White Spruce Stock Performance Trial in the Mixedwood Section of Saskatchewan

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FILE REPORT

Abstract

Spring-lifted, **cold-stored,** and fresh-lifted, **hot-planted** white spruce (Picea glauca (Moench) Voss) paperpot, 3+0, 4+0, 2+1 and 2+2 stock planted **May-June** and **August-October** respectively, were evaluated on the basis of survival and height growth after four growing seasons.

Despite favorable height gains and an excellent survival record, both cold-stored and hot-planted paperpots were generally unable to match the total height of alternative stock types tested. Transplant 2+2 stock did best overall, out-performing in descending order, 4+0 and 3+0 bareroot stock, 2+1 transplants and paperpots. Although bareroot and 2+1 transplants exhibited better survival following cold-storage and planting in May through July, the exceptional survival of both 2+2 and paperpot stock under both cold-stored and hot-planted treatments and the superior heights achieved by the latter should prove encouraging to those contemplating a hot-planting program in late summer/early fall.

Acknowledgements

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Introduction

This report evaluates a white spruce stock trial undertaken by Saskatchewan Department of Parks, Recreation and Culture (DPRC) staff in 1975. Involving both cold-stored and hot-planted material, this study compares the performance of five stock types out-planted in May through October. Spring-lifted, cold-stored stock was planted in May through July, followed by fresh-lifted, hot-planted stock in August, September and October. It was hoped that data collected might lend support to increasing containerized seedling operations affording shorter rearing periods, more efficient use of available nursery space and reduced production, handling and planting costs. Extension of the normal spring planting season through the summer and into the fall was also investigated.

Study Area

The trial is located 76 km northeast of Prince Albert, Saskatchewan (Fig. 1), in the Mixedwood Section (B.18a) of the Boreal Forest Region (Rowe, 1972). Prior to harvesting in the summer and fall of 1974 the site supported a white spruce softwood stand (over 75% by volume) in excess of 21 m tall and exhibiting 50-70% crown closure. Level to gently rolling, the site drains to the north and is characterized by sandy clay soils overlain by 5-15 cm of organic matter. In the absence of any special site preparation, duff depth and a heavy root mat made subsequent planting difficult at times.

Methods

The trial was established using a randomized block design with four replications of six treatments (planting dates) per block. Each treatment sub-block consisted of 150 seedlings spaced one metre apart in six rows of 25 seedlings each, each row representing one of five white spruce stock types and one of jack pine (Pinus banksiana Lamb.) (Fig. 2). Due to extensive snowshoe hare (Lepus americanus Erx.) damage to the jack pine following planting, attention here will be focused solely on the performance of white spruce stock types.

Each planting date-stock type combination was therefore represented by 100 seedlings. Sub-block rows 1, 2 and 3 were assigned to spring-lifted, cold-stored stock planted in May, June and July, 1975, respectively; while rows 4, 5 and 6 received fresh-lifted stock hot-planted in August, September and October. Although sub-block rows should also have been assigned on a random basis to maintain complete randomization throughout the study design, this was overlooked to facilitate subsequent remeasurement efforts.

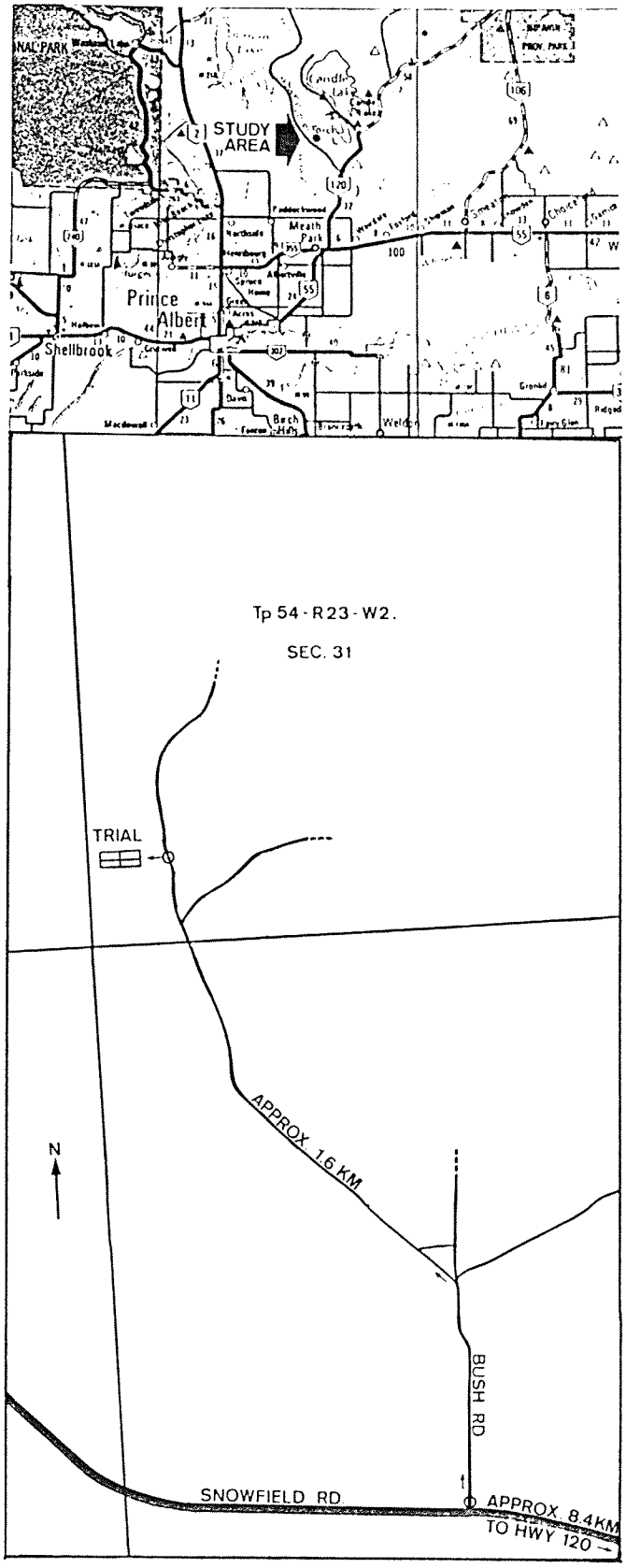

FIGURE 1. STUDY LOCATION

TREATMENT SUBBLOCKS - PLANTING DATE

1 MAY 20 - 23

2 JUNE 16 - 20

3 JULY 14 - 18

4 AUG. 11 - 15

5 SEPT. 8 - 12

6 OCT. 6 - 10

ROWS - STOCK TYPE

1 WHITE SPRUCE 2+2 BARE-ROOT TRANSPLANTS

2 WHITE SPRUCE 3+0 BARE-ROOT

3 WHITE SPRUCE 1+0 PAPERPOTS

4 JACK PINE 3+0 BARE-ROOT

5 WHITE SPRUCE 2+1 BARE-ROOT TRANSPLANTS

6 WHITE SPRUCE 4+0 BARE-ROOT

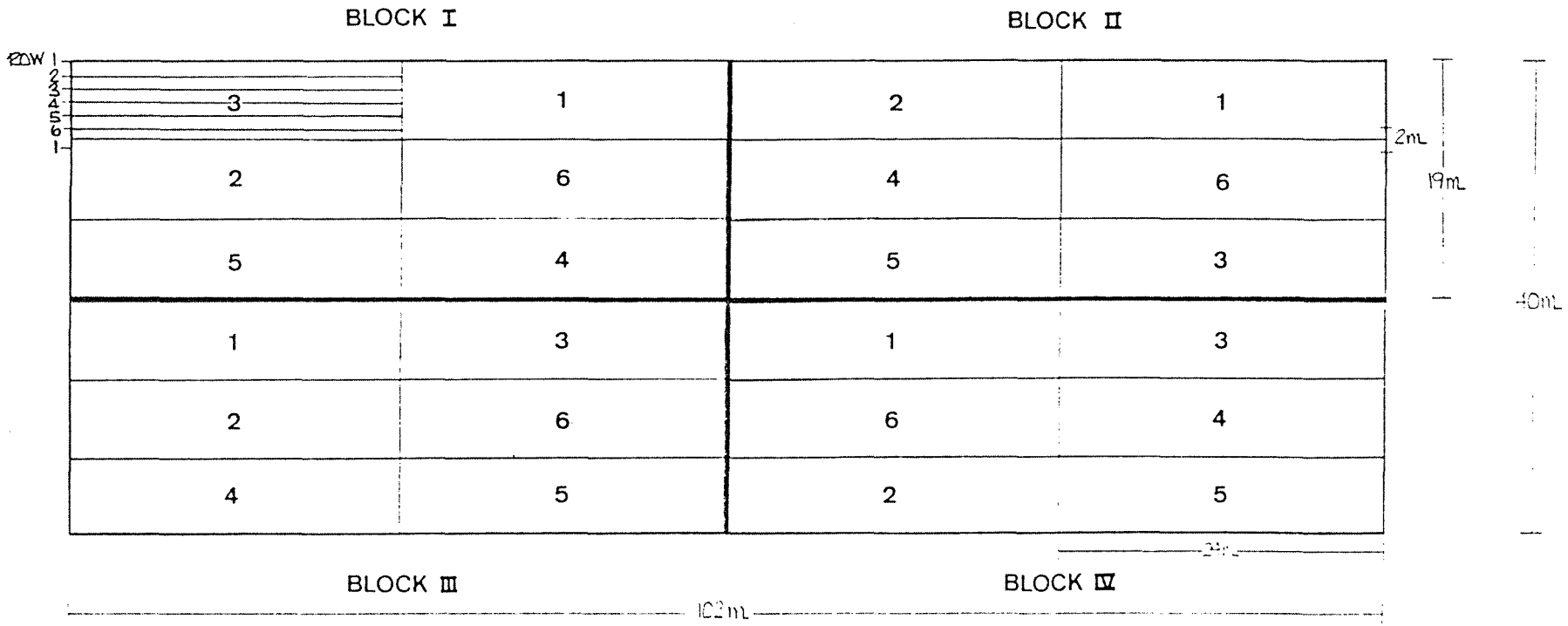

FIGURE 2. EXPERIMENTAL BLOCK DESIGN

Trial stock was planted by several DPRC staff to minimize planting quality variability and its affects on subsequent survival and growth performance. Aside from paperpots, planted with pottiputkies, all other stock was shovel planted. Duff was screefed off using boots and shovels to expose mineral soil.

Stock was re-measured during the fall of 1975 through 1979 and again in 1984. Data on hot-planted stock is unfortunately out of sync by one year, as this stock did not complete one growing season until the fall of 1976. Data measured in the fall of 1979 therefore reflects fifth year survival and growth for cold-stored stock, but only the fourth year performance of the hot-planted stock. This, and the absence of data for 1980-1983 and 1985, precludes consistent comparisons from being made beyond the first four growing seasons. This report will therefore limit itself to an analysis of the latter.[1]

Failure to record initial heights of cold-stored stock necessitated the use of heights taken following the first complete growing season for both cold-stored and hot-planted stock types in order to make valid height comparisons. In assessing the performance of stock types tested, survival, mean height, height growth ratios and aggregate height were used. Height growth ratios were determined by dividing average stock type heights observed after four growing seasons by those after year one in order to gain an appreciation of the relative height gains made by each stock type. As per Mullin (1980), aggregate height is a combined measure of survival and height obtained by multiplying percent survival in decimal form by mean height, which in turn is multiplied by a recommended planting density to yield aggregate height expressed in metres per hectare. Being interested in the comparative value of the calculation alone, incorporation of a planting density constant was overlooked here.

Analysis of variance tests at the 95% probability level were carried out for both fourth year survival and mean height growth ratios based on a 6x5 factorial design to complement the inherent planting date-stock type interrelationship. Techniques utilized are as outlined in Steel and Torrie (1960).

Lack of proper documentation relating to seed source and cultural practices applied to stock types prior to trial establishment partially undermines the interpretation of results observed over the study period. One can only conjecture that all five stock types examined originated from the same seedlot and that all stock was of high quality and in good physiological condition at the time of planting. Otherwise, observed performance is further clouded by the introduction of additional variables.

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[1] If interested, readers may contact the author regarding data summaries and graphs available for hot-planted and cold-stored stock types 9 and 10 years after planting respectively.

It is also assumed that stock used in August through October plantings was reared for the same period of time as that planted May through July such that fall planted 2+2 transplants for example, were in fact 2+2 and not 2+3.

Results

Combined fourth year survival among white spruce stock types and planting dates was 92%. Referring to Table 1 and Figure 3, the most successful treatments to the end of the fourth growing season were paperpot, 2+2, 3+0 stock types planted in May, July and October respectively, with 98% survival. Poorest survival was observed among 4+0, 3+0 and 2+1 stock types hot-planted in August, with survival rates of between 74% and 77%. Paperpot and 2+2 stock types out-performed all others with a survival of 96%.

Examination of planting dates indicates that highest overall survival was achieved by July and September plantings at 95%, followed closely by June and October plantings at 93% and those in May with 92% survival. Despite the favorable performance of 2+2 and paperpot stock, August plantings yielded the lowest mean survival at 83%.

Mean heights shown in Table 2 to the end of the first growing season point out that paperpots were considerably shorter than other stock types to begin with. Hot-planted September 2+2 seedlings were the tallest, 209% bigger than the best paperpots planted in September. Overall, the mean height for hot-plantings was 20% higher than that of cold-stored stock. With the exception of hot-planted 2+2 stock, which was only 4% smaller than cold-stored 2+2's, hot-planted paperpots, 2+1, 3+0 and 4+0 stock types were 46%, 44%, 30% and 16% taller than their cold-stored counterparts.

By the end of the fourth growing season, average total height for 2+2, 4+0, 3+0 and 2+1 stock was still significantly higher than that of the paperpots (Table 3), running 60%, 47%, 25% and 13% higher, respectively, for cold-stored stock, and 56%, 53%, 32% and 22% higher for hot-planted stock. Over the range of planting dates, 2+2 stock out-performed all others and the total average height of hot-planted stock continued to exceed that of cold-stored stock. Among cold-stored stock, May plantings yielded the best results.

Although fourth year survival results (Table 1, Fig. 3) achieved by 2+1, 3+0 and 4+0 stock types may lead to skepticism over August planting initiatives, the favorable performance of paperpots and 2+2 stock prompts a look at criteria beyond survival alone. As an indication of relative height gains, height growth ratios presented in Table 4 and again graphically in Figure 4 show that in all stock types but the paperpots, there was a significant increase in height growth associated with August planted stock. On the whole 3+0, 2+2 and 4+0 stock types

Table 1. Mean percent survival 4 years after planting

Stock type	Planting Dates: May 20-23 1975	June 16-20 1975	July 14-18 1975	Mean	Planting Dates: Aug. 11-15 1975	Sept. 8-12 1975	Oct. 6-10 1975	Mean
	Spring-lifted, cold-stored stock				Fresh-lifted, hot-planted stock			
Paperpots	98	94	95	96	94	96	97	96
2+1	91	93	94	93	77	97	93	89
3+0	95	91	94	93	76	93	98	89
2+2	96	95	98	96	95	97	95	96
4+0	82	94	95	90	74	93	83	83
Mean	92	93	95	**94**	83	95	93	**91**

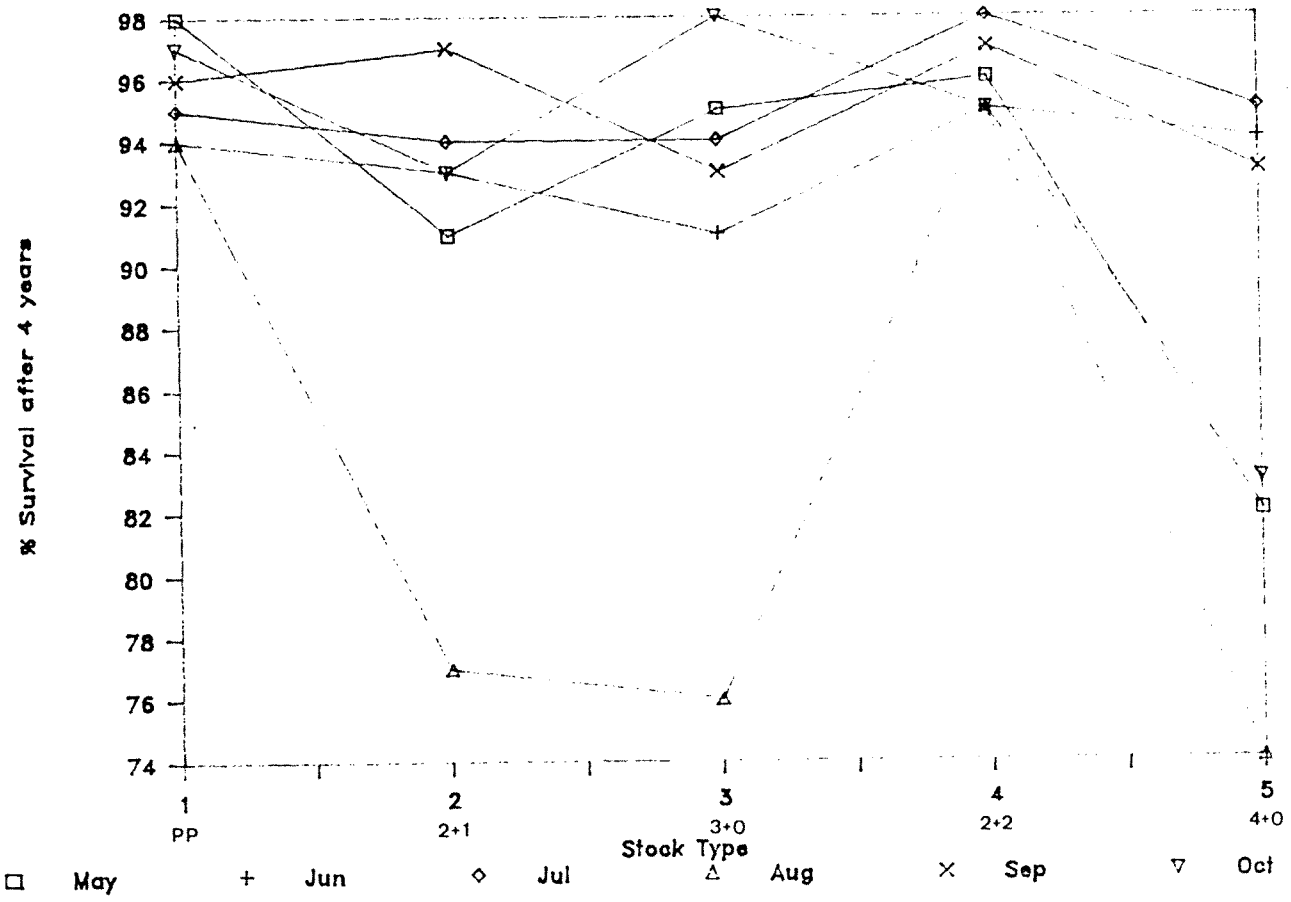

Figure 3. Mean percent survival 4 years after planting.

Table 2. Mean total height (cm.) 1 year after planting

Stock type	Planting Dates: May 20-23 1975	June 16-20 1975	July 14-18 1975	Average	% difference vs. paperpots	Planting Dates: Aug.11-15 1975	Sept. 8-12 1975	Oct. 6-10 1975	Average	% difference vs. paperpots	% difference, hot-planted vs. cold-stored stock
	Spring-lifted, cold-stored stock					Fresh-lifted, hot-planted stock					
Paperpots	8.47	8.28	9.94	8.90	-	13.13	13.64	12.30	13.02	-	46%
2+1	12.05	12.30	11.80	12.05	35%	12.31	20.06	19.57	17.31	33%	44%
3+0	17.31	13.46	15.68	15.48	74%	16.38	20.26	23.78	20.14	55%	30%
2+2	24.88	21.72	25.73	24.11	171%	18.01	28.48	23.25	23.25	79%	4%
4+0	20.34	23.07	22.19	21.87	146%	25.46	25.34	25.02	25.27	94%	16%
Total	83.05	78.83	85.34	**82.41**		85.29	107.78	103.92	**98.99**		20%

Table 3. Mean total height (cm.) 4 years after planting

Stock type	Planting Dates: May 20-23 1975	June 16-20 1975	July 14-18 1975	Average	% difference vs. paperpots	Planting Dates: Aug.11-15 1975	Sept. 8-12 1975	Oct. 6-10 1975	Average	% difference vs. paperpots	% difference, hot-planted vs. cold-stored stock
	Spring-lifted, cold-stored stock					Fresh-lifted, hot-planted stock					
Paperpots	26.88	25.68	25.14	25.90	-	33.26	33.38	30.50	32.38	-	25%
2+1	32.75	29.95	25.04	29.25	13%	32.64	43.00	43.10	39.58	22%	35%
3+0	36.77	31.38	29.02	32.39	25%	39.09	43.47	45.63	42.73	32%	32%
2+2	44.15	39.43	40.79	41.46	60%	44.19	55.33	52.03	50.52	56%	22%
4+0	39.04	39.19	35.93	38.05	47%	48.31	50.23	49.69	49.41	53%	30%
Total	179.59	165.63	155.92	**167.05**		197.49	225.41	220.95	**214.62**		28%

Table 4. Mean height growth ratios 4 years after planting

Stock type	Planting dates						Total mean
	May	June	July	Aug.	Sept.	Oct.	
Paperpots	3.18	3.11	2.55	2.54	2.45	2.48	2.72
2+1	2.72	2.45	2.13	2.65	2.15	2.20	2.38
3+0	2.13	2.33	1.86	2.39	2.16	1.92	2.13
2+2	1.78	1.83	1.59	2.46	1.95	2.24	1.98
4+0	1.92	1.70	1.62	1.94	1.99	2.00	1.86
Total mean	2.35	2.28	1.95	2.40	2.14	2.17	-

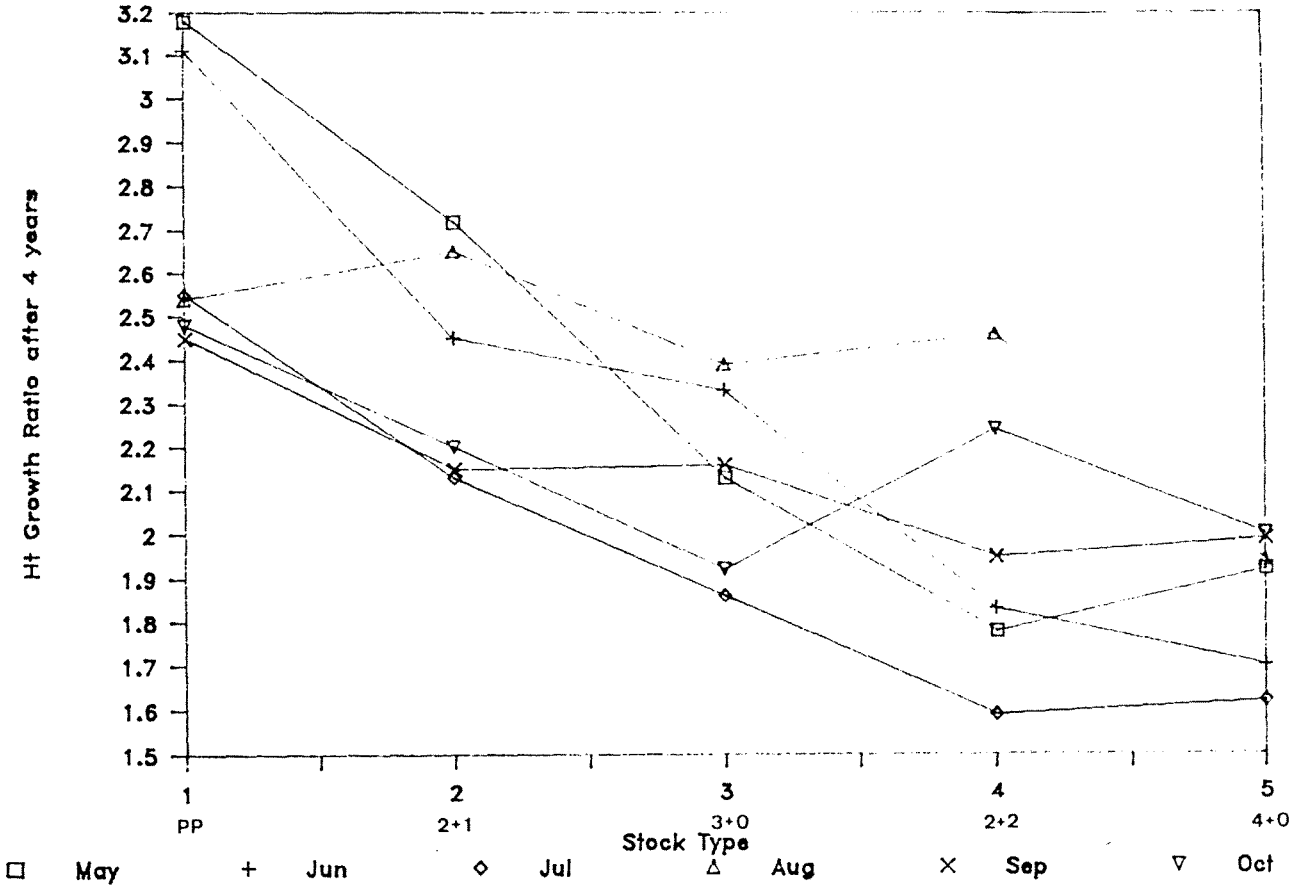

Figure 4. Height growth ratios 4 years after planting.

exhibited the greatest height growth gains following August plantings, while 2+1 seedlings were slightly behind those of the May planting. A comparison among paperpot plantings indicates a slight decline in performance by August plantings from that achieved by July-planted paperpots, but still a little better than that for September and October plantings. Out performing all other stock types and planting dates were the paperpots planted in May and June. July plantings yielded the lowest overall height gains among all stock types but the paperpots which exhibited slightly lower height gains following August, September and October plantings, although still surpassing the majority of stock type x planting date combinations (ie., except May/June-planted paperpots and May/August-planted 2+1's).

Despite showing the lowest average percent height gain among cold-stored stock types to the end of the fourth growing season (Table 4), 2+2 stock was still 9% taller than the next best 4+0 stock and 60% taller than paperpots (Table 3) which showed the highest percent height gain over the same period (Table 4). Among hot-planted stock types paperpots again had the highest percent height gain (Table 4) but were out-performed by all other stock types in terms of total height with 2+2 stock being best overall (Table 3).

As a last look at all treatments, Table 5 conbines survival and height after four growing seasons using aggregate height described earlier. The superior performance of 2+2 transplants is clearly shown, sitting 17%, 29%, 41% and 58% ahead of 4+0, 3+0, 2+1 and paperpot stock repsectively. On the whole, hot-planted stock was 24% better than that planted May through July following cold storage; September and October plantings being best overall.

Referring to Tables 6 and 7, analysis of variance on fourth year survival and height growth ratios did not indicate any significant differences between blocks 1-4 in the performance of the individual stock types. Conditions of microsite over the study area are therefore considered homogeneous and do not obscure interpretation of the differences attributable to stock types and/or planting dates. Although significant differences between stock types, planting dates and stock type-planting date combinations were borne out by the analysis, undefinable stock type-planting date interactions precluded a comparison of means so the preceding evaluation based on intuitive differences between treatment means was relied upon solely.

Discussion

White spruce seedlings grown in paperpot containers exhibited as good or better survival and superior height growth ratios than either of the bareroot or transplant stock types to the end of the fourth growing season (Tables 1 and 4) but were unable to out-perform these other stock types in terms of total mean height (Table 3). Transplant 2+2 stock maintained its

Table 5. Aggregate height (m) 4 years after planting

Stock type	Planting dates May 20-23 1975	June 16-20 1975	July 14-18 1975	Planting dates Aug. 11-15 1975	Sept. 8-12 1975	Oct. 6-10 1975	Total	% difference vs. paperpots
	Spring-lifted, cold-stored stock			Fresh-lifted, hot-planted stock				
Paperpots	26.34	24.14	23.88	31.26	32.04	29.58	167.24	--
2+1	29.80	27.85	23.54	25.13	41.71	40.08	188.11	12%>
3+0	34.93	28.56	27.28	29.71	40.43	44.72	205.63	23%>
2+2	42.38	37.46	39.97	41.98	53.67	49.43	264.89	58%>
4+0	32.01	36.84	34.13	35.75	46.71	41.24	226.68	36%>
Total	165.46	154.85	148.80	163.83	214.56	205.05		
Total	Cold-stored: 469.11			Hot-planted: 583.44				
% difference:	Hot-planted vs. cold-stored: 24%>							

Table 6. Analysis of variance for fourth year survival

Source	df	SS	MS (SS/df)	F (MS/EMS)	Tabular F p = 0.05
Blocks	3	151.87	50.62	1.08ns	2.72
Stock types	4	1,395.47	348.87	7.45**	2.49
Planting dates	5	2,028.40	405.68	8.66**	2.33
Stock x dates	20	1,698.93	84.95	1.81**	1.70
Error (EMS)	87	4,076.00	46.85		
Total	119	9,198.80			

Table 7. Analysis of variance for fourth year height growth ratios

Source	df	SS	MS (SS/df)	F (MS/EMS)	Tabular F p = 0.05
Blocks	3	0.2	0.07	1.75ns	2.72
Stock types	4	11.27	2.82	70.50**	2.49
Planting dates	5	2.65	0.53	13.25**	2.33
Stock x dates	20	4.37	0.22	5.50**	1.70
Error (EMS)	87	3.63	0.04		
Total	119	21.92			

** Significant differences exist between stock types, planting dates and stock x date combinations at p = 0.05.

superior survival ranking throughout the study period (Table 1) and exhibited the best mean total height in both hot-planted and cold-stored treatments, this despite fifth and third place height growth ratio rankings (Table 4).

Total mean height rankings attained by the different stock types to the end of the study period were to a large degree, influenced by stock height differences at the time of planting. Judging from Table 2, 4+0, 2+2, 3+0 and 2+1 stock types were all substantially larger than paperpot stock to start with, and there were significant differences amongst other stock types as well. For the most part, these initial differences served to secure relative height advantages observed to the end of the study. This, along with the findings of Ball and Kolabinski (1986), suggests that the size differential between container and bareroot/transplant stock need be narrowed if their use is to rival the latter, particuarly on high site mixedwood areas. According to Wood (1984), container grown seedlings must achieve the height of bareroot stock in the first two or three seasons (during which time bareroot stock typically experience planting check) if they are to match them in performance. Although 2+2 stock, hot-planted in September, exhibited the best mean total height after four years in this study (Table 3), at an assumed annual rate of growth of 8.95 cm (derived from Tables 2 and 3) it would have attained a height of only 64.28 cm after five years, well below the one metre Ontario standard (Armson, et al. 1980).

Survival of 2+2 and paperpot stock was as good after hot-planting as that following cold storage. In contrast, cold-stored bareroot and 2+1 transplants planted May through July showed a definite improvement in survival over the same stock types hot-planted August through October (Table 1, Fig. 3). Reference to Table 3 however, places hot-planted stock 28% ahead of cold-stored stock in terms of mean total height overall.

Aggregate heights in Table 5 reinforce the exceptional status of 2+2 transplants, place both bareroot stock types ahead of 2+1 transplants and leave paperpots well behind all others. Among plantings of cold-stored stock, those in May posted the best performance while those of September and October were closely ranked 1 and 2 among hot-plantings, well ahead of plantings conducted in August. Led by the superior record of September and October plantings, hot-plantings were judged best all-around, lending support to future initiatives involving the hot-planting of white spruce during late summer and fall. In general, findings here support the silvicultural recommendation of either spring or fall planting for white spruce (Mullin and Howard 1973, Mullin 1980, Alm 1983).

Costs associated with the production of stock types tested in this study are presented in Table 8. Although relative costs remain an important consideration in regeneration planning, one must not lose sight of the underlying objective to establish highly productive new forests.

Table 8. Production costs of stock types tested, in ascending order

Stock type	Cost per 1,000
3+0 Bareroot white spruce	$ 32.84
4+0 Bareroot white spruce	35.29
2+1 Transplant white spruce	42.68
2+2 Transplant white spruce	58.93
Paperpot white spruce	118.53

In the case of paperpot and 2+1 stock used in this study, consideration of both costs and height related shortcomings have provided sufficient justification to render their use unacceptable. Use of paperpots in Saskatchewan was abandoned in 1982 due to high costs of production attributable to an inefficient operation; subsequently being replaced by Can Am and Swedish Multipot container systems (Rempel 1987). Paperpots have also been found to restrict root growth due to a failure of the root plug casing to disintegrate fully following planting. A common concern, this has led to the recommendation that paperpot seedlings, particularly white spruce, not be used operationally on upland mixedwood sites (Ball and Kolabinski 1986). According to Rempel (1987), white spruce 2+1 stock was never actually shipped operationally because of its failure to reach an acceptable size at the nursery. Transplant 2+2 stock was discontinued following the spring of 1978 owing to high transplant labour costs and associated space requirements relative to 3+0 row seeded stock. Bareroot 3+0 stock subsequently replaced both transplant and 4+0 bareroot options. In addition to being judged the cheapest to produce, associated size, root-shoot ratios and outplant survival of 3+0 bareroot stock were all deemed acceptable.

However, if forest managers are concerned about averting potential height growth losses and their impact on long-term timber production, they will have to decide whether or not initial cost savings associated with the use of 3+0 versus 2+2 stock, for example, are worth the anticipated loss in yield borne out by this and other studies (Cooley 1969, Mullin and Howard 1973, Heikurinen 1981, Alm 1983, McMinn 1985, Hallet 1986). Despite working with the inevitable limited budget, it is hoped that they will weigh the costs and biological implications of stock type options more carefully so as to maximize net investment returns by ensuring a closer match between stock and site type constraints. Recognizing the dated and limited nature of this study, replication of such a trial incorporating stock types reared under more current cultural practices and outplanted on a broader range of sites is recommended in order to determine prescriptions which will yield the greatest returns on Saskatchewan mixedwood sites.

Conclusions

1. Paperpot stock matched or exceeded fourth year survival of all stock types tested but was considered unacceptable because of inferior total height.

2. Demonstrating exceptional survival and maintaining their relative height advantage over all other stock types from the time of planting, 2+2 transplants performed best overall.

3. Intermediate in survival-height performance to 2+2 transplants and paperpots, in descending order, were 4+0, 3+0 bareroot and 2+1 transplant stock types.

4. May planting performed best overall among plantings of cold-stored stock.

5. September and October hot-plantings out-performed those of August and were also best overall.

6. Initial height advantages enjoyed by hot-planted versus cold-stored stock types and transplant/bareroot versus paperpot stock types were, for the most part, maintained throughout the study period.

7. August plantings were the most sensitive, exhibiting the greatest range in survival.

8. An absence of failures across the range of planting dates tested suggests that white spruce can be successfully outplanted spring through fall.

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