CONIFER ESTABLISHMENT BY HAND SEEDING ON SITES PREPARED WITH THE BRÄCKEKULTIVATORN

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ABSTRACT

A hand seeding trial was carried out to compare the germination and survival of black spruce (*Picea mariana* [Mill.] B.S.P.), jack pine (*Pinus banksiana* Lamb.), lodgepole pine (*Pinus contorta* Dougl.), and a natural hybrid pine (jack pine x lodgepole pine) in seedspots prepared by the Bräckekultivatorn scarifier-seeder on two widely differing sites in northern Ontario. Despite the fact that one site was "moist" and the other "dry", after 4 years both sites showed similar patterns of germination and stocking for each species. For black spruce the stocking levels were 37% and 39% for the moist and dry sites, respectively. All three pines had stocking levels of 60% or greater on both sites.

The growth of jack pine was superior to that of the other species on both sites. Among the pine species, the difference in moisture did not produce major growth differences, but the height growth of black spruce was superior on the moist site.

RÉSUMÉ

On a effectué un ensemencement à la main afin de comparer la germination et la survie de l'Epinette noire (*Picea mariana* [Mill.] B.S.P.) du Pin gris (*Pinus banksiana* Lamb.), du Pin tordu (*Pinus contorta* Dougl.) et d'un hybride naturel (Pin gris avec Pin tordu) en des placeaux d'ensemencement préparés avec le semoir-scarificateur suédois Bräcke-kultivatorn, sur deux stations très différentes du nord de l'Ontario. Malgré le fait que l'une des stations présentait un soil "humide" tandis que l'autre était d'un type "sec", les deux stations, quatre ans plus tard, indiquaient des modèles semblables de germination et de matériel sur pied chez chaque espèce. Chez l'Epinette noire, les niveaux de matériel sur pied relatif furent de 37% et 39% respectivement dans les stations à sols humides et secs. Les trois espèces de Pins présentèrent un taux de matériel sur pied relatif de 60% ou plus sur les deux stations.

La croissance du Pin gris fut supérieure à celle des autres espèces sur les deux stations. Parmi les espèces de Pins, la différence de teneur en humidité ne produisit pas de différences majeures de croissance, mais la croissance en hauteur de l'Epinette noire s'avéra supérieure sur la station humide.

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INTRODUCTION

Although direct seeding is recognized as an acceptable regeneration technique for jack pine (*Pinus banksiana* Lamb.) in Ontario (Scott 1970), it is not generally considered suitable for regenerating spruce (*Picea* spp.). Waldron (1973) reported that attempts at direct seeding of spruce had been a dismal failure throughout most of Canada, as available records indicated an average stocking level of only 23%. Nevertheless, direct seeding of spruce continues to be of interest to the forest manager because of its potential for reducing regeneration costs.

In 1970 the Ontario Ministry of Natural Resources (OMNR) requested that the Great Lakes Forest Research Centre undertake an evaluation of the feasibility of seeding black spruce on upland sites in northern Ontario. Subsequently, a program was developed that combined autecological investigations of climate and seedbed with operational trials of available site preparation equipment and seeding techniques.

One of the more recent developments in site preparation equipment is the Swedish Bräckekultivatorn (Parker 1972), a scarifier-seeder which scalps the ground with large digging teeth (Fig. 1) and then drops seed from an integral hopper onto the prepared seedspot. In June 1971, one such unit was being tested operationally by OMNR at Manitouwadge, Ontario, for the regeneration of jack pine on a recent cutover. This provided an opportunity to conduct the trial reported here, in which four tree species, black spruce (*Picea mariana* [Mill.] B.S.P.), jack pine, lodgepole pine (*Pinus contorta* Dougl.), and a natural hybrid pine (jack pine x lodgepole pine), were hand seeded in seedspots prepared by the Bräckekultivatorn on two sites that differed widely in moisture status. Hand seeding was employed in this instance because of the differences in seed size.

Description of Experimental Area

In June 1971, two upland sites, one very moist, and the other very dry, were arbitrarily selected for the seeding trial in the Manitouwadge, Ontario area (Long. approx. 49° W) in the Central Plateau Section B.8 of the Boreal Forest Region (Rowe 1972). Both sites are located on the limits of the Ontario Paper Company Limited. The overall climate is described as modified continental and is in the Height of Land Climatic Region (Chapman and Thomas 1968). The average length of growing season based on a 5.5°C index is approximately 153 days, extending roughly from May through September, inclusive (Chapman and Thomas 1968). Mean total annual precipitation as measured at the nearest weather station, Manitouwadge, Ontario, is approximately 86 cm annually with approximately 64% of this falling during the growing season (Anon. 1973).

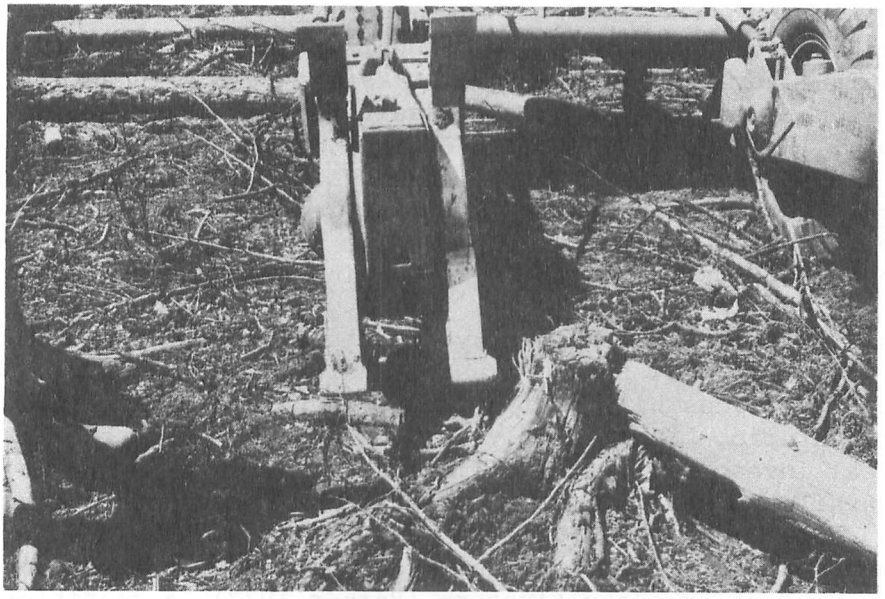

Fig. 1. Bräckekultivatorn scarifier-seeder, showing scalping teeth and seed dispenser.

Temperature and rainfall information for the 1971 growing season was obtained from OMNR's Manitouwadge office approximately 25 km southwest of the experimental area.

A comparison with climatic normals (Table 1) reveals that June was hotter and drier than normal. July was cooler and wetter, August was close to normal in temperature but lower in rainfall, and in September rainfall was slightly below normal while temperature was above normal.

METHODS

Soil pits were dug at both locations and profiles were described. A representative sample was taken from each horizon of each pit and transferred to the laboratory in Sault Ste. Marie for nutrient analysis. Nitrogen was analyzed by the semimicro-Kjeldahl technique. Phosphorus was determined by using a Bray P_1 solution compared to standards in a colorimeter. Potassium was measured in a flame-emission spectrophotometer, and calcium and magnesium were analyzed in an atomic-absorption spectrophotometer. The pH was measured using a pH meter with a 1:1 soil: water ratio. Organic matter was measured by loss on ignition.

Table 1. Comparison of 1971 air temperature and precipitation monthly means with normals for Manitouwadge, Ontario

		June	July	August	September	October
		Temperature (°C)				
Normal[a]	max.	21.2	24.0	21.9	15.8	9.4
	min.	7.4	10.8	9.6	5.6	-0.9
1971	max.	22.0	18.6	20.2	21.1	12.3
	min.	9.0	7.5	7.0	7.1	4.0
		Rainfall (cm)				
Normal		9.2	7.7	9.4	10.0	7.0
1971		3.4	13.9	5.3	8.1	8.3

[a] Anon. 1973.

The moist site, which previously had supported a stand of black spruce, was described as an ortho humo-ferric podzol (Anon. 1974), while the dry site, which previously supported a stand of jack pine, was described as a mini humo-ferric podzol. The soil on the moist site had a deeper organic mantle, greater depth of Ae horizon, a much shallower profile depth to groundwater, a considerably higher pH (Table 2) and higher calcium (lime) levels than the soil on the dry site. In addition, the soil on the moist site had higher nutrient levels of N, P, and Mg than that on the dry site (Table 2).

Description of Seeding Trial

Seedspots were prepared by a Bräckekultivatorn pulled by a Timberjack skidder. Experimental seeding was completed on both sites on June 2, 1971. The rotating teeth on the Bräckekultivatorn flipped over the upper 8-15 cm of the organic and mineral soil horizons. Scalps were made at a spacing of approximately 2.0 m between seedspots.

Table 2. Soil analysis from representative moist and dry study sites, Manitouwadge, Ontario.

Site	Horizon	Total N (%)	P	K	Ca	Mg	Fe	pH	Organic matter (%)	Cation exchange capacity (meq/100 g)
			ppm							
Moist	Duff	0.48	26.7	600	4460	420	0.2	5.8	53.1	33.0
	Ah	0.78	6.9	25	7710	520	0.3	5.8	51.2	102.7
	Ae	0.05	1.1	20	1310	100	0.2	5.9	1.3	9.5
	Bf	0.01	0.4	23	580	60	1.2	5.8	0.1	2.2
	C	0.01	2.6	19	360	30	0.7	6.5	0.0	1.8
Dry	Duff	0.64	18.5	430	2750	360	1.4	3.6	65.0	60.3
	Ah	0.19	2.2	1010	300	100	2.1	3.4	20.7	46.4
	Ae	0.02	1.5	310	50	10	1.4	3.7	0.9	4.0
	Bf	0.02	1.4	50	60	10	5.4	4.6	0.2	2.7
	C	0.01	1.3	50	60	10	0.6	4.9	0.0	0.8

The seeding experiment was designed as a completely random block with four replications. Each block contained four rows of 25 scalps per row, and to each row a species for seeding was assigned randomly, providing 100 seedspots per species per site. This design was established on the moist site but was modified on the dry site owing to an operational problem. Two blocks were established on the dry site, each block having four rows of 40-50 scalps per row, but still with approximately 100 seedspots per species. Seeding was done by hand, using a bottle-shaker obtained from OMNR. Seed was shaken onto the forward, flat part of the exposed seedbed and stepped on lightly to ensure seed–soil contact. Attempts to calibrate the shaker to release 5 to 8 pine seeds or 9 to 12 spruce seeds were not very successful; consequently, the exact number of seeds sown per scalp is unknown.

Germination was assessed periodically from 1971 to 1974. Colored toothpicks were used to mark new germinates.

Untreated jack pine and black spruce seeds from Site Region 3E (Hills 1960) were obtained from OMNR. The lodgepole pine and hybrid pine seeds were obtained from select individual trees in the vicinity of Marlborough and Fox Creek, Alberta, respectively. Tests of seed viability in the laboratory indicated that black spruce seed viability was 99%, hybrid pine 76%, lodgepole pine 90% and jack pine 76%.

Seedling Extraction and Assessment

In October 1974, eight seedspots per species per site were excavated. All seedlings were extracted carefully from the soil and measured in the laboratory for top height, length of longest root, root collar diameter, root area, and oven-dry weights of tops and roots. The current year's foliage was removed, ground in a Wiley mill and analyzed for nutrient content.

RESULTS

Assessment of Germination, Stocking and Mortality

Four years[2] after seeding, stocking[3] to each pine species was at least 60% regardless of site (Table 3). Stocking to black spruce was

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[2] Stocking levels remained the same after 6 years as they were at 4 years.

[3] Stocking as used in this report is based on the number of seedspots successfully stocked. As the spacing between seedspots was such that each mil-acre contained one seedspot, stocking is assumed to be equivalent to that based on mil-acre quadrats.

Table 3. Percent stocking and mortality index, by species, on moist and dry sites after six growing seasons, Manitouwadge, Ontario

Species	July 6 1971	Aug. 3 1971	Sept. 28 1971	May 18 1972	July 6 1972	Aug. 15 1972	May 30 1973	July 7 1973	Aug. 16 1973	June 21 1974	Sept. 17 1974	July 18 1976
						Stocking (%)						
Moist Site												
Jack pine	75	77	77	71	66	66	62	62	62	62	60	60 (12)[a]
Lodgepole pine	83	88	87	83	83	85	82	82	81	79	80	80 (8)
Hybrid pine	43	63	60	55	62	63	62	62	62	61	61	61 (14)
Black spruce	29	49	49	40	40	40	41	41	40	37	37	37 (20)
Dry Site												
Jack pine	81	84	82	76	74	75	74	74	74	74	73	73 (4)
Lodgepole pine	59	68	70	68	75	76	76	76	76	76	75	75 (4)
Hybrid pine	49	60	62	61	76	74	72	70	68	68	70	70 (4)
Black spruce	53	56	52	44	39	44	42	41	39	39	39	39 (8)
						Mortality Index						
Moist Site												
Jack pine	2.7	9.7	11.9	21.2	26.7	27.9	31.4	32.5	34.5	36.8	37.9	37.9
Lodgepole pine	3.7	10.3	12.6	16.5	19.9	20.2	23.1	23.7	25.3	25.3	27.6	27.6
Hybrid pine	1.7	10.4	17.0	26.4	25.7	26.1	28.6	28.6	30.0	30.0	30.9	30.9
Black spruce	0	6.2	21.1	32.7	38.9	38.6	40.3	43.1	44.8	48.3	53.3	53.3
Dry Site												
Jack pine	12.1	21.3	28.0	32.4	38.2	39.2	41.0	42.5	42.5	42.5	43.3	43.3
Lodgepole pine	6.3	11.5	13.0	17.3	20.2	21.4	22.4	23.6	23.6	23.6	24.8	24.8
Hybrid pine	7.0	16.0	17.0	22.5	19.5	22.7	24.6	26.9	26.9	28.3	27.5	27.5
Black spruce	27.5	46.5	53.9	65.4	69.8	68.5	71.7	73.5	73.5	74.9	70.8	70.8

[a] Value denotes additional stocking to conifers from natural sources.

similar on both sites but considerably lower than stocking to pines, i.e., 37% and 39% on the moist and dry sites, respectively.

Germination (Table 3) of jack pine, lodgepole pine and black spruce was generally completed by early August, approximately 60 days after sowing. Some germination of these species occurred in subsequent years. The hybrid pine seed may have been immature, and required some natural stratification in the field, since a considerable proportion of the seeds did not germinate until the second season. Except for lodgepole pine, more seeds of all species germinated on the dry site than on the moist site, and germination of all species was also faster on the dry site. Unfortunately, the inability to control the numbers of seeds sown precludes further comparisons of germination.

A mortality index, calculated as the number of dead seedlings divided by the number of seedlings germinated x 100, permits the measuring of relative survival capabilities, and circumvents some of the problems associated with the unknown numbers of seeds sown. The highest mortality index was recorded for black spruce on the dry site (Table 3). Little difference was noted among the three pines on either the moist or the dry sites. Most mortality occurred during the first 12 months after sowing, with very little mortality occurring after the spring of 1972, and none between 1974 and 1976.

Despite the fact that June, 1971 was hotter and drier than normal, climatic conditions obviously did not restrict germination in most scalps. Unfortunately, the heavier rainfalls of July and August caused considerable flooding of approximately 50% of the seedspots on the moist site, and washed soil from the steep-sloped scalps on both sites. Some mortality, estimated at 30% in 1971, can be attributed to an unknown agent, likely cutworms, that severed the newly germinated seedling at the base of the cotyledons.

DISCUSSION AND SUMMARY

Regardless of site, jack pine grew taller and heavier than all other species, and all pines outgrew black spruce considerably (Table 4).

Natural seedlings did occur (Table 3) on both sites and raised overall stocking levels, particularly on the moist site.

Site differences did not appear to affect seedling growth consistently. Top height and weight of black spruce and jack pine were greater for seedlings grown on the moist site. Height growth of lodgepole

Table 4. Mean growth of 4-year-old seedlings, sampled in hand-seeded spots near Manitouwadge, Ontario

	Shoot height (cm)	Root length (cm)	Shoot weight (mg)	Root weight (mg)	Root (wt) / Shoot (wt)
Moist Site					
Jack pine	35.0	23.6	1821	238	.13
Lodgepole pine	24.0	27.1	646	129	.20
Hybrid pine	21.8	23.1	720	118	.16
Black spruce	10.2	11.4	57	11	.19
Dry Site					
Jack pine	30.6	30.3	1115	172	.15
Lodgepole pine	24.4	26.8	862	169	.20
Hybrid pine	22.3	34.6	1079	205	.19
Black spruce	6.5	11.0	36	9	.25

pine and hybrid pine was not affected by site, whereas top weight of these species was greatest on the dry site. Root growth parameters indicated generally longer and heavier pine roots on the dry site but no difference in spruce root growth between sites. Calculation of root:shoot ratio indicated little difference between species; however, jack pine had the lowest ratio for both sites.

Black spruce foliage contents (Table 5) of N, P and Ca were greatest in seedlings grown on the dry site, but there was no difference in K and Mg levels in seedlings grown on the two sites. Black spruce appeared to accumulate P, K and Ca, since it had greater concentrations of these elements than pine foliage regardless of site. In foliage of the three pines, the dry site samples had higher levels of N, P and K but lower levels of Ca than the moist site samples. No one pine species appeared to have levels consistently different from those of the other two pines nor did seedling size appear to relate to nutrient concentration.

Table 5. Foliar nutrient content of current foliage of 4-year old seedlings, sampled in hand-seeded spots near Manitouwadge, Ontario

	N	P	K	Ca	Mg
			(%)		
Moist Site					
Jack pine	1.42	0.16	0.50	0.35	0.11
Lodgepole pine	1.45	0.14	0.52	0.35	0.11
Hybrid pine	1.33	0.14	0.47	0.37	0.12
Black spruce	1.31	0.17	0.79	0.57	0.10
Dry Site					
Jack pine	1.49	0.18	0.58	0.19	0.09
Lodgepole pine	1.57	0.17	0.66	0.20	0.09
Hybrid pine	1.75	0.19	0.68	0.22	0.09
Black spruce	1.82	0.22	0.79	0.64	0.09

In pot trials supporting this field work, Winston and Schneider (unpublished data) found that differences in site had little effect on pine growth and affected significantly only the height growth of black spruce. Such findings are consistent with the field results reported above. Similar differences in foliage nutrient concentrations were also obtained. When the field trial nutrient levels of foliage are compared to standards suggested by Swan (1970, 1972), no obvious nutrient deficiencies are indicated for any species on either site.

The higher Ca levels in the moist site foliage of the pines corresponds with the high soil Ca levels (Table 2) in all soil horizons. Even though the soil analyses indicate deficiencies of several nutrients, especially N, this was not reflected by foliage nutrient levels on either site.

The results show that a wide difference in soil moisture did not have as important an effect on germination and seedling growth as might have been expected. The higher soil moisture increased the height growth of black spruce and jack pine, but germination was not seriously affected on the dry site. On the contrary, too much moisture, i.e., flooding, reduced survival of all species on the moist site.

For all the pine species on both sites, stocking reached the "desirable" level established by OMNR for the jack pine working group[4]. This suggests that the Bräckekultivatorn is an effective tool for regenerating pine. For black spruce, stocking was below the "desirable" level, but better than the average reported by Waldron (1973). These results might have been better but for the fact that the scalps were deep and subject to both flooding and soil washing. Parker (1972) notes that adjustments can be made on the Bräckekultivatorn to control both scalp depth and seed release position. Further trials to determine whether these adjustments can produce the required increase in stocking of black spruce appear warranted.

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[4] Anon. 1971. Province of Ontario minimum stocking standards for timber production. Ont. Min. Nat. Resour., For. Manage. Br., Mimeogr. Rep. 12 p.

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