DIVERSIFIED SPECIES TECHNICAL NOTE

Number:DSTN-031
Date: June 2012

Assessment Results from the 2008 Cypress Hybrid Trial

Summary

Cypress timber is valued for its stability, attractive grain and naturally durable heartwood. A number of different species have been trialled in New Zealand and all have proved much more difficult to grow than radiata pine. The "Leyland" and "Ovensii" clones have been propagated from hybrids that were accidentally discovered, and these have shown advantages of superior health, wood properties and improved tolerance of poor or exposed sites. Leyland growth rates are slightly down on those of the pure *Cupressus* species, and this could be because of their advanced physiological age (more than one hundred years). This trial tests the hypothesis that hybrids created from improved parents of each species could grow better than existing clones.

Hybrid crosses were made in 2005 using four different cypress species: *Chamaecyparis nootkatensis*, *Cupressus macrocarpa*, *C. lusitanica* and *C. guadalupensis*. The seed was extracted in 2007, sown, and trials were planted out at Kaingaroa and Ruatoria in 2008. Pure *C. lusitanica* and *C. macrocarpa* seed of the parents used in the crossing was also sown.

By 2011 the trees on the Kaingaroa site were growing well and the better trees were three metres high. The viability of the seed produced by *C. lusitanica* and *C. macrocarpa* trees using *Ch. nootkatensis* pollen had been poor, so there was concern that some seeds may have been pollinated by *Cupressus* pollen. Existing Leyland and Ovensii clones are easily recognised by their flattened foliage inherited from the *Chamaecyparis* parent, so trees were scored for this attribute. In general, most trees from hybrid families with a *Ch. Nootkatensis* parent featured flattened foliage, but a few trees had foliage identical to the mother *Cupressus* parent.

The hybrid between *C. guadalupensis* and *C. lusitanica* had the best growth on the Kaingaroa site at 2.83 metres, closely followed by the hybrid between *C. lusitanica* and *Ch. Nootkatensis* (2.63 m), then the hybrid between *C. macrocarpa* and *Ch. Nootkatensis* (2.57 m). The hybrids were slightly larger than the pure *C. lusitanica* and *C. macrocarpa* from the same mothers that made the hybrids. Tree form was good for all taxa, with about 80% of the trees rated as acceptable. It proved to be too soon to identify canker symptoms with certainty, although stem cankers were seen on some pure *C. macrocarpa* trees.

The Ruatoria site was more exposed, and tree heights were much shorter than at Kaingaroa. There had been significant mortality as well. The hybrid between *C. lusitanica* and *C. guadalupensis* had not fared so well on this site, as the pure *C. lusitanica* was slightly taller. The hybrid between *C. lusitanica* and *Ch. nootkatensis* was the tallest taxon at this site.

These hybrids have shown the potential to produce better stands of cypresses than any currently available. Low germination rates of hybrids with *Ch. nootkatensis* preclude raising commercial quantities of plants from seed, but a wide choice of hybrid trees for vegetative multiplication should furnish real winners. Further hybrid crosses will be planted out in trials in 2013 along with rooted cuttings taken from around one hundred hybrids in the Kaingaroa trial.

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Background and Introduction

The main cypress species identified for New Zealand forestry are *Cupressus lusitanica* and *C. macrocarpa*. Breeding programmes for these species have been running since the mid 1980s and good parents have been identified. While capable of good growth rates (on the right sites) and producing good timber, both species have proved tricky to grow well, with rather patchy track records and some problems with cypress canker (*Seiridium unicorne* and *S. cardinale*).

Leyland cypress clones were accidental hybrids between *C. macrocarpa* and *Chamaecyparis nootkatensis* and these appear to have overcome some of the health and siting issues. However, the existing Leyland hybrids grow more slowly than *C. macrocarpa* or *C. lusitanica* on good cypress sites and can take two years in the nursery to produce good planting stock.

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Controlled pollination of cypresses has been carried out successfully, but with low success rates in New Zealand since the 1950s. Collaboration with the *Ch. Nootkatensis* breeding programme in British Columbia from the 1990s led to a better understanding of techniques. An exchange with Cathy Horgan and Canadian tree breeder, John Russell in 2005 resulted in breakthroughs in pollen storage and pollen viability tests. The exchange also resulted in the application of *Ch. nootkatensis* pollen from Canada to selected New Zealand clones of *C. lusitanica* and. *C. macrocarpa*. Crosses involving the reputedly cypress canker-resistant *C. guadalupensis* were also made. These crosses are shown in Table 1, and the *Ch. nootkatensis* pollens in Table 2. The cone flowers developed into cones which were collected in April 2007 and seed was extracted.
Seed had already been collected from two of the *C. lusitanica* clones used in the crossing and from the two *C. macrocarpa* clones. This seed was taken to the nursery with the hybrid seed and the stratification process was started in May 2007 (Table 3). The seed was sown earlier than is normal for cypresses as it was feared that the trees from the hybrid crosses might develop more slowly than pure *C. lusitanica*. The seed obtained from the crosses with *Ch. Nootkatensis* had very low viability (Table 1), so more seed was sown (stratified 28 August, sown end of September).

The trees that grew from the first sowing attained a height of around 75 cm in winter 2008. The trees from the second sowing were much smaller and only a few attained the plantable height of 40 cm.

Sites were selected in Kaingaroa and Ruatoria forests (Table 4 and Figure 1) and the trees were planted in early September 2008. The trial design was six replicates of 5-tree-row-plots, where a row of hybrid trees was planted next to a row of pure species trees from the same mother if possible. Some of the small leftover hybrid plants were planted in demonstration rows in the Long Mile clonal archive on the Scion campus.

Table 1. Hybrid seed sown in June 2007

Family	Seed	Female		Male	
Code	viability	Clone	Species	Clone	Species
GL403	> 20%	2003.015	*C. guadalupensis*	893.403, 411	*C. lusitanica*
GL413	> 10%	893.413	*C. lusitanica*	2003.015	*C. guadalupensis*
GL426	> 10%	893.426	*C. lusitanica*	2003.015	*C. guadalupensis*
NL127	1.6%	890.127	*C. lusitanica*	PM1	*Ch. nootkatensis*
NL403	0.02%	893.403	*C. lusitanica*	PM1	*Ch. nootkatensis*
NL408	0.08%	893.408	*C. lusitanica*	PM1	*Ch. nootkatensis*
NM001	1.7%	2001.001	*C. macrocarpa*	PM2	*Ch. nootkatensis*
NM706	3.0%	896.706	*C. macrocarpa*	PM2	*Ch. nootkatensis*

Table 2.*Chamaecyparis nootkatensis* polymixes

Polymix name	British Columbia clone numbers
PM1	Cy429, 433, 440, 458, 459
PM2	Cy500, 506, 508, 515, 520

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Table 3. Pure species seed sown in June 2007

code	Clone	Species	Location of mother tree (pollen origin)
M706	896.706	*C. macrocarpa*	Strathallan 1985 progeny trial
M001	2001.001	*C. macrocarpa*	Strathallan 1985 progeny trial
L127	890.127	*C. lusitanica*	Amberley Seed Orchard
L413	893.413	*C. lusitanica*	Amberley Seed Orchard
L426	893.426	*C. lusitanica*	Amberley Seed Orchard

Table 4. Site details

Forest	Compartment	Latitude	Elevation	Remarks
Kaingaroa	Cpt 320	38° 37'	530 m. a. s. l.	Farmed, then 2 crops of radiata pine
Ruatoria	Whakaangiangi	37° 43'	320 m. a. s. l.	Farmed, then 1 crop of radiata pine

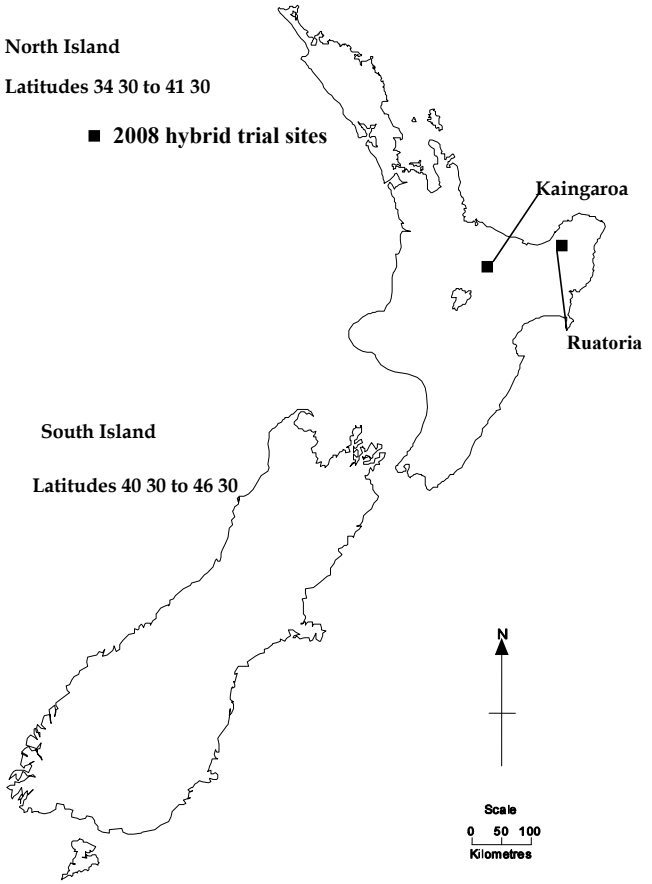

Figure 1. Map of New Zealand showing the location of the 2008 Cypress hybrid trials

Methods

The trees at the Kaingaroa site were inspected regularly, were growing well and were assessed in late November 2011. The Ruatoria site was assessed in mid March 2012.

Assessment traits were tree height (measured by height pole); foliage type where 1 = flattened foliage, 2= fluffy foliage and 3= not able to be classified into either category; acceptability (at Kaingaroa only) where 0 = unacceptable as a crop tree, 1 = acceptable and 2 = a plus tree; canker where 0 = no canker, 1= canker symptoms on branches, 2= canker on stem.

Analysis

The data from each site were analysed separately. Two analysis models were used. The reason for the two different analyses was to look at individual families in the first analysis, then group families into taxa for the second analysis. The first analysis type considered replicates, families and the replicate by family interaction. The second analysis considered replicates, taxa, families within taxa and a taxon by replicate interaction.

Results

The sources of variation for each trait at each site are presented as an analysis of variance at Kaingaroa (Table5) and family means are shown in Table 6.Tree height showed significant family differences, somewhat tempered by the

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interaction between replicate and family. A more complicated analysis that could adjust for microsite differences could be a better option, but was not warranted for an assessment at this age. Family means (Table 6) showed that all hybrid families had better height growth than the pure species families from the same mother.

The foliage type score helped identify trees to families. The real use of this score was that it was intended to identify trees that may not be true hybrids. The replicate by family interaction may have been caused by their lack of familiarity with the appearance of the *C. guadalupensis* x *C. lusitanica* hybrid, whose trees got the full range of scores.

Tree form was generally very good for all families on this sheltered site, and this translated to a high proportion of acceptable trees.
It proved difficult to identify canker symptoms at this age, especially since a large population of cicadas (*Kikihia cutora*) had damaged many branch tips. However stem canker was identified on some of the pure *C. macrocarpa* trees.

Survival was not analysed, but most families fared well at Kaingaroa (Table 6). The exception was family NL408, which had the smallest number of plants (13 instead of 30) and some that appeared to be mutants. Less than half of the plants of NL408 have survived, so *C. lusitanica* clone 893.408 should not be considered as a parent for hybrid crosses with *Ch.nootkatensis.*

Table 5.Sources of variation for traits (analysed by family) at Kaingaroa

Source	Df	Height	Foliage type	Acceptability	Canker
Rep	5	0.20	1.15	0.75	0.69
Family	13	3.98***	16.43***	2.21*	2.00*
RepxFamily	51	2.10***	1.88***	1.12	2.41**
Error	256				

* = p ≤ 0.05, ** = p ≤ 0.01, *** = p ≤ 0.001

Table 6. Kaingaroa family means

Family	n.	Survival (%?)	Height (metres)			Foliage	accept	canker
			Mean	minimum	maximum	type		
GL403	29	97	3.13 a	2.4	4.0	2.10 a	0.83 ab	0.00
GL413	37	93	2.75 abc	1.9	3.5	1.05 c	0.76 ab	0.11
GL426	29	97	2.54 abc	1.4	3.8	1.28 bc	0.90 a	0.03
L127*	29	97	2.52 abc	1.5	3.2	1.00 c	0.90 a	0.07
L403*	20	100	2.32 c	0.8	3.2	1.00 c	0.85 ab	0.05
L408*	27	90	2.58 abc	1.1	3.7	1.00 c	0.67 ab	0.11
L426*	29	97	2.71 abc	1.6	3.7	1.00 c	0.93 a	0.21
M001*	28	93	2.28 c	1.4	3.1	1.00 c	0.93 a	0.43
M706*	10	100	2.42 abc	2.0	3.2	1.00 c	0.70 ab	0.50
NL127	29	97	2.89 abc	1.8	4.0	1.90 ab	0.86 ab	0.21
NL403	8	80	2.69 abc	2.3	2.9	2.00 a	1.00 a	0.00
NL408	13	43	2.15 c	0.6	3.4	1.92 ab	0.42 b	0.31
NM001	29	100	2.36 bc	1.4	3.2	2.04 a	0.75 ab	0.03
NM706	9	90	3.09 ab	2.7	3.6	1.89 ab	1.11 a	0.00
Least Significant diff.			0.77			0.67	0.45	0.55

Means sharing a letter (within a column) are not significantly different from each other by at p ≤ 0.05
* indicates a family of a pure cypress species

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Families were collected into taxa that shared the same parental species. The F tests for taxa are shown in Table 7 and the taxon means in Table 8. The F tests show that the taxa had very different foliage types and there were significant taxon differences for height and canker scores, although both had significant rep by taxon interactions. Interestingly, there was no real difference between taxa for acceptability as all taxa had good form.

The significant difference for canker symptoms was a result of higher scores for the pure *C. macrocarpa* trees. The field crew were not confident that canker had caused the death of branch tips as there had been considerable damage by cicadas, but stem cankers were observed on some *C. macrocarpa* trees.

Table 7. F tests from Analysis of variance of taxa and families at Kaingaroa

Source	Df	Height	Foliage type	Acceptability	Canker
Rep	5	0.37	1.01	0.53	1.40
Taxon	4	2.80*	36.79***	0.66	5.88**
Family(Taxon)	9	7.84***	10.91***	2.41*	2.48**
RepxTaxon	20	2.26**	1.17	1.24	3.10***
Error	256				

Table 8. Kaingaroa taxon means

Taxon	Planted	Survival%	Height (metres)			Foliage type	Canker	Acceptability
			mean	min	max			
Leyland	40	95	2.53 ab	1.4	3.6	2.00 a	0.03 a	0.84
Ovensii	70	71	2.67 ab	0.6	4.0	1.92 a	0.20 a	0.78
Guadlusi	100	95	2.80 a	1.4	4.0	1.44 b	0.05 a	0.82
Lusitanica	110	95	2.55 ab	0.8	3.7	1.00 c	0.12 a	0.84
Macrocarpa	40	95	2.32 b	1.4	3.2	1.00 c	0.45 b	0.87
Least significant difference			0.41			0.28	0.32	0.26

The taxon name Leyland is used for *C. macrocarpa* by *Ch. nootkatensis* crosses
The taxon name Ovensii is used for *C. lusitanica* by *Ch. nootkatensis* crosses
The taxon name Guadlusi is used for *C. lusitanica* by *C.guadalupensis* crosses and the reciprocal cross

At Ruatoria, the trees did not get off to the good start that they did at Kaingaroa. The F tests (Table 9) showed big replicate differences for height and little difference between families. The family means for height (Table 10) showed that the *C. lusitanica* by *C. guadalupensis* families were not growing as well as the *C. lusitanica* families and had suffered mortality of more than 50% of the trees. The hybrids with *Ch. nootkatensis* had the best growth, although the *C. macrocarpa* by *Ch. nootkatensis* family had only enough plants for a single 5-tree row.

Foliage type proved more difficult to score at Ruatoria, as the score of 3 for foliage not fitting into either fluffy or flattened categories was used in all families. Consequently foliage type did not separate families as clearly as it did at Kaingaroa.

There were a lot of cicadas in the trial, so it is probable that the canker score for dead branch tips related to damage by cicadas, rather than cypress canker. The *C. macrocarpa* family would be expected to have the worst canker score, but it was the best on this site.

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Table 9. F tests from Analysis of variance of families at Ruatoria

Source	Df	Height	Foliage type	Canker
Rep	5	7.81***	2.27	1.72
Family	9	2.69*	6.37***	2.11*
RepxFamily	35	0.99	1.77*	0.82
Error	124			

Table 10. Ruatoria family means

Family	Planted	Survival%	Height (metres)			Foliage	Canker
			mean	minimum	maximum	type	score
GL403	55	55	1.58	0.50	2.60	2.80 a	0.47
GL413	30	27	1.56	0.70	2.80	2.50 ab	0.63
GL426	30	43	1.65	0.70	2.70	2.92 a	0.23
L127	30	50	1.51	0.60	2.40	2.67 ab	0.53
L403	30	87	1.86	1.10	3.10	2.85 a	0.58
L408	30	57	1.69	1.10	2.20	2.94 a	0.59
L426	30	60	1.62	1.10	2.20	2.89 a	0.39
M001	30	60	1.43	0.80	2.40	2.83 a	0.22
NL127	30	87	1.95	1.20	2.50	1.77 bc	0.69
NM001	5	60	1.83	0.70	2.70	1.67 c	0.67
Least Significant difference			0.61			0.96	0.67

Analysing the Ruatoria data by taxon (Figure !!?) was not as useful as it was at the Kaingaroa site as there was only one *C. lusitanica* by *Ch. nootkatensis* family and very few plants of a single family for the *C. macrocarpa* by *Ch. nootkatensis* cross. The *Ch. nootkatensis* hybrids had the best growth on this site and the pure *C. macrocarpa*was the slowest. The *C. lusitanica* by *C. guadalupensis* hybrids showed genotype by environment interaction as they performed poorly at Ruatoria, but were best at Kaingaroa. Foliage type separated taxa better than it separated families.

Table 11. F tests from Analysis of variance of taxa and families at Ruatoria

Source	Df	Height	Foliage type	Canker score
Rep	5	4.23*	2.11	1.70
Taxon	4	2.65	15.06***	2.55
Family(Taxon)	9	1.92	0.86	1.18
RepxTaxon	20	1.29	1.46	0.83
Error	287			

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Table 12. Taxon means at Ruatoria

Taxon	Planted	Survival%	Height (metres)			Foliage	Canker
			mean	minimum	maximum	type	score
Leyland	5	60	1.83	0.7	2.7	1.67 b	0.67
Ovensii	30	87	1.95	1.2	2.5	1.77 b	0.69
guadlusi	115	44	1.59	0.5	2.8	2.78 a	0.43
lusi	120	63	1.70	0.6	3.1	2.84 a	0.53
macro	30	60	1.43	0.8	2.4	2.83 a	0.22
Least significant difference			0.53			0.64	0.58

Conclusions

The good growth of the hybrids, especially on the Kaingaroa site, was unexpected. Trees of both *Ch. nootkatensis* and *C. guadalupensis* had grown more slowly than *C. lusitanica* and *C. macrocarpa* in previous trials (C. Low, unpublished data). We had hoped that growth rate would be the same as that of trees of the *Cupressus* species, but the hybrids were actually growing more quickly, which would mean that these hybrids would also grow faster than those of Leyland and Ovensii clones in previous trials[1]. We hope that the canker resistance of *C. guadalupensis* and *Ch. nootkatensis*, tolerance of poorer soils and good wood properties will also persist in the hybrids, but the tree age was too young to find differences in those traits at the time of assessment.

Good form of all taxa was expected as all trees used in the crossing were selected from families of very good growth and form in progeny trials. The foliage type trait confirmed that most hybrid trees were true hybrids and not a product of pollen contamination.

Future Work

Cuttings were taken from 109 hybrid families at the Kaingaroa site in 2009 and set as stool-plants in the Scion nursery. Cuttings will be set from these stool-plants and from more cuttings taken from the trees at Kaingaroa for a trial to be planted in 2013.

More hybrid crossing has provided seed that will be sown this year to provide seedlings to compare with the cuttings. These include the cross that we wanted to make in 2005 but could not because of pollen unavailability. This was the cross between *C. macrocarpa* and *C. guadalupensis* to see if the canker resistance of *C. guadalupensis* can combine with the sought after wood properties of *C. macrocarpa*.

References

1. Geard B. 2001: Comparison of the growth rate, form, branching characteristics, health and wood characteristics of clones and seedlings of *Cupressus macrocarpa* and *Cupressus lusitanica.* A dissertation submitted to the University of Canterbury as a thesis for the degree of Master of Science (Forestry).

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