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Short Notes

Performance of White spruce [Picea glauca (Moench) Voss] Progenies after Selfing

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Summary

Self-, and open-pollinated white spruce (Picea *glauca*) progenies were compared in three field tests. These tests were first evaluated in 1976 at ages 18, 14 and 7 years respectively. The average heights of the selfed trees were 33, 18 and 25 percent shorter than the open-pollinated trees in these tests; the degree of depression was not related to the age of the tests. Survival of selfed progenies was 11, 20, and 11 percent less respectively. There was considerable tree-to-tree variation in tolerance of selfing. The importance of avoiding inbreeding for the maintenance of plant quality is discussed.

Key words: Inbreeding effect, cross breeding effect, growth vigour, performance.

Résumé

Des descendances d'Epinette blanche (Picea glauca) obtenues par autopdlinisation ont été comparées dans trois essais sur le terrain avec des descendances maternelles résultant de pollinisations libres. La premiere évaluation de ces essais a eu lieu en 1976 aux âges 18, 14 et 7 années, respectivement. Les hauteurs moyennes des arbres autopollinisés étaient de 33%, 18% et 25% inférieures à celles des arbres obtenus par pollinisation libre dans ces essais; le degré de perte en hauteur n'était pas relié a l'âge des essais. La survie des descendances par autopollinisation était de 11, 20 et 1 pour-cent moins respectivement. Il y avait une variation considérable d'un arbre a l'autre quant a tolérance de l'autopollinisation. L'importance d'éviter la consanguinité pour conserver la qualité des arbres est discutée.

Zusammenfassung

Titel der Arbeit: Leistung von Nachkommenschaften der Picea glauca nach Selbstung.

Nachkommenschaften der Picea glauca, die aus Selbstung und von freiabgeblühten Bäumen stammen, wurden in 3 Feldversuchen im Alter von 18, 14 und 7 Jahren geprüft. Die mittlere Höhe der Bäume aus Selbstung war um 33, 18 und 25% geringer als die Höhe der vergleichbaren aus freier Bestäubung hervorgegangenen Gruppen, doch war die geringere Leistung unabhängig vom Testalter. Es überlebten 11, 20 und 1% weniger als bei den frei abgeblühten Nachkommenschaften. Die Selbstung hatte eine von Baum zu Baum sehr unterschiedliche Wirkung. Die Notwendigkeit der Inzuchtkontrolle wird allgemein diskutiert.

Introduction

With the probable exception of red pine (Pinus resinosa AIT.) (FOWLER 1965), inbreeding depression commonly results from self-pollination in pine and spruce (FRANKLIN 1970). In comparison with out-crossed progenies, selfing results in low seed set, poor survival, reduced growth and vigor and an increase in frequency of dwarfs and seedlings with pigment and morphological aberrations.

Among spruce species, the oldest existing experiment investigating the effect of self-pollination involved 5 parent trees of Norway spruce (Picea abies [L.] KARST) planted in 1916 by Sylven. At age 61, average height and DBH of the selfed progenies were respectively about 28 and 25% less than for wind-pollinated progenies (ERIKSSON et al. 1973). The same experiment was carried into the second generation by further selfing and variously constructed crosses to create a range of inbreeding coefficients from 0 to 0.75. The initial results indicated that increased inbreeding was accompanied by decreased height growth (ANDERSSON et *al.* 1974).

Studies of inbreeding depression of white spruce have mostly concentrated on seedlings in greenhouses and nurseries. Information about field performance of inbred progenies is still scanty. MERGEN et al. (1965). reported no difference in the first year height growth between self- and wind-pollinated progenies. YEATMAN and VENKATESH (1974) found no apparent effect of selfing on time of flushing of 2-year-old white spruce seedlings, although typically the selfed progenies were smalller than the out-crossed seedlings. A recent study by COLES and FOWLER (1976) indicated that selfing reduced both seed set and seedling growth. Similar results were also reported by KING et al. (1970).

This note compares the performance of selfed white spruce progenies with wind-pollinated ones in three different trials at Petawawa Forest Experiment Station (PFES), Chalk River, Ontario.

Table 1. — Comparison in survival and height growth between self- and open-pollinated white spruce progenies.

Exp. No.	Age	Survival (%) Open	Self	Difference[1]/		Height (cm) Open	Self	Difference[1]/	
208	18	91	81	11	NS	291	194	97	**
279[2]/	14	88	68	20	*	327	268	59	*
331	7	92	91	1	NS	75	55	20	**

[1]) Level of significance: NS = not significant; *, ** = significant at 5% and 1% level of probability respectively.

[2]) Based on paired t-test.

Materials and Methods

All parent trees chosen for these studies were native and located at PFES. The first experiment (Exp. 208) involved 6 progenies (3 selfed and 3 open-pollinated) and was established in 1964 with 2 + 2 stock in a randomized complete block design with 5 replications of 5-tree plots. The trees were spaced at 2.4 × 2.4 m.

Both self- and open-pollinated progenies from 8 neighboring trees were included in the second test (Experiment 279) which was planted in 1966 using 1 + 3 stock. Sixty seedlings each of the two types of progenies from the same parent were planted side by side, without replication, at a spacing of 1.8 × 1.8 m. The number of seedling pairs for each parent tree ranged from 1 to 21.

The most recent test (Experiment 331) is a 5 × 5 diallel crossing including selfed and open-pollinated progenies. The crosses were made in 1967 by Dr. Yeatman. A field test consisting of the complete set of diallel crosses was laid out in a randomized complete block design of 5 replications of 9-tree square plots. The test was planted in 1974 with 2 + 2 stock at 1.8 × 1.8 m. Only the data from self- and open-pollinated progenies are included in this report.

All three trials were first evaluated in 1976. Differences between the two types of progenies were compared on the basis of the t-test.

Results

Survival and height differences between selfed and open-polinated families for all three experiments are presented in *Table 1*. Open-pollinated progenies survived better but differences of statistical significance were detected only in the second test. There was virtually no difference in the third one. The effect of selfing on survival will be reduced if pre-germination mortality resulting from lethal genes eliminates many of the inbred individuals (Coles and Fowler 1976).

Effect of selfing on height growth was obvious. Selfed progenies in the three tests averaged 33, 18 and 25 percent less in height growth than open-pollinated ones in the older to younger plantings respectively. The differences were all statistically significant *(Table 1)*.

Considerable tree to tree variation in tolerance of selfing was also observed. In the third test (Exp. 331), selfed progenies of one parent suffered only 11% loss in height growth as compared with 26 to 33 percent for others. Selfing depression in height growth ranged from —2 to 26 percent in the second experiment. However, the mean depressions in the latter were estimated on the basis of relatively few seedlings, and the wide range of differences may be fortuitous.

Discussion

Adverse effect of selfing was clearly shown in these three small scale trials. Mortality is expected to increase as the trees grow older because the selfed progenies are slow growing and less able to withstand competition. The degree of depression in height growth was not directly related to the age of the trees. The second test (Exp. 279) planted on rich loamy soil of a former mixed hardwood stand, showed the least depression and was taller than the first one which was 4 years older *(Table 1)*. This is probably due to soil fertility (Andersson *et al.* 1974). Actual depressing effect of selfing would probably have been even greater if comparisons had been based on controlled cross-pollination instead of open-pollinated progenies because an undetermined portion of seed from open pollination will result from selfing (Coles and Fowler 1976). Variation from tree to tree in tolerance of selfing seems common in conifers and is explained by parental differences in heterozygosity (Orr-Ewing 1976).

Selfing occurs naturally in most coniferous species. Very little published information is available about natural selfing in white spruce but it undoubtedly occurs. Wang (1976) found germination of white spruce seeds collected in poor flowering years amounted to only 25 and 30% of that in good years. He suggested a high frequency of natural selfing in poor years as a contributing factor. King *et al.* (1970) reported that pollination in white spruce depended on the availability of pollen. Foreign pollen had no particular advantage over pollen from the same tree in the ability to fertilize the ovule. The indications are that rate of natural self-pollination of white spruce can be very high under unfavourable conditions.

A substantial portion of the seeds collected from natural stand could be inbred as a result of selfing and pollination by closely related neighbouring trees. The quality of our sedelings could upgraded if these inbred seeds could be eliminated or reduced. Avoiding seed collection in a poor flowering year may be one way to avoid a crop which may contain a high proportion of inbred seeds. Nursery culling may also eliminate a substantial number of inbred seedlings (Sorensen and Miles 1974).

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