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Early Growth of Progenies from some phenotypically superior White Spruce Provenances in Central Newfoundland

By M. A. K. KHALIL*

(Received May 1975)

Introduction

The widespread distribution of white spruce (Picea glauca (MOENCH) Voss) in Canada and northern U.S.A., combined with its high economic value, has prompted research on its genetic improvement in several parts of the continent. Detection of superior provenances, and verification of their genetic superiority, is an important aspect of this research. One such study was started in the fall of 1971 in Newfoundland to verify the genetic superiority of a number of phenotypically superior trees of white spruce located in small, partially isolated stands in the Exploits River Valley in central Newfoundland. Some results which indicate that the characters of cone morphology are genetically controlled but not associated with height growth, and that the heritability of these characters differs at the two locations under study, have already been reported (KHALIL, 1974). This paper presents further results concerning germination, survival and early height growth of progenies from these trees.

Material and Methods

Phenotypically superior trees of white spruce have been located at several sites in the Exploits River Valley in central Newfoundland (Forest Section B.28a; ROWE 1972) in natural second growth stands as individual trees or small groups of trees. Such trees have distinctly superior height and diameter growth. The study was restricted to two locations in the above tract, near Frenchman's Pond (latitude 48° — 50' N., longitude 55° — 40' W.) and Lake Douglas (latitude 48° — 30' N., longitude 56° — 40' W.). The two locations, which are about 50 miles apart, have similar climate and both are situated on gently undulating, well-drained sites. At each location five average ("ordinary") and five exceptionally tall ("plus") trees were selected. Table 1 shows the phenotypic differences between these classes of trees.

Table 1. — Mean age, height and breast height diameter of "plus" and "ordinary trees."

	Frenchman's Pond			Lake Douglas		
	Age (yrs)	Height (m)	Diameter (cm)	Age (yrs)	Height (m)	Diameter (cm)
"Ordinary" trees	23	9.82	15.5	56	9.39	21.3
"Plus" trees	26	13.17	25.9	51	13.53	30.2

Seeds were collected from the 20 trees in 1971. Samples of current year's foliage from each selected tree and of sail from beneath the same trees were collected in September 1972 and chemically analysed to test for the existence of differences which might be responsible for variations in growth. The soil samples were analysed for texture, total organic matter content, organic carbon, C/N ratio, pH, cation exchange capacity, and total and available nitrogen, phosphorus, potassium, calcium and magnesium. The means of the above variables for "plus" and "ordinary" trees at both locations were compared using Student's t-test. The needles were analysed for nitrogen, phosphorus, potassium, calcium, and magnesium contents, and the means were compared in the same way.

Genetic studies comprised a four- replicated experiment in a laboratory germination test (25 seeds per plot) in February, 1972 and a five-replicated nursery experiment at Pasadena, Newfoundland (400 seeds per plot). Randomized complete block design was used in both cases and progenies were kept separate by individual parent.

Data were collected on the germination percent in the laboratory experiment as also on the germination and survival percent and height of 10 randomly selected seedlings in each plot at the age of 2 years.

The data were tested by analysis of variance followed by Student-Newman-Keul's multiple range test and single degree of freedom comparisons between the progenies of the above classes of trees. Narrow sense individual tree heritability of 2-year height growth was calculated from the analysis of variance, using Wright's formulae 61 and 62 (WRIGHT 1962).

* Research Scientist, Environment Canada, Canadian Forestry Service, Newfoundland Forest Research Centre, St. John's, Newfoundland, Canada.

Results and Discussion

No statistically significant differences were detected between the soils and foliage of "ordinary" and "plus" trees at either of the two locations. Thus. the phenotypic superiority of the "plus" trees over "ordinary" trees cannot be attributed to differences in soil conditions.

Results of analysis of variance *(Table 2)* show significant variation among parent trees in germination, survival and height growth. The Student-Newman-Keul's multiple range tests do not show any meaningful trends between trees for any of the four variables studied. However, grouping of the trees into classes and single degree of freedom comparisons *(Table 3)* indicate that all classes of trees in the Frenchman's Pond area are superior to the corresponding classes in the Lake Douglas area in terms of the same variables. Statistically significant differences between "ordinary" and "plus" trees were not found in any of the variables studied, with the single exception of laboratory germination of the Lake Douglas seed. The analysis of variance on the basis of individual observations (Steel and Torrie 1960, pp. 142—146) shows that the variance is distributed among replications, trees, replications × trees interaction and sampling error in the ratio of 2, 17, 12 and 69 percent respectively, which shows a very high within-plot variation. Similarly, the single-tree narrow sense heritability, which is found to be 0.2279, shows high within-plot phenotypic variance. The high within-plot variance masks the among-trees variance, for which reason the latter could not be detected.

Statistically significant differences between each class of trees at the two locations with very similar climates are very interesting. The most probable explanation appears to be genetic drift caused by partially isolated stands and small sample size. Micro-climatic differences resulting in differential dysgenic selection partially accounts for such differences. Different migratory histories are the least probable cause. Further investigations on this are in progress.

The phenotypic difference between "ordinary" and "plus" trees might be explained by the occurrence of white spruce in the Exploits Valley in small groups, which may have led to different degrees of inbreeding within stands. Though cross-fertilization is normal in white spruce outcross pollen has no advantage over self-pollen prior to fertilization (Nienstaedt and Teich 1972) and self-sterility is not caused by the failure of self-fertilization (Navasaitis 1966). Most of the embryos fail to develop, probably as a result of homozygous lethal recessive loci (Klaehn and Wheeler 1961; Mergen, Burley and Furnival 1965; King, Jeffers and Nienstaedt 1970). Nevertheless, some self-pollination is not ruled out and limited quantities of viable seed from self-pollination have been obtained at Rhinelander, Wisconsin, U.S.A. (Nienstaedt and Teich 1972). Hence, there is a reasonable probability of inbreeding in these small isolated groups of white spruce in the Exploits Valley. Therefore, it is possible that the "ordinary" trees are more intensively inbred than the "plus" trees, and exhibit inbreeding depression, resulting in slower growth

Table 2. — Summary of results of statistical analyses.

Statistic or variable	Germ. % in lab test		Germ. % in nursery test		Surv. % in fall of 1973		Hgt. in fall of 1973	
	M.S.	F	M.S.	F	M.S.	F	M.S.	F
Var. among repl.	1.90	0.04NS	150.51	4.46**	230.72	8.44**	3.06	2.55*
Var. among trees	684.65	15.63**	151.92	4.51**	144.76	5.30**	5.09	4.24**
Frenchman's Pond all trees vs. Lake Douglas all trees	4,143.60	94.58**	483.08	14.33**	924.34	33.82**	63.33	52.78**
Frenchman's Pond "ordinary" trees vs. "plus" trees	99.60	2.27NS	35.15	1.04NS	73.98	2.71NS	0.0085	0.01NS
Lake Douglas "ordinary" trees vs. "plus" trees	387.44	8.84**	43.23	1.28NS	4.37	0.16NS	0.0375	0.03NS
"Ordinary" trees: Frenchman's Pond vs. Lake Douglas	941.58	21.49**	474.94	14.08**	718.96	26.31**	32.24	26.87**
"Plus" trees: Frenchman's Pond vs. Lake Douglas	3,642.00	83.13**	87.89	2.61NS	261.93	9.58**	31.09	25.91**
Experimental error	43.81		33.72		27.33		1.20	
Coefficient of intra-class correlation	0.7853		0.4121		0.4622		0.3933	

NS - Non-significant at the 0.05 level.

* - Significant at the 0.05 level.

** - Significant at the 0.01 level.

Note - Analysis of variance of all percentages were performed after arcsin $\sqrt{\text{percentage}}$ transformation.

Table 3. — Summary of the results of single degree of fredom comparisons.

Germination percent in laboratory tests	Germination percent in nursery tests	Survival percent in the fall of 1973	Height in the fall of 1973
Frenchman's Pond all trees (mean 78.4%) > Lake Douglas all trees (mean 56.5%); significant at 0.01 level.	Frenchman's Pond all trees (mean 13.91%) > Lake Douglas all trees (mean 8.99%); significant at 0.01 level.	Frenchman's Pond all trees (mean 10.57%) > Lake Douglas (mean 4.94%) significant at 0.01 level.	Frenchman's Pond all trees (mean 5.44 cm) > Lake Douglas all trees (mean 3.85 cm,); significant at 0.01 level.
Lake Douglas: "Ordinary" trees (mean 61.0%) > "plus" trees (mean 52.0%); significant at 0.01 level.			
"Ordinary: trees: Frenchman's Pond (mean 77.4%) > Lake Douglas (mean 61.0%); significant at 0.01 level.	"Ordinary" trees: Frenchman's Pond (mean 14.10%) > Lake Douglas (mean 7.86%); significant at 0.01 level.	"Ordinary" trees: Frenchman's Pond (mean 11.29%) > Lake Douglas (mean 4.82%); significant at 0.01 level.	"Ordinary" trees: Frenchman's Pond (mean 5.43 cm) > Lake Douglas (mean 3.82 cm); significant at 0.01 level.
"Plus" trees: Frenchman's Pond (mean 79.4%) > Lake Douglas (mean 52.0%); significant at 0.01 level.		"Plus" trees: Frenchman's Pond (mean 9.85%) > Lake Douglas (mean 5.06%); significant at 0.01 level.	"Plus" trees: Frenchman's Pond (mean 5.45 cm) > Lake Douglas (mean 3.88 cm); significant at 0.01 level.

Note - Twenty-five seeds per plot were sown in the laboratory experiment and 400 in the nursery experiment.

than the "plus" trees. Most of the seed of both classes of trees, used in this study, has resulted from outcrossing with individuals which have different degrees of relationship. This has produced large within-plot (or within-tree) variation.

Conclusions

The important conclusions available from the early results of this study are that (1) all classes of trees in the Frenchman's Pond area are genetically superior to the corresponding classes in the Lake Douglas area, (2) with one minor execption, statistically significant differences between "ordinary" and "plus" trees do not exist at either location, and (3) the penotypic superiority of "plus" trees over "ordinary" trees may be due to a higher degree of inbreeding in the latter than in the former.

Acknowledgement

The constructive criticism and advice received from Dr. Gene Namkoong, Geneticist, U.S. Forest Service is gratefully acknowledged.

Summary

A study was started in 1971 to verify the genetic superiority of a number of phenotypically superior trees of white spruce (*Picea glauca* (Moench) Voss) from two locations in central Newfoundland. There were significant differences between the two locations in germination, survival and two-year height growth, but essentially no differences between "plus" and "ordinary" trees in terms of these same characteristics at either location. There were no significant differences in foliar nutrient contents or in the properties of the soils beneath these two classes of trees that could be responsible for the differences in growth.

Key words: "Plus" trees, *Picea glauca* (Moench) Voss, Genetic superiority.

Résumé

L' auteur commenca en 1971 de vérifier la supériorité génétique d'individus phénotypiquement supérieurs de Epinette blanche *(Picea glauca* (Moench) Voss) ec deux endroits dans le centre de l'ile de Terre-Neuve. Il trouva des différences significatives entre les deux endroits en ce qui concerne la germination, la survie et la croissance de deux ans, mais essentiellement aucune différence en ce qui concerne les arbres plus et ordinaires en termes de ces mêmes caractéristiques. Aucune différence significative n'existait concernant la teneur de nourriture dans les feuilles, ou les propriétés des sols, ce qui auraient pu créer des différences de croissance.

Zusammenfassung

Im Jahre 1971 wurde eine Untersuchung zur Klärung der angeblichen Wachstumsüberlegenheit von „Plusbaum"-Nachkommenschaften auf zwei Standorten in Zentral-Neufundland bei *Picea glauca* (Moench) Voss durchgeführt. Hierbei wurden die Nachkommenschaften von Einzelbäumen geprüft. Signifikante Unterschiede konnten im Keimprozent der Samen, im Überlebensprozent und in der im Alter 2 erreichten Gesamthöhe der Pflanzen zwischen den beiden Herkünften gefunden werden, jedoch nicht zwischen den Plusbaum-Nachkommenschaften und den Nachkommenschaften anderer Ausgangsbäume des jeweils gleichen Bestandes.

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Natural hybridization between Pinus halepensis and Pinus brutia in Greece

By C. P. PANETSOS

Forest Research Institute
Athens 615, Greece.

(Received June / October 1975)

Introduction

Aleppo pine (*Pinus halepensis* MILL.) is widely distributed in the Mediterranean region ranging from Morroco to the main land of Greece. It grows also on some small islands of the west Aegean sea, while in Asia Minor is rarely found, only in one locality above Adana. It is native in coastal region of Syria and is also found in Israel and Jordan.

Pinus brutia TEN., which was treated as a variety of Aleppo pine is at present considered to be a well established species (MIROV 1955). To the same conclusion came NAHAL (1962) after morphological, geographical, biochemical, and ecological studies of the two species. This species has a more restricted range and grows from Greece to Iraq. A detail map of distribution of the species is given by CRITCHFIELD (1966).

From fossil record it appears that *Pinus brutia* in Tertiary had a larger distribution than today, while *P. halepensis* occupied the same region with a considerable northern distribution in latitude (NAHAL 1962).

In Greece both species occur, *P. halepensis* on the west part of the country and *P. brutia* on the east and the main islands of the Aegean sea and Crete *(Fig. 1)*.

There is a well defined spatial isolation of the two species, the shortest distance being about 50 Kilometres, between the natural populations of Aleppo Pine in Chalkidiki (peninsula of Holly mountain), and those of *P. brutia* on island Thassos.

Isolated occurences of the one species inside the range of the other have been reported by PAPAIOANNOU (1935, 1936, 1954) and MOULOPOULOS (1951) *(Fig. 1,* points C, D and G). According to PAPAIOANNOU the two species form natural hybrids, when they come in contact. In N.E. Chilkidiki *(Fig. 1,* Point C) there is a natural overlap of the two species. In this particular area, PAPAIOANNOU (1936) identified natural hybrids. He described them as intermediate forms between the two species and gave them a specific name *(Pinus golaïana* sp. nov). In central Greece *(Fig. 1,* Point D) a stand of *Pinus brutia* occurs inside the range of *Pinus halepensis*, as PAPAÏOANNOU states (1954), there is enough evidence that it was established artificially one hundred years ago. In island Rodos *(Fig. 1,* Point G) *P. halepensis* occurs inside the range of *P. brutia* which again is considered by the author mentioned previously, as an outcome of human interference, going back some hundred years. At this point only the species today are intermixed and there is also a continuous population of the native species. In the two other places (Points C and D) the populations described are isolated from stands of the native species by a distance ranging from 5 to 14 Kilometers.

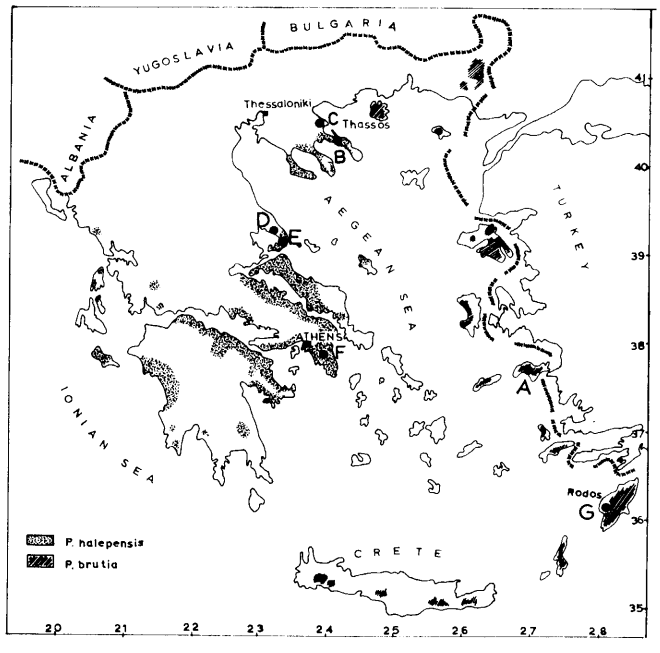

Fig. 1. — Natural range of *P. halepensis* and *P. brutia* in Greece, and location of sample collections (black circles).

Artificial crossings between the two species were performed for the first time in 1948 by MOULOPOULOS and BASSIOTIS. Thirteen years later (1961) they report that the crossings were only successful when *P. brutia* was the female parent and not reciprocally.