CARDINAL TEMPERATURES FOR GERMINATION OF SIX PROVENANCES OF BLACK SPRUCE SEED

by
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ABSTRACT

The influence of constant temperature and provenance on germination of six provenances of black spruce seed was investigated. None of the seed tested germinated below 45F or above 95F. Optimum temperatures for maximum germination were 50F to 80F, 60F to 70F, and 60F to 80F for Ontario Department of Lands and Forests Zones 5E, 4E, and 3E respectively. The optimum temperatures were 50F to 90F for germination of seed from Petawawa, Ontario, 55F to 85F for seed from Escanaba, Michigan, and 60F to 70F for seed from Fort Smith, North West Territories.

Provenance also had a significant effect on germination at different temperatures.

Cardinal Temperatures for Germination of Six Provenances of Black Spruce Seed

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INTRODUCTION

This report deals with the effect of constant temperature and provenance on the germination of black spruce (Picea mariana (Mill.) BSP.) seed. The objective of the work was to determine for seed from each of six provenances the lower cardinal temperature (LCT) below which no germination occurs, the upper cardinal temperature (UCT) above which none occurs, and the optimum cardinal temperature (OCT) where maximum germination occurs.

Practical applications of cardinal temperatures for germination of native tree seeds were suggested in earlier reports dealing with red, white, and jack pine (Pinus strobus L., P. resinosa Ait., P. banksiana Lamb.) and with white spruce (Picea glauca (Moench) Voss) (Fraser 1970a, 1970b).

MATERIALS AND METHODS

Materials

The six provenances of black spruce seed used in this experiment were obtained from forest geneticists engaged in tree population studies at the Petawawa Forest Experiment Station (P.F.E.S.). The location, and climate of the six collection areas are summarized in Table 1.

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The Petawawa (P4) seed was collected by Canadian Forestry Service personnel from one particular group of trees at P.F.E.S. Fort Smith (P2) seed was also collected by Canadian Forestry Service personnel, probably from relatively few trees also. Escanaba (P3) seed was purchased from a commercial seed dealer and may be from a general area collection. Ontario Department of Lands and Forest (ODLF) seed (P1, P5, P6) was from zone seed lots consisting of several district collections from within each zone. Therefore, the data pertaining to P1, P5, and P6 in Table 1 are either ranges or averages for the contributing districts.

Methods

All seed lots were stored dry in sealed containers at 34F to 38F (1.1C to 3.3C) prior to use in these experiments.

The germination medium was short grain, black germination paper saturated with distilled water.

This was a completely randomized experiment employing the same methods previously used to determine cardinal germination temperatures for white spruce seed (Fraser, 1970b), including floatation to eliminate empty seeds, pre-treatment to break dormancy, and surface sterilization to inhibit mold.

Seeds were sown on double layers of saturated germination paper in sterile petri dishes placed in illuminated, forced-draft, constant-temperature cabinets at prescribed temperatures $\pm$ 1F for 28 days. There were six petri dishes of 50 seeds from each of the six provenances in each of 11

Table 1. Location and climate of provenances (seed collection areas). Data for the Ontario Department of Lands and Forests (ODLF) provenances are either ranges (location) or averages (climate) of several contributing stations in the collection area.

Provenance and Code	Location			Climate				
	Elevation in feet	North Latitude	West Longitude	Mean Annual Air Temperature (F)			Mean Annual Precip. (inches)	# Years Observation
				Minimum	Maximum	Mean		
ODLF 5E P1	550 to 662	45°20' to 46°29'	77°26' to 84°30'	31	50	40	32.23	45
Fort Smith, N.W.T. P2	665	60°01'	111°58'	15	36	26	12.63	30
Escanaba, Mich. P3	594	45°48'	87°05'	35	50	42	28.32	31
Petawawa, Ont. P4	600	46°00'	77°26'	29	51	40	29.21	17
ODLF 4E P5	662 to 1405	46°19' to 48°22'	79°28' to 89°19'	26	37	37	28.14	26
ODLF 3E P6	752 to 1243	48°36' to 50°07'	-81°02' to 91°54'	21	43	32	26.21	28

temperature treatments at 5-degree intervals from 45F to 95F inclusive. In preliminary tests, there was no germination from any provenance at either 40F or 100F.

Germination was tallied daily. Seeds were tallied as germinates when radicles were plainly visible. Percent germination corrected for percent full seed, and transformed to degrees by the arc sine method to normalize the data, was subjected to analyses of variance as completely randomized experiments. Duncan's multiple range test was used to test the significance[2/] of treatment means.

RESULTS

General

Analyses of variance of the germination data presented in Figure 1 showed that both temperature and provenance had a significant effect on germination of black spruce seeds.

There was no germination below 45F or above 95F. At 45F, the LCT for all six provenances, there was no germination until the end of the third week after seeding: seeds from each provenance were still germinating on the 28th day but the best germination (P1, and P4) was less than 50%.

At 95F, the UCT common to all provenances, germination began within one week from seeding, and was complete or 90% complete before the third week but never exceeded 40%.

2/ Probability p = 0.05 throughout this report.

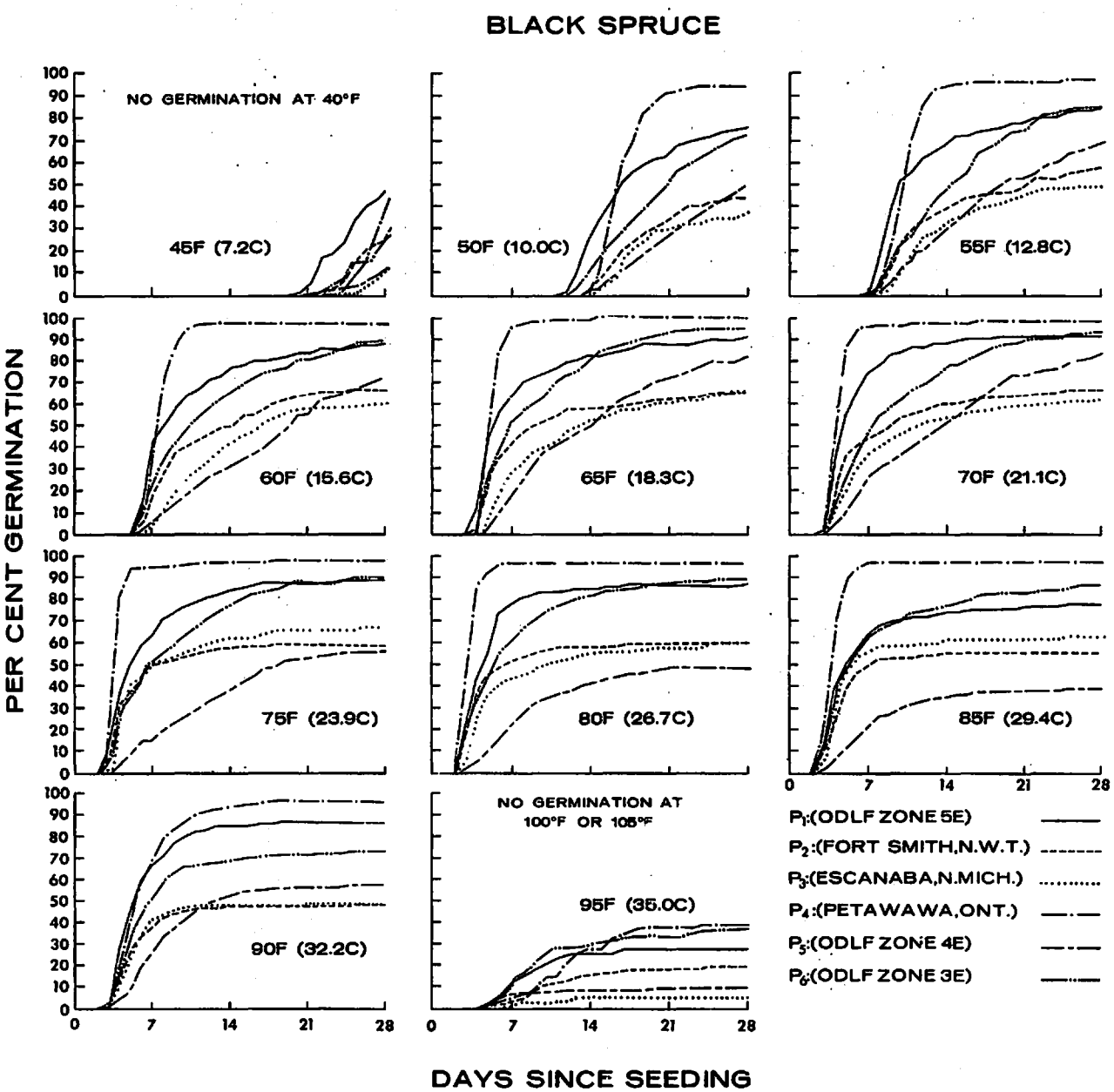

Figure 1. Percent germination of black spruce seed at different temperatures.

Germination began progressively sooner with each 5-degree increase in temperature up to 60F. From 60F to 95F inclusive seed from all six provenances began to germinate within one week from seeding, and at 75F to 85F seed from some provenances began to germinate as early as the third day after seeding.

Germination response to temperature by provenance

Figure 2 illustrates germination responses to temperature by provenances. LCTs and UCTs are self evident. When OCTs occur as single temperatures they are indicated with asterisks; when they include a range of temperatures within which there is no significant difference in germination they are shown as shaded plateaus.

The rapid decline in germination above 90F is immediately apparent for each provenance of seed as is the failure of any seeds to germinate above 95F regardless of the duration of the test. However, increasing the germination period from 7, to 14, to 28 days lowered the LCT for each provenance of seed from 60F, to 50F to 45F, respectively. The only exception was the 14-day LCT (55F) for seed from P3.

The vertical grouping of results, by provenances, in Figure 2 is based on some similarity in rapidity and amount of germination of seeds from P1, P4, and P6, and from P2, P3, and P5. Precise conclusions about any effects of provenance on germination responses to temperature are precluded by the several bulk collections of seed. Nevertheless, as the best germination was from seed originating at about 46N latitude (P1 and P4), and the worst was from seed originating at 60N latitude (P2) and 45N latitude

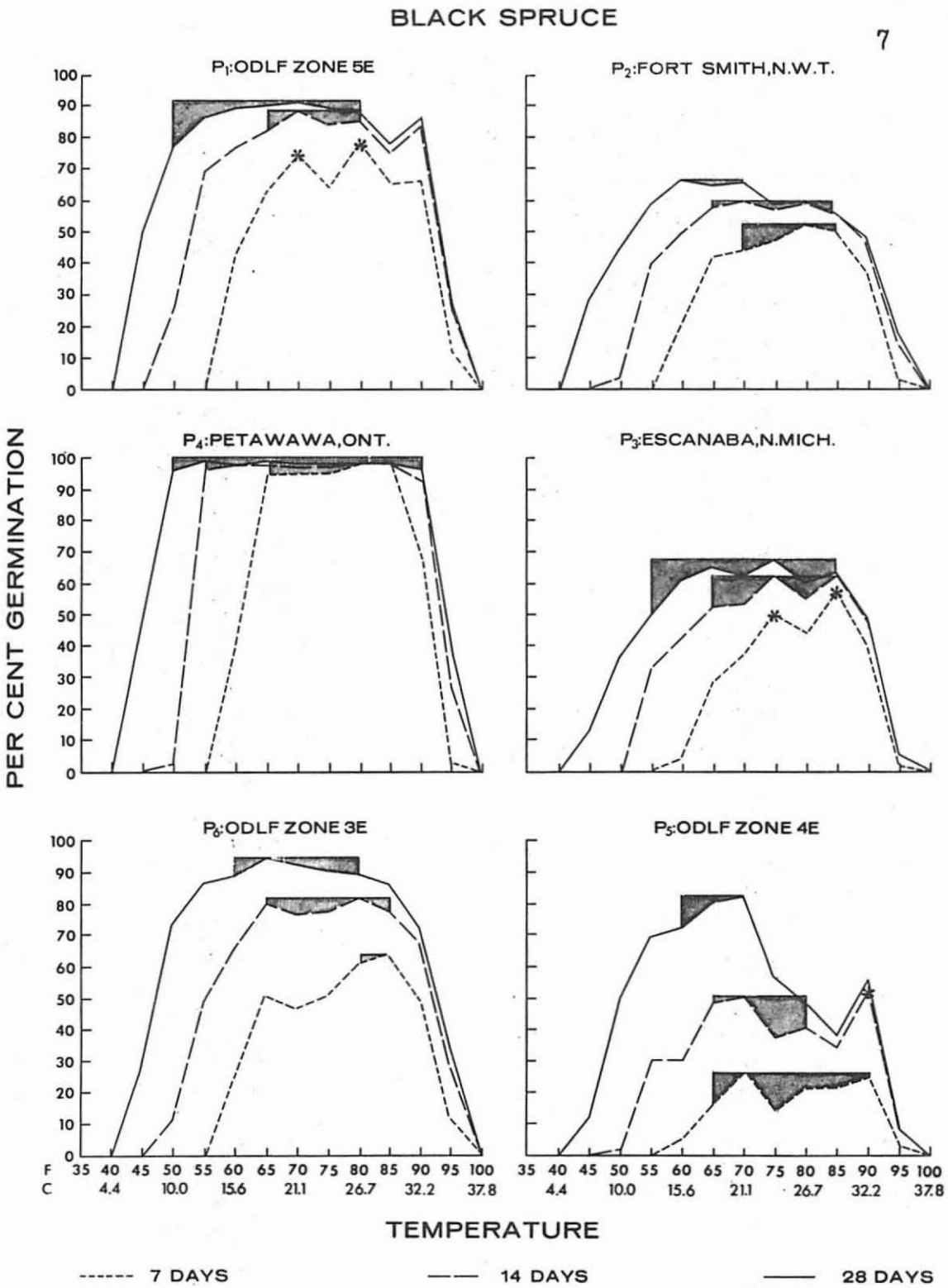

Figure 2. Percent germination of black spruce seed, by provenance, 7, 14, and 28 days after seeding. When OCTs occur as single temperatures they are indicated with asterisks: when occurring as a range of temperatures within which there is no significant difference in germination they are shown as shaded plateaus.

(P3) there is some indication that provenance may influence the germination response to temperature of black spruce seed as well as white spruce seed (Fraser, 1970b).

The 7-day OCTs for germination occurred within or at one extremity of the 28-day OCT ranges for maximum germination. By the 14th day OCTs were more clearly established within or overlapping the 28-day OCTs. The noticeable variability of OCT patterns as the germination period increased (P1, 2, 3, 5, 6) may be related to mixtures of seed from different environmental sources within these provenances. When seed came from a few trees at one exact location (P4) the OCT pattern changed quite uniformly from 7, to 14, to 28 days.

Germination response to provenance by temperature

Germination responses of different provenances of seed after 28 days at treatment temperatures 40F to 100F are illustrated in Figure 3.

At the LCT (45F) and the UCT (95F) common to all provenances, germination from P1, 2, 4, and 6 was significantly better than from P3 and P5; with the possible exception of 47% germination from P1 and P4 the responses at 45F and at 95F were too low to be of practical interest.

From 50F to 90F, inclusive, germination was significantly better from P1, P4 and P6 than from the other three provenances and significantly better from P4 than from P1 and P6.

In the same temperature range germination responses of seed from P2, P3, and P5 were less consistent. In general, germination from P5 was superior to germination from P2 and P3 at and below 70F, but inferior to

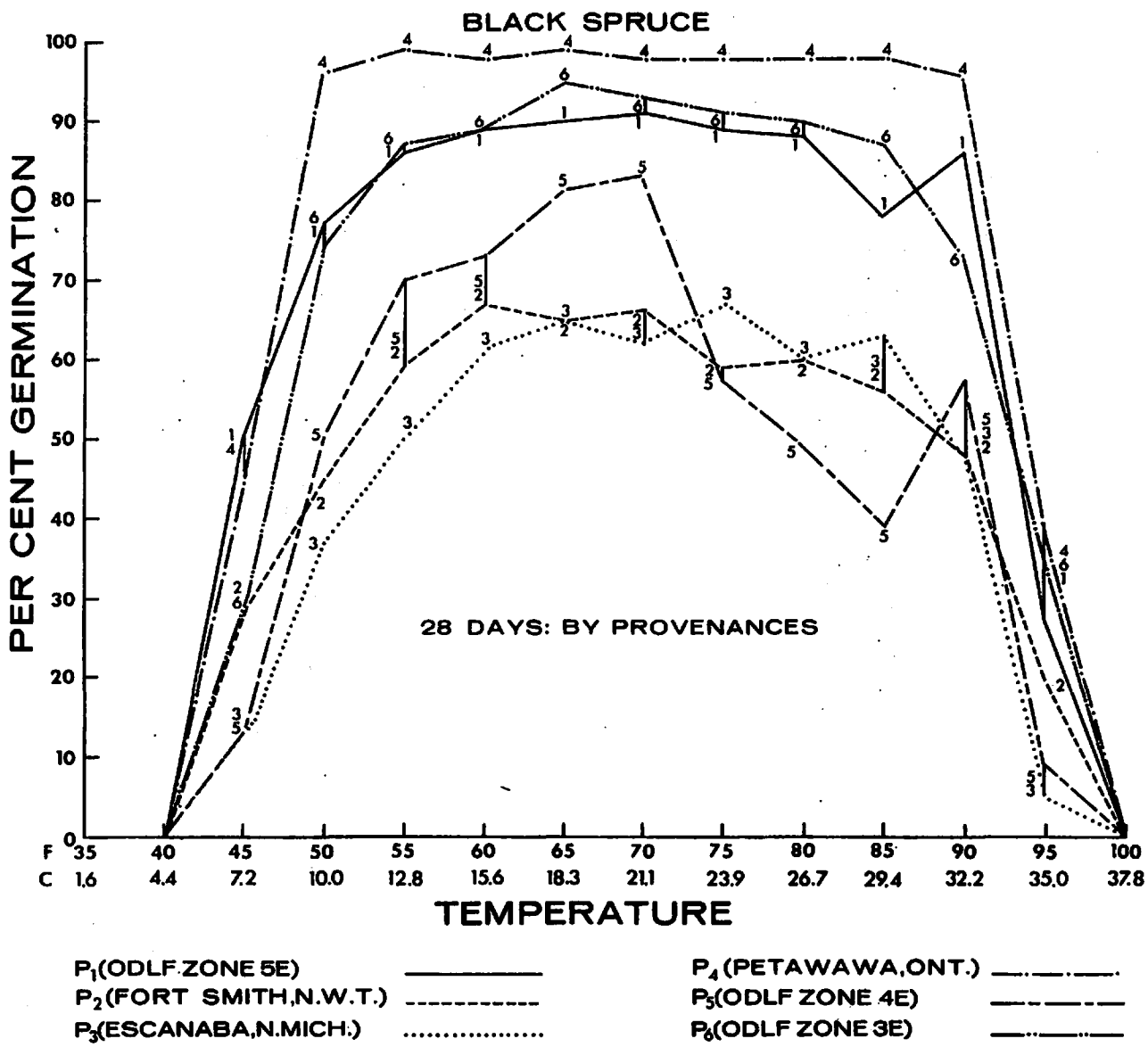

Figure 3. Percent germination of six provenances of black spruce seed at different temperatures 28 days after seeding. Vertical lines join provenances between or among which there was no significant difference in germination.

germination from both of them at 75F to 85F inclusive. Considering only P2 and P3, germination from P2 was significantly better than from P3 from 50F to 60F; above 60F germination was the same from both provenances except at 75F the one temperature at which the response was significantly better from P3 than from P2.

DISCUSSION

The experiment determined and demonstrated cardinal temperatures for germination of the six provenances of black spruce seed as well as the effect of different levels of constant temperature on the initiation and rate of germination. It also demonstrated significant differences among the six provenances in germination response to temperature.

Because of the methods employed to collect five of the six provenances of seed used in this experiment one must exercise care even when using these results to speculate about the indicated effects of provenance on germination responses to temperature. Thus, although there is condiderable variation in the 28-day OCTs among provenances, germination is at a maximum value for all provenances at 60F, 65F and 70F. Within this range (Figure 3) there was no practical difference in germination of seeds from Fort Smith, N.W.T. (P2), the northernmost provenance with the coolest environment and of those from Escanaba, Mich. (P3), the southernmost provenance with the warmest environment. It is probably significant that the best germination was from seed from Petawawa, Ont. (P4), ODLF zones 3(P6), 5E(P1), and 4E(P5), all between the extremes of latitude and mean temperature for Fort Smith and Escanaba.

Differences, among provenances, in maximum germination at OCTs are attributed to different germinative capacity of the seed lots Marked irregularity in germination patterns e.g. P1 at 85F, P5 at 75F to 85F, etc., are probably attributable to collection methods or subsequent handling of collections.

CONCLUSIONS

1. Cardinal constant temperatures for laboratory germination of black spruce seed from six provenances included in this study were as follows:

Provenance	LCT	OCT	UCT
P1 ODLF Zone 5E.	45	50 - 80	95
P2 Fort Smith, N.W.T.	45	60 - 70	95
P3 Escanaba, Mich.	45	55 - 85	95
P4 Petawawa, Ont.	45	50 - 90	95
P5 ODLF Zone 4E.	45	60 - 70	95
P6 ODLF Zone 3E.	45	60 - 80	95

2. Provenance of seed had a significant effect on germination responses of black spruce seed to temperature.

ACKNOWLEDGEMENT

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REFERENCES

Fraser, J.W. 1970a. Cardinal temperatures for germination of two provenances of white, red, and jack pine seed. Can. Dept. Fisheries and Forestry. Can. For. Service. Petawawa Forest Experiment Station, Information Report PS-X-15.

_____ 1970b. Cardinal temperatures for germination of six provenances of white spruce seed. Can. Dept. Fisheries and Forestry. Can. For. Service. (In press).