Effects of length of seed chilling period and sowing date on family performance and genetic variances of Douglas-fir seedlings in the nursery

FRANK C. SORENSEN

1 Forestry Sciences Laboratory, Pacific Northwest Research Station, 3200 SW Jefferson Way, Corvallis, OR 97331, U.S.A.

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Application. Date of sowing and length of chilling period had a predictable effect on date of emergence, seedling phenology, and seedling size; interacted with families; and had an unpredictable effect on family and within-plot components of variance. To produce vigorous seedlings early sowing and long seed chilling are recommended. Because families interacted with treatments, it is important for genetic evaluations in the nursery that sowing date and chilling period be as consistent as possible from year to year.

Abstract. Seeds of four full-sibling Douglas-fir families (F) were moist chilled (C) for 14, 33, and 77 days and sown (S) March 29, April 26, and May 24 at two densities (D = 111 and 200 seeds/m²), grown for 2 years in nursery beds and phenology and size traits recorded. The study was analyzed in two parts: part I evaluated seed treatment effects and their interactions with families; and part II investigated the effect of treatments on genetic variances, particularly among-family ($\sigma^2_F$) and within-plot ($\sigma^2_w$) components and the intraclass correlation for families ($r_f$). In part I there were large and highly significant differences associated with C and S and among F for all traits. Early S combined with long C resulted in early emergence and gave large seedlings with little loss and damage. Many interactions between C and F, and S and F, were significant. Interactions involved rank changes for size but not for phenology traits, and were larger for C × F than for S × F. Seedling density affected seedling size but not phenology, did not interact with seed treatments, and interacted significantly but weakly with families. In part II, C and S, but not D, had significant effects on $\sigma^2_F$, $\sigma^2_w$, and $r_f$, but not in a predictable manner. Because of significant interactions, it is recommended that standardized seed treatments be used in family nursery tests. This should aid in keeping the results from these tests as repeatable as possible. Long chilling and sowing as early as practicable are recommended to minimize disease losses and winter damages and to provide good nursery stock.

Introduction

Several studies have indicated, both in agricultural crops (Black and Wilkinson 1963; Alessi and Power 1975; Gray 1976; Cook 1980) and trees (Skeates 1986; Jenkinson and McCain 1993), including Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) (Sorensen 1978), that date of seedling emergence influences seedling size, as well as phenology (Dormling 1973;
Sorensen 1978) and survival or seedling yield (Cook 1980; Miller 1987; Jenkinson and McCain 1993). Two factors, length of growing season and synchrony between the developmental cycle of the plant and the annual climatic cycle, may be important. In addition to direct effects on first-year growth, there may be carry over effects into the subsequent year or years (Heide 1977; Sorensen 1978; Schmidt-Vogt 1995). In Douglas-fir (Sorensen 1978) and Norway spruce (Picea abies (L.) Karst.) (Dormling 1973), provenances responded differently to date of sowing, and in Norway spruce to year of sowing (Schmidt-Vogt 1995). In annual crops, highly significant variety × year and variety × year × location interactions have been observed (Robinson and Moll 1959). These and other observations point out the intimate connection between the climatic and photoperiodic regime and the phasic developmental cycle of the plant (Rasumov 1930; Watson and Baptiste 1938; Hammerton 1975; Lawn 1979). If families react differently to these factors, it could influence genetic and environmental variances and genetic rankings in nursery evaluations (Johnson and Frey 1967).

Time of emergence can be affected by date of sowing and by length of time that seeds are moist chilled or stratified prior to sowing. Chilling increases both rate and uniformity of germination, and the effect is inversely related to the incubation temperature; i.e., the lower the substrate temperature within the germinable range, the more chilling increases the speed and uniformity of germination (Weber and Sorensen 1990; Sorensen 1991). Therefore, depending on substrate temperature, genetic variances for time of emergence and for nursery growth and phenology could be affected by sowing date and chilling pretreatment.

The objective of the present test was to investigate the effect of length of chilling period and date of sowing on genetic evaluation (early testing) in nurserybed trials (e.g., Robinson and van Buijtenen 1979, Bastien and Roman-Amat 1990). Particular emphasis was placed on family × sowing date and family × chilling period interactions. The test was designed so that the effect on among- and within-family variances could be analyzed. Two sowing densities were used to determine if competition influenced the magnitude of the effects, particularly effects carrying into the second year (Fowler 1984; Magnussen 1989; Mazer and Schick 1991; Miller et al. 1994).

Materials and methods

Families (F)

Four full-sib and unrelated families were randomly chosen from about 30 control-pollinated crosses made in a natural second-growth stand in the