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Geographic Variation and Relationships Among Shoot Characteristics of Red Pine Seedlings

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Knowledge of variation among provenances grown in a common environment is basic to understanding the genetic diversity of a species and its improvement through breeding. Red pine (*Pinus resinosa* Ait.), when compared to other species of genus *Pinus*, is morphologically uniform throughout its geographic range and numerous studies of red pine provenances grown in plantations suggest relatively little genetic variability (Fowler and Lester, 1970). Seedling characters, however, have not been studied extensively. Hough (1952) found substantial variation among red pine seed sources in seed weight, seedling height, and seedling weight and Fowler (1964) reported variation in cotyledon number and hypocotyl length. The present study was initiated with the following objectives:

1. To provide additional information on variation among red pine provenances for seed weight and various seedling characters and relate this variation to latitude and longitude of origin.
2. To examine relationships between these traits.

MATERIAL AND METHODS

Seeds from 12 seed sources representing the natural geographic range of red pine (Fig.) were sown in petri dishes on moistened filter paper. The number of cotyledons was recorded for 99 or more 2-3 cm long seedlings from each seed source before they were transplanted to pots (16x16 cm) filled with 1:1 sterilized sand-peat mixture. A seed source was represented by 15 pots randomly placed on a greenhouse bench. Each pot initially contained 12 systematically arranged seedlings and was thinned to 4 seedlings one month after sowing. Day/night temperatures in the greenhouse were about 25°C/20°C, and a 16 hour photoperiod was maintained.

Six months after sowing, all pots with less than four live seedlings were discarded. The remaining plants in each seed source were harvested and the following observations were recorded:

- a. Shoot weight: For each seed source, 4-5 samples of five seedlings each were selected randomly. Shoot portion of each seedling was separated by clipping at the root collar. Samples were oven dried and mean shoot weight for each sample recorded.

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- b. Individual seedling characters: The remaining 18-24 seedlings per seed source were used for recording the following observations:
1. Hypocotyl length
 2. Length of one cotyledon picked at random
 3. Epicotyl length
 4. Number of primary needles
- c. Seed weight: For each seed source three or four lots of 50 seeds each were weighed after oven drying.

Data were examined using analyses of variance. Correlation coefficients among the character pairs were calculated using the seed source means. The 5% probability level was used to determine statistical significance.

RESULTS AND DISCUSSION

The differences among seed sources for all the characteristics were found to be significant. The range of seed source means (Table 1), expressed as percentage of the overall mean, was the lowest for cotyledon number (93-105) and the highest for shoot weight (79-146). Differences among seed sources, measured on individual seedling basis, accounted for a small portion (4-18%) of the phenotypic variance.

None of the variables were related to the longitude of seed source. However, seed weight, cotyledon number, cotyledon length, number of primary needles, and shoot weight were significantly and negatively correlated with the latitude of seed origin. Significant negative correlations between latitude and seed weight (Hough, 1952) and between latitude and cotyledon number (Fowler, 1964) were reported earlier. Hypocotyl length appeared to be independent of the latitude of seed origin.

All the character pairs were positively associated with each other (Table 2). Seed weight was significantly correlated with all other characters. Hypocotyl length, however, was not significantly correlated with other shoot characters. Correlations among all other character pairs, except cotyledon number/cotyledon length, were statistically significant and moderate to high.

Since seed weight was highly correlated with all the other characters and accounted for 42-69% of variation in these variables, partial correlation coefficients for pairs of variables were calculated after eliminating the effect of their association with seed weight (Table 2). None of the correlations between shoot weight and other characters were significant. Hypocotyl length was significantly and negatively correlated to cotyledon number and number of primary needles. Furthermore, all the correlations involving hypocotyl length as one of the variables, were negative. It is interesting since other character pairs were positively related although most of the correlations were not significant.

The variation in six month old seedling characters appears to be generally larger than that noted in older red pine plants by other workers. Seed weight, however, has a strong modifying influence on phenotypic expression and relationships among characters of red pine seedlings. Its effect should be considered when evaluating morphological traits of red pine seedlings.

LITERATURE CITED

Fowler, D.P. 1964. Effect of inbreeding in red pine, Pinus resinosa Ait. Silvae Genetica 13:170-177.

Fowler, D.P., and D.T. Lester. 1970. Genetics of red pine. Forest Service Research Paper WO 8, U.S.D.A.

Hough, A.F. 1952. Relationships of red pine seed sources, seed weight, seedling weight and height growth in Kane test plantations. Northeastern Forest Expt. Sta., Forest Service Station Paper 50, U.S.D.A.

Figure. Natural geographic range of red pine (shaded area) and the location of seed sources.

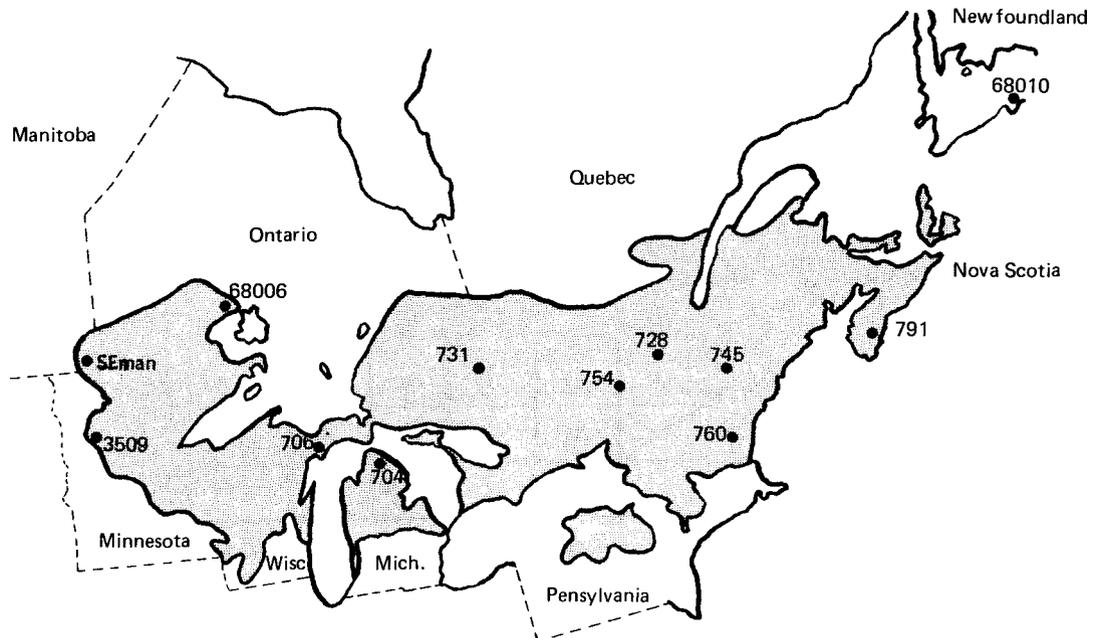


Table 1. Summary of variation among seedling characteristics of red pine seed sources.

Character	Mean	Range of seed sources Percent of mean	Proportion phenotypic variance attributed to seed sources
Seed weight	393 mg	75 - 120	---
Shoot weight	86 mg	79 - 146	---
Number of cotyledons	6.3	93 - 105	.15
Cotyledon length	18.6 mm	82 - 115	.04
Hypocotyl length	34.1 mm	74 - 122	.18
Epicotyl length	13.1 mm	85 - 121	.12
Number primary needles	32.6	90 - 113	.04

Table 2. Simple and partial¹ correlations among red pine seedling character pairs.

	Cotyl. no.	Cotyl. length	Hypocot. length	Epicotyl length	No. prim. needles	Shoot weight
	Simple Correlations					
Seed weight	.65*	.81*	.83*	.82*	.81*	.77*
Cotyl. no.		.55	.24	.71*	.78*	.48
Cotyl length			.53	.89*	.83*	.78*
Hypocot. length				.49	.42	.44
Epicotyl length					.94*	.82*
No. prim. needles						.81*
Shoot weight						
	Partial Correlations					
Seed weight						
Cotyl. no.						
Cotyl length						
Hypocot. length						
Epicotyl length						
No. prim. needles						
Shoot weight						

¹Partial correlation coefficients represent the degree of association among character pairs after the common influence of seed weight on character expression is eliminated.

* Significant at 5% probability level.