationship with the surrounding soil during the initial establishment period.

4. Inducement of air root pruning is not recommended during the hardening off period. It is considered preferable to place the containers on ground covered with coarse sand; this encourages increased root development and slow stem growth which is desirable to provide a more balanced ratio between shoots and roots. A high shoot/root ratio by weight, or by length, such as those for seedlings grown in Jiffy 7 pellets (Table 4), is not desirable. A high ratio indicates too large a stem which will suffer after planting when water stress becomes severe.

This seedling can be expected to wilt or die, bend to the ground, or break from wind or snow. Tap roots extending through the drainage holes at the bottom of the containers during the hardening off period should be pruned before transporting to the field, to decrease the shipping volume, or before planting, to ease extraction of seedlings from the containers. Root pruning at this stage will not inhibit the development of a strong root system, rather it will stimulate the growth of fibrous lateral roots after out planting. (Stoeckeler and Slabaugh, 1965).

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