Variation in clonal and controlled pollinated radiata pine seed-lots established in Hawke's Bay forests

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Abstract

Six clones and three control pollinated (CP) seed-lots were compared for diameter and stiffness variability, the data coming from operational plantings in four Hawke's Bay forests. Analyses show that diameter variability for clones is significantly less (between 9% and 16%) than for CP seed-lots. In contrast, there was no significant difference for variability between clones and CP families for modulus of elasticity.

Introduction

Genetic improvement of *Pinus radiata* in New Zealand has been progressing since the early 1950s, starting at the (then) Forest Research Institute in Rotorua (Burdon, 1966, 1992). Initially breeding focused on growth and form traits, but more recently has included adaptability traits (e.g. *Dothistroma pini* resistance) and wood properties, such as basic density and modulus of elasticity. The deployment of improved material in stand establishment allows breeding gains to be captured in commercial forestry.

The last 50 years has seen a progression of improvement techniques beginning with so-called 'climbing select' – seed obtained from cones of assessed superior trees (Shelbourne, 1986; Burdon 1992), then open pollinated (OP) material, where a selected 'mother' is naturally fertilised by wind pollination in seed orchards (Shelbourne, 1986), followed by controlled pollinated (CP) stock where both parents are known and crossed (Vincent, 1986; Shelbourne, 1986; Carson, 1996) and, finally, to the concept of clones.

Clonal forestry of radiata pine is when the deployment of tested clones became possible with the development of somatic embryogenesis, involving multiplying embryos and cryopreserving them (Attree & Fowke, 1993; Sutton, 2002). The embryos chosen for multiplication come from CP crosses of superior parents. All copies of an embryo have the same genotype and are therefore clones (Johnson, 1988). The planting of clones in commercial stands represents the latest deployment of genetic material at an operational level.

Pan Pac Forest Products Ltd (Pan Pac) is an integrated forest company in Hawke's Bay that is comprised of a pulp mill and an appearance grade sawmill, together with 35,000 ha of radiata pine plantations. Operational clonal plantings have become a large part of their establishment programme. However quantifying the clonal performance in the estate has so far been based on a few trials and a small number of immature sample plots. Published literature on clonal growth characteristics is almost entirely based on field experiments rather than actual operational assessments. There is a danger these may give biased estimates as to production efficiency because of extra care taken in planting, limiting sites to those of high quality, reliance on single-tree plots and practising a different silviculture to that adopted in operational stands.

In this paper, we describe and analyse growth and stiffness data obtained from clonal and CP blocks planted in Pan Pac's Hawke's Bay forests. Our principal objective is to estimate the relative variation in the material, based on the premise that the clonal stocks should produce more uniform stands.

Methods

The selection of suitable sites for the study was inevitably somewhat restricted. We sought closely adjacent blocks (maximum distance 800 m) of clonal and CP material, comparable in age, aspect, elevation and stocking, but suitable plantings proved hard to find. Ultimately, five comparisons were located in four Pan Pac forests (Gwavas (2), Esk, Mohaka and Tangoio). The five block comparisons involved six clones, genetically unrelated to each other (unidentified here for commercial reasons). There were also three genetically unrelated CP seed-lots. The number and identity of seed-lots and clones varied by site. Three of the locations came from 4.5-year-old plantings, the remainder were age 7.5. The five sites comprised of:

- Gwavas Forest, age 4.5, four clones, one CP
- Gwavas Forest age 4.5, two clones, one CP
- Mohaka Forest, age 4.5, one clone, one CP
- Esk Forest, age 7.5, two clones, one CP
- Tangoio Forest, age 7.5, three clones.

The blocks had received the same silvicultural practice. Data were collected from 0.04 ha circular plots, with six plots measured in each block of genetic material. Stockings were approximately 750 stems/ha, so about 30 trees were captured within each plot. There was a buffer gap between each plot of 20 m and plots were established at least 10 m from any block edge. Tree diameters were measured through a diameter tape at breast height (1.4 m).

Acoustic velocity was measured using a FAKOPP tool. The trees were measured for acoustic velocity on two opposite sides of any sampled tree to average within-tree variation (Chauhan & Walker, 2006). As a precaution, sample trees were measured at 90 degrees to the prevailing wind to help avoid compression wood (Grabianowski et al., 2006).

Analyses and results

To investigate whether the clonal and CP material differed in uniformity (variation), we needed to eliminate the confounding influence of the two plantation ages. A complication arises because inevitably the age 7.5 material is considerably larger than the age 4.5, so will

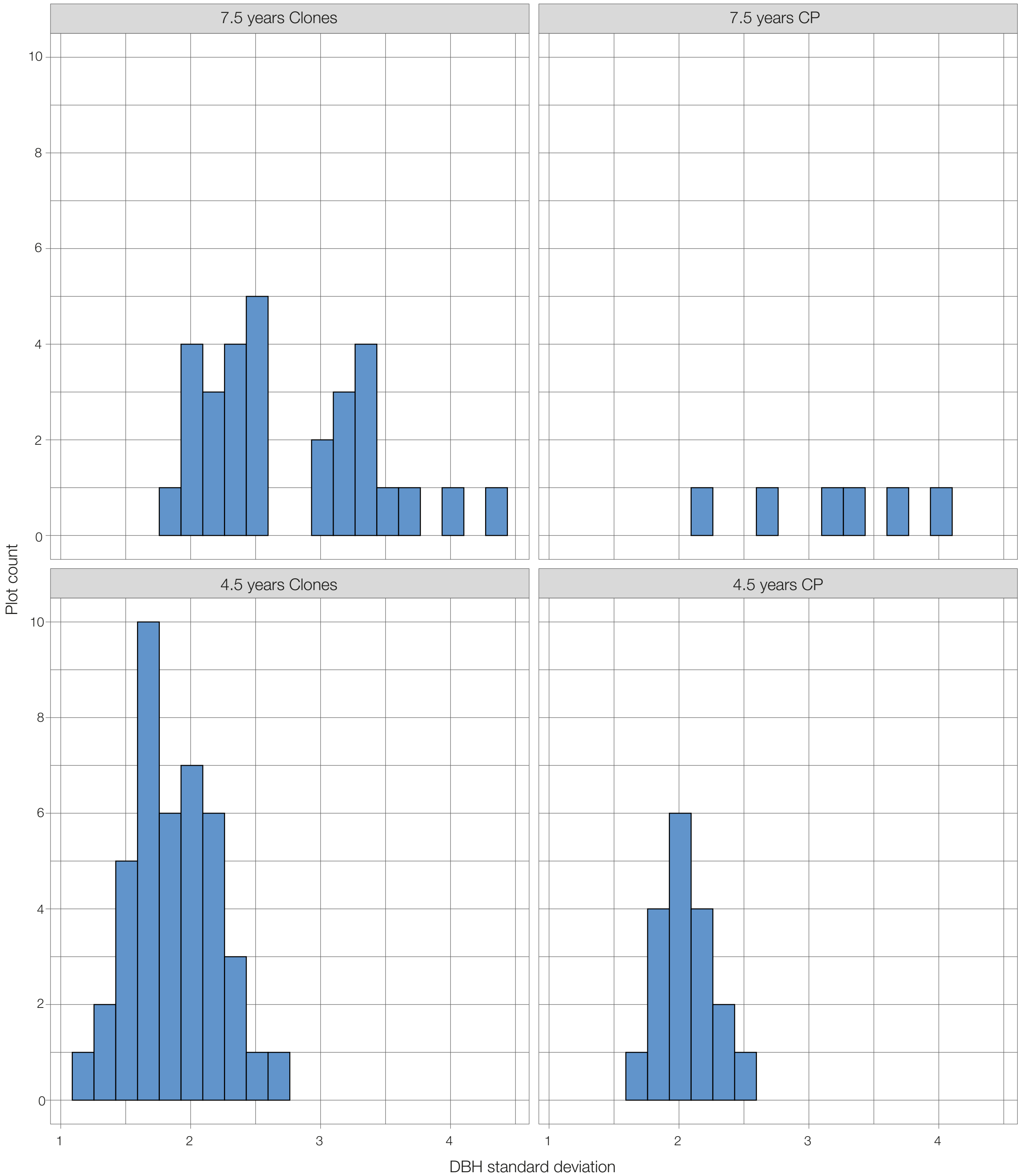

Figure 1: Distribution of diameters by groups

also exhibit more variation (see Table 1 which gives the basic data). To help overcome this the data were divided into four groups:

- 4.5 years CP material
- 4.5 years clonal material
- 7.5 years CP material
- 7.5 years clonal material.

Table 1: Number of plots and variability for diameter and modulus of elasticity by deployment material type and age

Group	No. of plots available	Mean diameter standard deviation	Mean modulus of elasticity standard deviation
4.5 years CP	18	2.07	0.58
4.5 years clones	42	1.88	0.57
7.5 years CP	6	3.20	1.03
7.5 years clones	30	2.69	0.89

An analysis of variance was carried out using the standard deviation tree diameter of each plot as the dependent variable and utilising a nested structure of groups and genetic material within groups. The effect of the groups was strongly significant ($p < 0.001$) and the genetic material within the groups was significant ($p < 0.023$). Histograms of the group diameters are shown in Figure 1.

This analysis was repeated for plot modulus of elasticity. Analysis shows, however, there are no significant differences for modulus of elasticity between the clones and CP families.

Discussion and summary

Despite a somewhat unbalanced dataset, the group of clones is more uniform than the CP seed-lots for diameter at breast height, for both age classes. The older age class has a greater difference in variability between the clones and the CP, which might indicate that the natural variation of larger objects is not as wide in clones, although this can only be substantiated with future re-measurement. Increased uniformity of clones is widely talked about in the forest industry, but until now there has been no operational data available to quantify this.

Earlier, we alluded to the point that clonal research has very largely been confined to experiments in tightly controlled environments. It is reassuring to find favourable results in standard operational plantings. Uniformity is one of the main selling points of clones and it has the potential to increase the efficiency of forestry, harvesting and mill operations.

The average reduction in variability (9% and 16 %) may not seem especially large, but it should be reconciled with potential micro site and stand influences affecting the results. The modulus of elasticity data suggests some decrease in variation for the older age class, but this effect is not significant. It could be that the sampling intensity utilised for wood properties was insufficient, creating additional variation.

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