TECHNICAL NOTE: THE SUITABILITY OF YOUNG FAST-GROWN RADIATA PINE CLONES FOR CONVERSION INTO VINEYARD TRELLIS POSTS

*Philip D. Evans**†

Professor
Centre for Advanced Wood Processing
University of British Columbia
Vancouver, Canada

Chris Borough

Consulting Forester
Forest Science Consultancy Pty Ltd
PO Box 4378
Kingston, Canberra, Australia

Robin Wingate-Hill

Forest Engineer

Ross B. Cunningham

Professor
Fenner School of Environment and Society
The Australian National University
Canberra, Australia

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Abstract. In this note, we test the hypothesis that vineyard trellis posts of the required size and strength properties can be produced from young radiata pine trees obtained from clonal plantations established using a dense stocking of physiologically aged cuttings selected for fast growth, good straightness, above-average juvenile wood density, and fine multinodal branching. Radiata pine trees from four different clones were all large enough to be converted into vineyard posts when they were 6 yr old. Posts made from the fastest growing clone had below-average wood density and a high grain angle and were significantly weaker than commercial posts made from 14-yr-old thinnings. Another clone, however, produced posts whose average breaking load and modulus of rupture were only 8.6 and 9.2% lower, respectively, than those of commercial posts. Posts from this clone had a low grain angle and above-average wood density as well as fine multinodal branching. We conclude that the use of selected radiata pine clones for the manufacture of vineyard posts shows promise as an alternative to the production of posts from thinnings and suggest how the strength properties of posts from clonal radiata pine trees might be further improved.

Vineyard trellis posts and connecting steel wires create an aerial structure for training and supporting grape vines. Trellis posts must be strong enough to support vines when they produce a heavy crop of grapes and are shaken during mechanical harvesting or exposed to high winds (Mollah et al 2004). Vineyards typically require about 620 in-line posts/ha and in Australia alone, approximately 9 million new posts are needed yearly (McCarthy et al 2005). Seventy-five percent of these posts are obtained from plantation-grown radiata pine (*Pinus radiata* D. Don) trees (Mollah et al 2004). Radiata pine produces straight posts with a high strength-to-weight ratio and the wood is easily treated with

* Corresponding author: phil.evans@ubc.ca
† SWST member

preservatives to increase service life. Radiata pine thinnings are the preferred source of material for trellis posts because they are inexpensive and widely available, but supply is often insufficient to meet peak demand (Mollah et al 2004). Hence, it would be desirable to develop alternative sources of small-diameter radiata pine trees to convert into vineyard posts. One alternative strategy to the use of thinnings for trellis posts is to grow radiata pine trees specifically for conversion into posts. Radiata pine trellis posts are straight, 75-100 mm dia, and 2.4-m long (Mollah et al 1995). Radiata pine trees show large variation in growth rates and fast-growing trees can reach 250 mm dia and exceed 10 m in height after only 7-8 yr. Hence, it should be possible to select fast-growing trees that can quickly grow to sizes that are large enough for the stems to be converted into vineyard posts. It is more challenging, however, to rapidly grow trees that are strong enough to be used as trellis posts, because radiata pine trees less than 10 yr old consist exclusively of low-density juvenile wood, which has inferior strength properties. Furthermore, there is a significant negative correlation between diameter growth and density and strength in radiata pine (Baltunis et al 2007). This problem might be mitigated by selecting trees that still grow fast but have above-average juvenile wood density and do not contain the large knots that reduce wood strength. Knot size in wood can be minimized by selecting trees that produce fine, evenly distributed (multinodal) branches (Bamber and Burley 1983). Tree age is positively correlated with wood strength in radiata pine because of favorable variation in wood density and grain and microfibril angle from "pith-to-bark" in stems. The physiological age of radiata pine trees can be advanced by growing trees from cuttings (clones) rather than seeds, and radiata pine trees grown from cuttings have increased height, less stem taper, and finer branches than trees grown from seed (Burdon and Harris 1973). Radiata pine trees planted closely together also tend to produce stiffer wood than trees planted more widely apart (Waghorn et al 2007).

This note tests the hypothesis that vineyard trellis posts with the required size and strength properties can be produced from young radiata pine trees obtained from clonal plantations established using a dense stocking of physiologically aged cuttings selected for fast growth, good straightness, above-average juvenile wood density, and fine multinodal branching.

MATERIALS AND METHODS

Seed for the experiment was selected from families of some of the best control-pollinated seed available in Australia and New Zealand based on a score that weighted the parents for fine multinodal branching, growth rate, and wood density. Twenty seeds from each family were sown and the 10 most vigorous seedlings multiplied vegetatively. Each ortet was kept hedged to approximately 1 m tall and ramets of each clone were multiplied vegetatively and planted out in field trials. Ramets of each clone were taken from the hedged ortets 2 yr later and grown in a nursery. Based on early assessments of multinodal branching and growth rate in field trials, the highest ranking clones were selected, multiplied vegetatively, and planted out in clonal blocks. The cuttings appeared to have a physiological age of about 3-4 yr at planting. Blocks of 25 ramets for each clone were planted at a high initial stocking of 2500 stems/ha. After 6 yr, trees from four clones were selected for conversion into vineyard posts: Clone A (804.02) had above-average wood density and it was anticipated that this might improve post strength; Clone B (806.01) had below-average wood density but exceptional straightness and height growth; and Clones C (809.01) and D (809.02) both came from the same family and had good straightness and multinodal branching. Two trees from each of the four clones were felled, delimbed, debarked, and cross-cut to produce posts, about 100 mm dia and 2.4 m long (Table 1). One or two posts were produced from each tree giving a maximum and minimum replication of four or two posts per clone, respectively. Posts were air-dried for 6 wk and their weight, length, and circumference were measured to

Table 1. Dimensions of clonal radiata pine trees and dimensions and wood properties of clonal and commercial posts.

	Tree size after 6 yr		Post properties		
Post type and number[a]	Diameter (mm)	Height (m)	Diameter (mm)	Density (kg/m^3)	Grain angle (°)
Clone A (2)	133	9.8	93	334.8	1.7
Clone B (4)	140	10.8	111	305.9	5.8
Clone C (4)	126	10.9	105	313.6	1.7
Clone D (3)	122	9.8	99	314.3	0.8
Commercial (13)	—	—	97	363.5	2.3

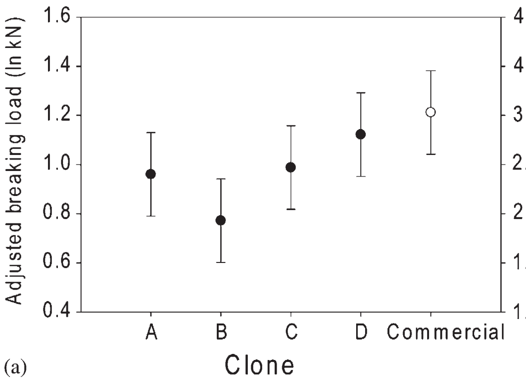
[a] Number of posts produced and tested for each clone in parentheses.

calculate their air-dry wood density. The grain angles of the wood on the outer surface of the posts were measured using a scribe and protractor. Posts were treated in a commercial treatment plant with a CCA-C preservative using a full cell process to nominal retentions of 12 kg/m^3 (H5, Standards Australia 2000). These treated clonal posts (13 in toto) and an equal number of similarly treated commercial vineyard posts made from the tops of 14-yr-old radiata pine thinnings were air-dried for 2 wk and conditioned at 20 ± 1°C and 65 ± 5% RH for 6 wk. The breaking load and modulus of rupture (MOR) of posts was measured as described previously (Evans et al 1994).

Diagnostic checks were used to determine if strength data conformed to all the assumptions of analysis of variance (ANOVA). Data met these assumptions once they were transformed into natural logarithms. ANOVA was used to compare the breaking loads and MOR of the clonal posts and the commercial vineyard posts. Separate ANOVAs were used to analyze the breaking loads and MOR of posts from each clone and the breaking loads and MOR of the commercial posts. The breaking load of posts was also analyzed using covariate ANOVA because the diameters of the posts varied. This covariate ANOVA used the circumference of the posts as the covariate. All statistical computation was performed using Genstat. Error bars on graphs can be used to compare the strength properties of clonal and commercial vineyard posts.

RESULTS AND DISCUSSION

The clonal radiata pine trees were large enough after 6 yr to be converted into vineyard trellis posts (Table 1). Clone B, which was selected for fast growth, produced the largest diameter trees and posts (Table 1). The average breaking load of clonal posts was 2.74 kN compared with 3.16 kN for commercial posts. This difference in the breaking load of the two types of posts was not statistically significant (p = 0.232). The clonal posts, however, were larger in diameter than the commercial posts (Table 1), and when their breaking loads were adjusted for their larger size by covariate ANOVA, there was a significant (p = 0.012) difference between the breaking loads of the clonal and commercial posts. The average adjusted breaking loads of the clonal posts varied from 2.16 kN (Clone B) to 3.07 kN (Clone D) compared with 3.36 kN for commercial posts (Fig 1a). The average MOR of the clonal posts was 43.9 MPa compared with 56.0 MPa for commercial posts. This difference in MOR of the clonal and commercial posts was also statistically significant (p = 0.002). However, there was a significant (p = 0.006) difference in the MOR of the posts from the different clones. Posts from Clone B, which had a high grain angle of 5.8° and below-average wood density, were significantly weaker than posts made from the other clones (Fig 1b). The strength properties of posts from Clone D were the closest to those of the commercial posts. The adjusted breaking load and MOR of posts obtained from Clone D were 8.6 and 9.2% lower, respectively, than those of the commercial posts. Posts from this clone had a very low grain angle of 0.8° (Table 1). Grain angle is inversely correlated with the mechanical properties of radiata pine wood, and the low grain angle of posts from Clone D probably explains why it produced



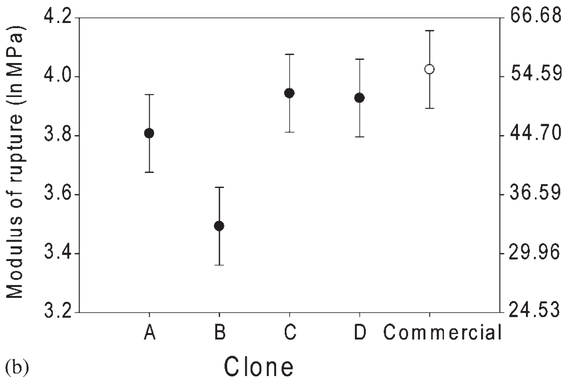


Figure 1. The adjusted breaking load (a) and modulus of rupture (b) of vineyard trellis posts derived from two trees for each of four different 6-yr-old radiata pine clones. One or two posts were manufactured from each tree and the total number of posts tested for Clones A, B, C, and D were 2, 4, 4, and 3, respectively. Thirteen commercial vineyard posts manufactured from different 14-yr-old radiata pine trees (thinnings) acted as controls. The graphs plot the natural logarithms of the strength properties of the posts and error bars representing ± standard error of the difference can be used to compare means (on the log scale). The Y2 axes present back-transformed values (e^x) so that the strength properties of posts can be compared on the natural scale.

relatively strong posts. It is possible that clonal trees that combine the desirable properties of Clone D such as low grain angle and fine multinodal branching in combination with high rather than above-average juvenile wood density might produce vineyard posts as strong as those made from thinnings. Wood density in radiata pine, however, is negatively correlated with growth rate. Therefore, clonal trees with this desirable suite of properties might take longer than 6 yr to reach a size large enough for the trees to be converted into 100-mm-dia posts. Nevertheless, such an approach would still reduce the time required to produce posts from radiata pine compared with the current approach of using thinnings. Furthermore, posts obtained from a clone with the aforementioned desirable suite of properties are likely to show less variability in size, strength, and form than posts obtained from thinnings, which might help radiata pine posts to compete better with plastic and steel posts that are starting to penetrate the market for vineyard posts in Australia.

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