PAPERPOT STOCK PERFORMANCE ON AN UPLAND CLAY SITE SCARIFIED BY A MARTTIINI FOREST PLOW-- EFFECT OF PLANTING POSITION

C. R. MATTICE

GREAT LAKES FOREST RESEARCH CENTRE

SAULT STE. MARIE, ONTARIO

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Information Office
Great Lakes Forest Research Centre
Canadian Forestry Service
Department of the Environment
Box 490
Sault Ste. Marie, Ontario
P6A 5M7

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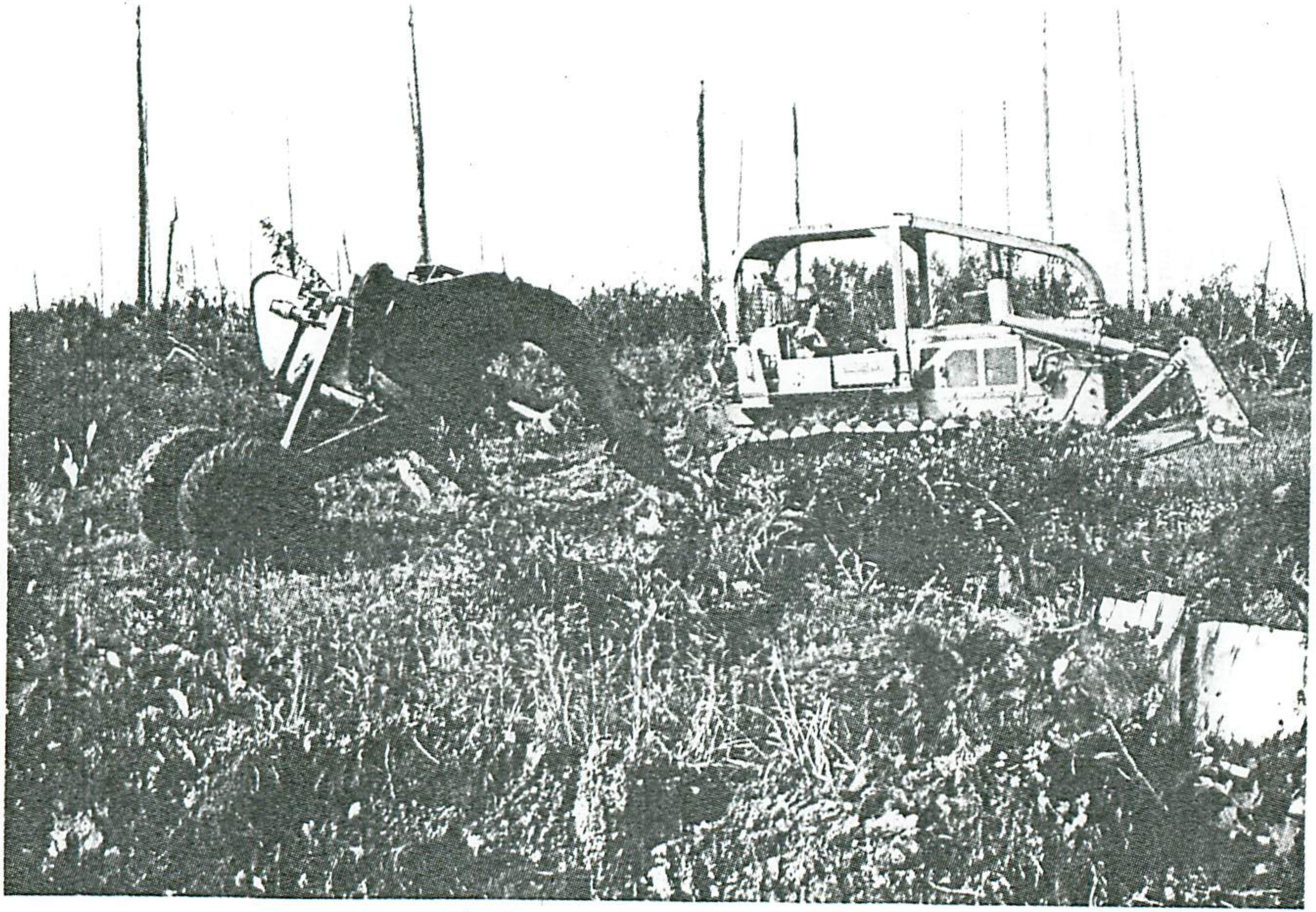

Frontispiece. The Marttiini Forest Plow.

ABSTRACT

White spruce (*Picea glauca* [Moench] Voss) and black spruce (*Picea mariana* [Mill.] B.S.P.) Japanese paperpot seedlings were planted in northern Ontario's Clay Belt on a clay cutover site that had been scarified with a Marttiini Forest Plow. Better seedling performance was obtained on the flat shoulder near the base of the spoil bank than on the top of the spoil bank or on the shoulder near the top of the trough. Sixteen-week-old greenhouse-grown stock of both species, planted in late spring or early summer, performed best in this position. The only treatment that proved successful three years after planting was the spring-planted white spruce, which had 88% survival and reached a height of 18.2 cm.

RÉSUMÉ

Des semis d'Épinette blanche (*Picea glauca* [Moench] Voss) et d'Épinette noire (*Picea mariana* [Mill.] B.S.P.) en godets de papier japonais ont été plantés dans la ceinture d'argile du nord de l'Ontario sur une station coupée à blanc qui avait été scarifiée avec une charrue forestière Marttiini. Les semis ont mieux produit sur l'épaulement plat près de la base du talus formé par le surplus de déblai que sur le sommet de celui-ci ou bien sur l'épaulement avoisinant le sommet de la rigole. Elevés en pépinière, les semis de seize semaines des deux essenses ont donné un meilleur rendement à cet endroit. Le seul traitement qui se soit avéré un succès trois ans après le plantage a été l'Épinette blanche plantée au printemps, dont la survie s'est établie à 88% et la hauteur a atteint 18.2 cm.

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INTRODUCTION

The Marttiini Forest Plow is a towed, curved, V-blade supported by two large rubber-tired wheels (frontispiece). The depth to which the plow scalps is adjustable hydraulically for different site conditions. Its ruggedness and ability to provide local drainage of its scalp make it very attractive as a scarifier for upland clay sites.

The purpose of this experiment was to determine which of the potential planting positions or plantable microsites created by this scarifier resulted in the best performance of paperpot stock. Since white spruce (*Picea glauca* [Moench] Voss) and black spruce (*Picea mariana* [Mill.], B.S.P.) are planted on these sites, both were included in the experiment. Because we expected to find relative differences in the various microsites between the spring and summer, planting treatments were carried out in both seasons.

Plot Location and Site Description

The experimental area is located 60 km east of Cochrane, Ontario in the southwest quarter of Challies Township (49°6' N. Lat., 80°13' W. Long.).

The site, which slopes moderately (8-15%) to the southeast (Fig. 1), is part of the lakebed of glacial Lake Ojibway. The soil is a deep, relatively stone-free clay. Before it was harvested it supported a mature forest of white spruce, black spruce, balsam fir (*Abies balsamea* [L.] Mill.) and white birch (*Betula papyrifera* Marsh.). This is a very common forest type in the Northern Clay Section of the Boreal Forest Region (Rowe 1972).

The climate of northern Ontario has been termed "modified continental" by Chapman and Thomas (1968). The modification in the Northern Clay Belt Climatic Region is provided more by Hudson Bay and James Bay than by the Great Lakes. With a mean temperature of 5.6°C the growing season averages 160 days, and usually begins in the first week of May. Although the mean annual temperature is only 1.1°C, mean monthly temperatures of approximately 15°C are normally attained during June and July. The mean May to September precipitation for the area is 45.2 cm.

Site Preparation

The site was clearcut in 1967-1968 and scarified during the fall of 1974 with a Marttiini KLM 240 Forest Plow drawn behind a Komatsu D65A crawler tractor. This scarifier produces a central trough, with a relatively flat shoulder on each side and a spoil bank of scalped and excavated material along the outside edges. The swath modified by the plow is approximately 3.4 m wide with 50, 35 and 15 percent of that width in spoil bank, shoulder, and trough, respectively.

On upland sites where the duff is thin (0-10 cm) scalping was shallow to minimize exposure of the clay mineral soil, and consequently the spoil banks were discontinuous along the edges of the swath.

Fig. 1. Plot area 4 years after planting.

EXPERIMENTAL DESIGN

The experiment was a completely randomized factorial design, with two factors: species and planting treatment (the latter an amalgam of planting date and microsite or position). Although the design required planting four replicates of 25 seedlings per treatment, stock shortages and failure of the planting tools resulted in fewer replicates for some of the summer treatments. Table 1 indicates treatments, number of replicates planted and initial sample size. In addition, the summer plant on the spoil bank was not undertaken because suitable planting spots could not be found for the spring plant.

Rigorous definitions were not established for the three planting positions used in this experiment. However, for the planting position at the top of the spoil bank, only those microsites on which there was considerable mounded clay (i.e., mounds more than 50 cm high) in firm contact with the original soil surface were selected for planting. Two shoulder positions were chosen only where the shoulder width exceeded approximately 40 cm. Where this occurred, the inner shoulder was within 10 cm of the base of the spoil bank, and the edge of the shoulder within 10 cm of the lip of the trough. For both shoulder positions, most of the seedlings were planted in exposed clay soil. This was necessitated by the very infrequent presence of the organic horizons in the shoulder.

Table 1. Replication and sample size by treatment.

Species	Planting treatment		Number replicates	Sample size
White spruce	spring plant:	spoil bank	4	100
		inner shoulder	3	75
		edge shoulder	4	100
	summer plant:	inner shoulder	2	50
		edge shoulder	3	75
Black spruce	spring plant:	spoil bank	4	100
		inner shoulder	4	100
		edge shoulder	4	100
	summer plant:	inner shoulder	2	50
		edge shoulder	2	50

PLANTING STOCK AND ITS ASSESSMENT

Stock for the spring planting was an overwinter product sown during May of the year prior to outplanting. Stock for the summer planting was sown during February in the year of planting. Both products were raised in a heated greenhouse using growing regimes developed at the Great Lakes Forest Research Centre. With the completion of production, stock was moved to a shadehouse for hardening off. Once acclimatized, stock was exposed to full sunlight and remained at the Centre until shipment. Plywood racks enclosed on all sides except the front (Fig. 2) were used to transport stock to the planting site where it was off-loaded and held for planting. Table 2 shows the date on which the production and outplanting started and the duration of the summer component periods.

Fig. 2. Plywood racks used in transporting paperpot planting stock.

Samples were collected from each stock type for detailed laboratory measurements. For the overwinter and current-year stock, samples of 50 and 20 seedlings, respectively, were measured. Measurements included shoot length, root collar diameter, oven-dry weight and shoot/root ratio based on oven-dry weights. Samples were bulk-weighed to reduce the work involved. Therefore, no data are available to indicate variation about the mean for either shoot/root ratio or dry weight.

In the evaluation of seedling performance, percent survival, seedling condition, shoot height, and height increment were determined at the end of the first, second, and third growing seasons. In the determination of percent survival, seedlings were considered alive if they had any live buds or foliage. Seedling condition (Scarratt 1974) is a subjective measurement of seedling vigor which integrates foliage length, diameter, density, color, stem caliper, form and growth. The four condition classes used are described in the Appendix. Total height is, in effect, total aboveground shoot length. Height increment is generally a measure of the length of leader or lateral shoot most likely to develop that status because of its length, vigor and position on the main stem. One must use considerable judgment in making each of these observations or in taking measurements.

Table 2. Starting date and duration of production and outplanting.

Production and outplanting periods	Start/duration by stock type			
	Overwintered		Current year	
	Start (mo/day)	Duration (day)	Start (mo/day)	Duration (day)
Production - greenhouse culture	5/15[a]	108.0	2/7	89.0
- nursery holding	9/1[a,b]	288.0	5/6	72.0
- shipment	6/14	1.0	7/17	1.0
Outplanting - field holding	7/14	.5	8/17	.5
- planting	7/14	2.0	8/17	1.0
	Total	399.5		163.5

[a]Dates apply to year prior to shipment.

[b]Since the exact date on which stock was moved to the shadehouse was unknown, the first day of the week during which stock was moved has been used.

RESULTS

Changes in percent survival and total height, the two most common measures of stock performance, are presented in Figure 3 for each of the planting treatments. Note the loss in mean total height from time of planting to assessment at the end of the first fall. For both species and both planting dates, stock planted on the inner shoulder has consistently performed best in terms of percent survival condition of living seedlings, and total height.

To provide further insight into the performance of surviving seedlings, the percentage of live seedlings in the best condition classes are combined with percent survival in Figure 4. Since very few seedlings were poor enough to be included in the worst condition class, the remaining seedlings that survived are essentially Class 3 seedlings. By the third fall assessment, only spring-planted white spruce, planted in the inner shoulder position, had more than 50 percent of its planted seedlings in the two superior condition classes.

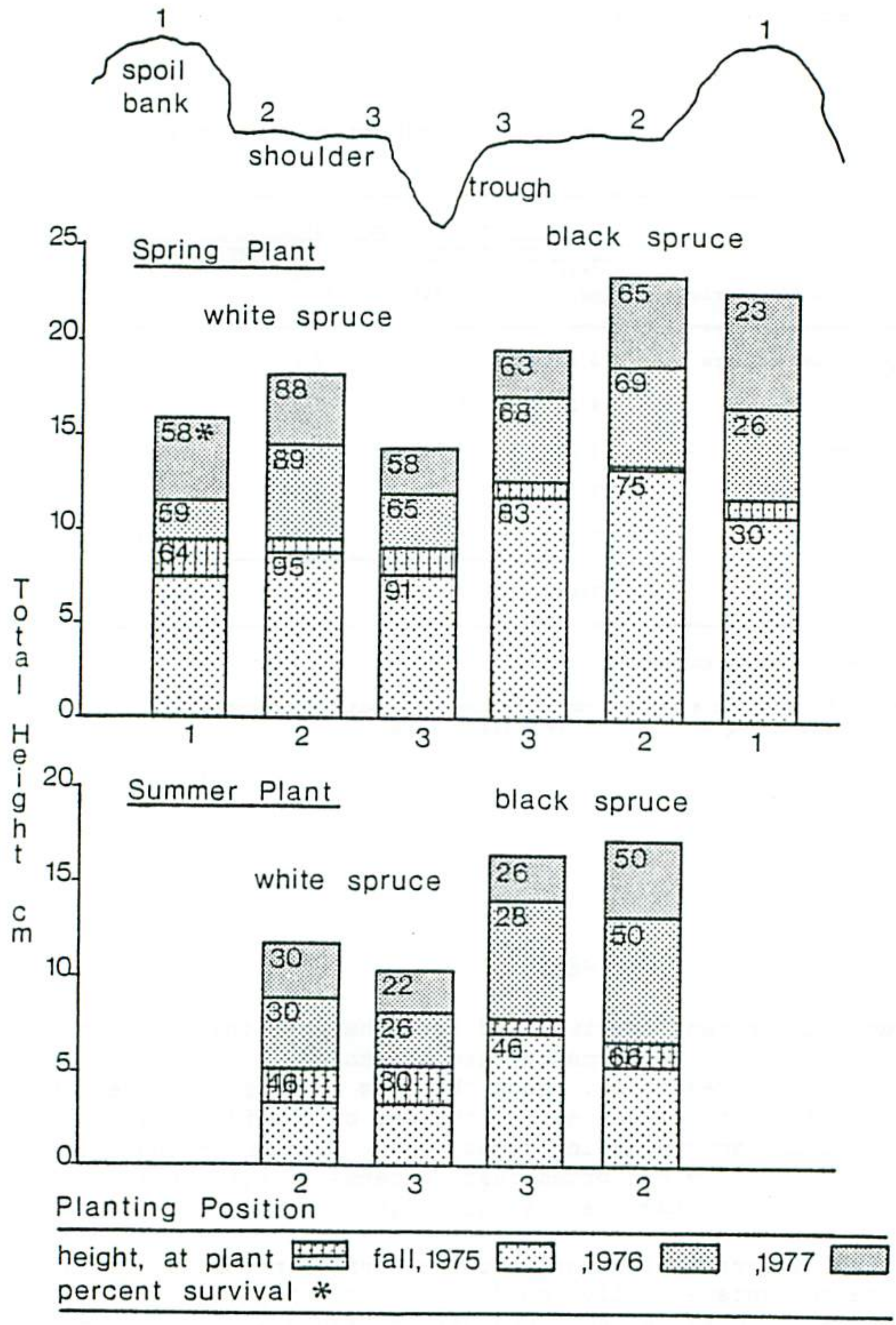

Fig. 3. Total height and percent survival by treatment.

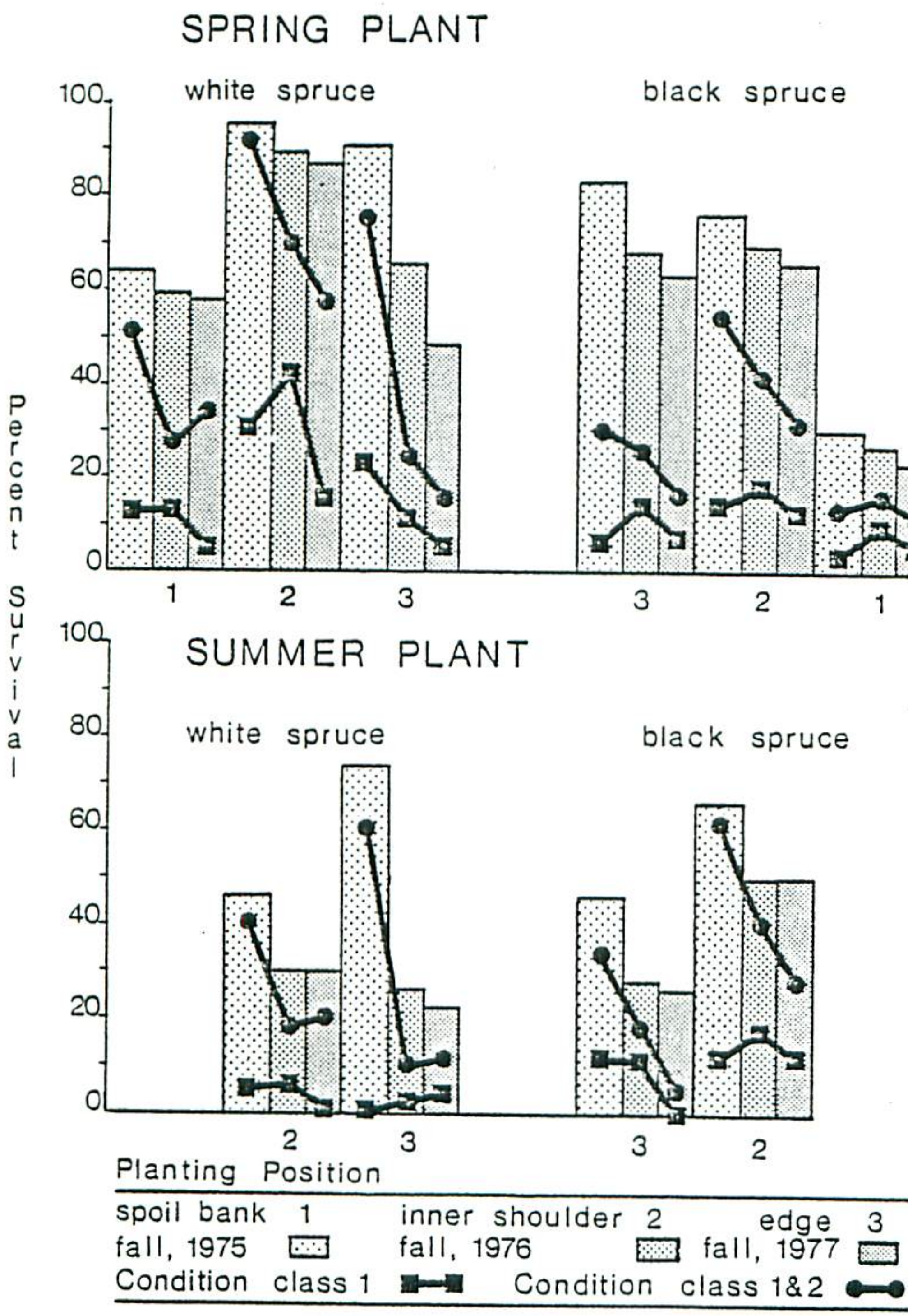

Fig. 4. Percent survival and seedling condition by treatment.

DISCUSSION

Growth data for planting stock characteristics given in Table 3 reveal that black spruce stock was taller, larger in stem caliper and heavier than its white spruce counterpart. For each species, the overwinter product was superior to the current-year product. If we accept that a lower shoot-root/root ratio is also preferable, the same relativities exist, with the exception that the current-year white spruce product had a lower ratio than its black spruce counterpart.

Table 3. Growth data for planting stock at time of planting.

Species/stock type[a]	Statistic	Seedling parameter Shoot length (cm)	Root-collar Diameter (mm)	Shoot/root ratio -	Oven-dry weight (mg)
Overwintered planting stock					
White spruce 74-2 paperpot 308	mean	6.7	1.2	3.7	240
	S.D.	1.2	.15	-	-
	C.V.	.179	.124	-	-
Black spruce 74-2 paperpot 308	mean	9.4	1.3	3.4	285
	S.D.	2.3	.33	-	-
	C.V.	.245	.246	-	-
Current-year planting stock					
White spruce 75-1 paperpot 308	mean	5.0	.9	4.0	175
	S.D.	0.5	.13	-	-
	C.V.	.100	.149	-	-
Black spruce 75-1 Paperpot 308	mean	7.3	.9	5.1	180
	S.D.	2.5	.16	-	-
	C.V.	.342	.180	-	-

[a]The designation "74-2" identifies the second crop in 1974 and "308" the paperpot size.

Analysis of variance among the various stock types, in terms of mean initial height measured immediately after planting, indicates that only some of the height differences among the stock types were significant (P.01). For both species the overwinter product is significantly taller. In comparisons of treatments differing only in species, only the overwinter black spruce was significantly taller than its white spruce counterpart. However, there are no significant differences in height for treatments differing only in planting position.

Scarification with the Marttiini plough created four categories of planting position or plantable microsites, each with several discernible variants. The fourth position was the central trough or furrow with variants derived from depth and slope of trough. Variants of the spoil bank were derived from variation in amount of slash and litter sandwiched under the clay cap and position on the bank itself--top versus slope. Variants of the shoulder position depended upon the degree to which the surficial organic horizons were truncated by the scalping, and the width of the shoulder. With a narrow "shoulder" there would be no difference between an inner and an outer edge.

None of the furrow microsites were tested because of the high seasonal risk of flooding. It is also well established that planting in exposed clay soil results in considerable frost-heaving of seedlings in the boreal climate. Therefore, the certainty that clay would be exposed in the furrow ruled out the use of this position. Conversely, seedlings were planted in the clay on the "shoulder" positions to see if the localized drainage of air and ground water as well as the deposition of soil eroded from the spoil banks would offset the normally high incidence of heaving in the clay. Planting on the spoil bank was not repeated in the summer. Experience gained in the spring-plant proved that on this site the spoil banks were discontinuous along the rows, with a high degree of slash and litter incorporated in the mound; consequently, it was not a suitable operational alternative.

An examination of stock performance to the end of the third fall after outplanting showed that planting in the "inner shoulder" position resulted in performance consistently superior to that in the other planting position with respect to percent survival, condition of living seedlings, and total height. However, an analysis of the variance among treatments for percent survival, total height, and percent increase in total height indicates that there were no significant differences (P.01) for any of the treatments that differed only in planting position. In subjecting treatment means to Scheffe's Means Test in which the treatment means are ranked, we found that only the extreme results in seedling performance were significantly different from each other (P.01).

Figure 4 shows that seedling condition decreased more rapidly over time than did percent survival, especially for stock planted in the shoulder position between the second and third assessment (i.e., over the second year after outplanting). This reflects the development of vegetation on the site, and its adverse influence on seedling performance. Figure 3 shows the same deterioration in height growth in the same position.

Decrease in mean total height in the year of planting for both the overwinter and current-year stock was probably due to physiological causes. The overwinter stock, raised in the milder climate of Sault Ste. Marie, flushed prior to shipment and outplanting. Planting stresses caused this succulent new growth to wilt and die. As well, there was undoubtedly physical damage to the elongated buds during handling, shipment and planting. Similarly, the current-year stock may not have been adequately hardened off, and consequently the more succulent tops died back.

The regeneration prescription for the planting chance in which this experiment is located did not include any measure to control vegetation development. Since the success of most of the treatments in this experiment was essentially determined by the end of the year of planting, this was not an important omission. However, for spring-planted white spruce on the shoulder position (i.e., the only successful treatment, effective the last assessment) the decrease in seedling condition and height growth over the second year was not an acceptable development. Control of the vegetation, either as a part of the site preparation process or within two years of planting, could have prevented this. For white spruce, which is partially protected from frost damage by other nearby vegetation, control should not entail a complete destruction of its protective presence.

The development of vegetation on this site was different for the various planting positions. An inspection of the site during the summer of 1979 revealed that competition was most severe on the inner shoulder and least severe on top of the spoil bank. This means that the superiority in performance of stock planted in this position would be decreased by the third fall because of the lack of competition control. Consequently, we abandoned this experiment prior to fifth-year remeasurement.

What is required is a repetition of this experiment with the regeneration prescription altered to include vegetation control and to reduce the depth of scarification so as to leave a part or all of the surface organic layer intact. By having treatments with no vegetation control, with control as a part of site preparation, and with control prior to a decline in seedling condition (perhaps during the second year after outplanting), we could examine the influence of competition on stock performance. By planting only on the inner shoulder with the forest floor intact or only partly truncated in half the treatments and completely removed in the balance, we could examine this factor and its interaction with vegetation control.

CONCLUSIONS

On upland sites with a thin organic horizon over clay soil where the Marttiini Plow is used as the scarifier, seedlings should be planted on the flat shoulder near the base of the spoil bank. Although superiority in performance may never be statistically significant, it is consistently so, and will contribute to improved stock performance.

Suggestions for modifying the regeneration prescription should be tested experimentally before they are accepted as part of operational practice.

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APPENDIX

CLASSIFICATION OF SEEDLING CONDITION

Vigorous seedling	exceptional, fast-growing tree with sturdy stems, healthy green foliage of good length; good form with one straight leader (i.e., continuous axial growth)
Healthy seedling	above-average seedling with good growth stem, may be less sturdy than Class 1 tree and foliage, may be somewhat shorter or more slender; foliage may be slightly yellow; form still generally good, but may have a forked or crooked leader
Mediocre seedling	mediocre seedling generally appearing sickly or stunted; needles may be quite sparse or slender or discolored; may have some defoliation; generally poor form if not sickly, with no well-defined leader; rather a bushy appearance
Moribund seedling	sickly seedling with a poor chance of surviving. virtually no growth or only adventitious shoots; foliage may be badly discolored with considerable defoliation