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ROTORUA

EARLY PERFORMANCE OF *E. GRANDIS* X *E. NITENS* HYBRIDS IN NEW ZEALAND

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REPORT NO. 17 MARCH 1996

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EXECUTIVE SUMMARY

The hybrid cross between *E. grandis* and *E. nitens* is aimed at capturing the benefits of both species. It may extend the site ranges, increase growth rates, and improve the pulping characteristics of each species. Unlike *E. grandis, E. nitens* does not root easily from cuttings, however a hybrid between the two species could introduce the capacity for vegetative propagation and allow clonal forestry to be explored.

E. grandis x *E. nitens* hybrids were produced using eight New Zealand selected parents of *E. nitens*, each from central Victoria and New South Wales provenances as pollen parents and nine *E. grandis* seed orchard clones in South Africa as females.

The performance of the control-pollinated hybrid and the open-pollinated progenies of the parent species are being tested at four sites within New Zealand and were assessed 10 months after planting. The best growth was at the North Island, Bay of Plenty site at Te Teko where the central Victorian hybrid averaged 30.9 dm in height. There is large variation between and particularly within hybrid crosses which suggests that selection within families will be important.

The techniques for producing coppice cuttings from the hybrid are being developed and early results suggest that cuttings of the best individuals in the field trials can easily be propagated from coppice shoots as a lead into clonal forestry.

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INTRODUCTION

E. grandis is a fast-growing eucalypt adapted to subtropical climates with a summer rainfall and is well known for its good form, and desirable pulp and timber properties. However, in New Zealand conditions it has performed poorly, being susceptible to cold temperatures, insect attack and fungal diseases. These problems with *E. grandis* might be overcome by crossing with another member of the subgenus Symphyomyrtus with complementary characteristics, such as *E. nitens.*

E. nitens is currently the most widely grown eucalypt species for pulpwood production in New Zealand which is cold-hardy and may be planted up to altitudes of 800m . A hybrid between *E. nitens and E. grandis* with intermediate characteristics might reduce the siting limitations of both species, enhance *E. nitens* pulping characteristics and give the hybrid propagability by rooted cuttings, which is lacking in *E. nitens.* The capability of propagating individual hybrids from coppice cuttings would allow development of clonal forestry.

With this in mind crosses were made between New Zealand-selected *E. nitens* pollen parents of both central Victoria and southern NSW populations, with seed orchard clones of *E. grandis* at Tzaneen, eastern Transvaal, South Africa as female parents. The pollen was shipped to South Africa and the control pollinations were completed by the Division of Forest Science and Technology of Combined Scientific and Industrial Research (FORESTEK), Nelspruit.

E. GRANDIS X *E. NITENS* HYBRID TRIALS

A single-pair-cross mating design was used to provide interspecific crosses and these were compared with open-pollinated progenies of the pure species selections, using nine *E. grandis* clones selected in South Africa by FORESTEK as female parents and eight selected parents of *E. nitens* of central Victorian and New South Wales origin from New Zealand as males.

The mating design and a listing of the *E. nitens* and *E. grandis* ortet codes is shown in Table 1.

The seed from these crosses and open-pollinated seed was raised in root -trainers and planted in field trials in November 1994. There were a total of 40 seedlots.

The trial design is a randomised complete block with single-tree-plots and eight replications were established at four sites.

Site Details

1. Tairua, Coromandel Peninsula - warm site, Carter Holt Harvey Forests Ltd, lat. 37° 12', sea-level, NNE aspect, ex pasture, ripped.

2. Te Teko, Rangitaiki Plains - mild site, Tasman Forestry Ltd, lat. 38° 02', <50m altitude, flat, previously *P. radiata* seed orchard, ripped and rotary hoed.

3. Kinleith - moderate site, Carter Holt Harvey Forests Ltd, lat 38°25', 250m altitude, cutover, v-bladed.

4. Awarua, Southland - cold site, South Wood Exports Ltd, lat.45° 05', 220m altitude, NE aspect, 15 - 20° slope, ex-pasture.

ASSESSMENT

This hybrid is a new taxon to New Zealand and these trials are measured regularly to record their progress. The trials were 10 months from planting at the time of assessment.

The hybrid seedlings displayed intermediate morphological characteristics from each parent species. The stem shape and petiole were the features that best distinguished *E. grandis*, *E. nitens* and the interspecific hybrid. In Figure 1, Photo A is *E. grandis* typically with a rounded stem and petiole. Photo D shows *E. nitens* with a square stem and no petiole . Photos B and C are examples of the *E. grandis* x *E. nitens* hybrids displaying a combination of the characteristics of both pure species. Invariably the hybrids had a square stem and petiole.

The following traits were assessed:

1.	Height:	In decimetres
2.	Stem shape:	1 - 5 scale 1 = Square, pure *E. nitens* 5 = Rounded, pure *E. grandis*
3.	Petiole:	1 - 5 scale 1 = no petiole present, pure *E. nitens* 5 = well developed petiole present, pure *E. grandis*
4.	Foliage Health:	1 - 3 scale 1 - very unhealthy 2 - some infection or insect attack 3 - healthy.

5 Malformation: 1 - 5 scale
1 - multileadered to 5 - dominant leader with no distortion.

The site at Kinleith was not assessed as it had sustained damage from spray-drift during a preplant spraying operation in the adjacent compartment.

ANALYSIS

The data was analysed by SAS, using PROC ANOVA. Duncan's Multiple Range Tests for family means and species means were calculated for each site separately.

Family code 207 was removed from the analysis. At all three sites it had rounded stems and a well-developed petiole and appeared to be pure *E. grandis* and not a hybrid. This may have been an error during the crossing operation or during sowing and trial establishment.

RESULTS AND DISCUSSION

Survival of *E. nitens* and the hybrid was generally good at all sites, but as expected the survival of *E. grandis* at the cold site at Awarua, Southland, was much lower, 36.1%. (Table 8). The average values and Duncan's Multiple Range Test for height, petiole, stem shape, leaf health and malformation for each species group at each site are shown in Tables 2, 3, 4, 5, 6, and 7. The best growth was at Te Teko with the central Victorian hybrid averaging 30.9 dm. When comparing the frequency distributions for the pure species and the hybrid it is evident that the curve for the hybrid is severely skewed to the left (Fig 2). The seedlings in this tail are stunted and malformed, probably indicating some genetic abnormality in these individuals. This situation was also observed in the nursery soon after germination and while many of these seedlings soon died, others grew to plantable size and condition and were included in the field trials.

At Teko both hybrid groups (CV and NSW) grew better in height than open-pollinated progenies of the same provenance, at Tairua there was little difference and at Awarua pure *E. nitens* grew better than the respective hybrids. However, if the mean heights of the best 5 individuals, per site are compared similarly (Table 3), the hybrids show an advantage at Te Teko and Tairua, but not at Awarua.

There are considerable rank changes at the three sites with changing status of the hybrids and pure *E. nitens* as well as the near-failure of *E. grandis* at Awarua.

The variation in height between individuals within a cross is large. The ANOVA results are shown in Tables 9 a, b and c for species group mean values and Tables 10 a, b and c for family mean values. There are highly significant differences in all traits, both between families and between species/hybrid groups at each site. An overall-sites analysis was not done because of the rank changes at different sites.

Leaf health was assessed at each site. It was noted at the time of assessment that there appeared to be a high incidence of leaf-spotting at the Te Teko site. The overall leaf heath score for the Te Teko site was 2.2 compared with 2.8 at the Tairua site. (Table 3d). The trial is located beside a clonal seed orchard which is regularly sprayed to keep the site totally weed-free and spray drift may have effected the hybrid trial. The *E. grandis* scored 1.5 for health at the Awarua site where cold is most likely the cause.

CONCLUSIONS AND RECOMMENDATIONS

From the early assessment of the *E. grandis* x *E. nitens* hybrid trials it appears that there is large variation between and within crosses and the high incidence of abnormal seedlings in the hybrid crosses suggests that in any future development of these hybrids many parental cross combinations should be made and that selection within families will be important. The parents with high breeding values in the pure species will not necessarily produce good hybrid families.

The South African experience with this hybrid has shown that it propagates well from coppice shoots. Techniques for rooting cuttings from hybrid seedlings are currently being developed at the NZ FRI nursery and will extend to taking coppice cuttings from coppice shoots derived from selected seedlings growing in field trials.

It seems likely that the best-grown individuals can be selected in the field progeny tests after several years growth and these individuals can then be felled and propagated from the resulting coppice. These clones can then be tested in field trials with eventual commercial production of cuttings from the best clones. Unlike radiata pine there should be no problem in rejuvenating clones by coppicing to recover fully juvenile propagation material.

ACKNOWLEDGMENTS

I wish to thank Brian Pierce and his team at CSIR Forestek, Nelspruit for producing the *E. grandis* x *E. nitens* hybrid seed, Eucalypt Breeding Cooperative members for their assistance with the establishment, weed control and measurement of these trials, and Michael Hong for the statistical analysis.

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SHELBOURNE, C.J.A. 1992: Possibilities for clonal forestry with *Eucalyptus grandis* x *E. nitens* hybrids in New Zealand. NZFRI Project Record 3475, Eucalypt Breeding Cooperative Report No. 6 (unpublished)

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Morphological Characteristics

Figure 1

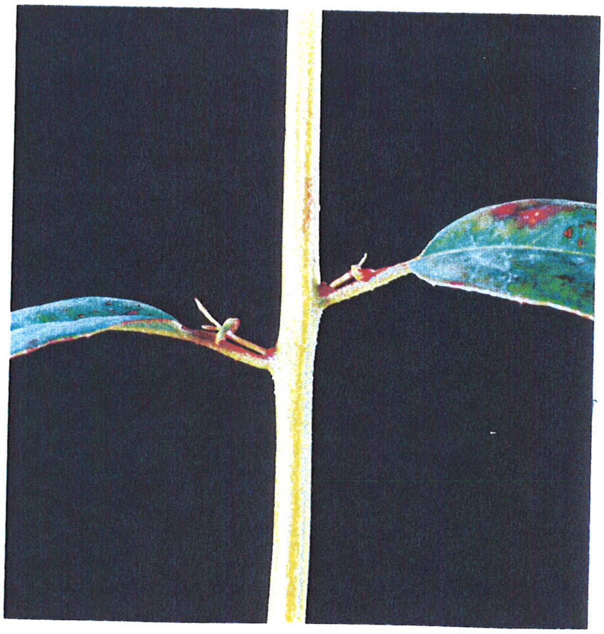


Photo A *Eucalyptus grandis*

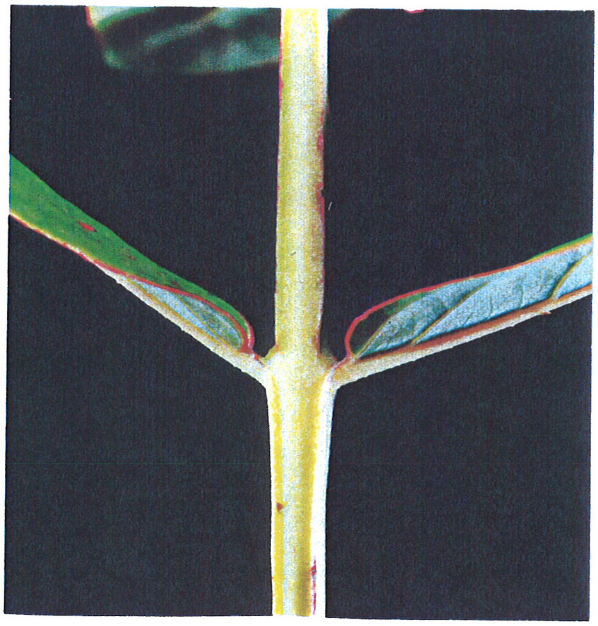


Photo B *Eucalyptus grandis* **x** *Eucalyptus nitens*

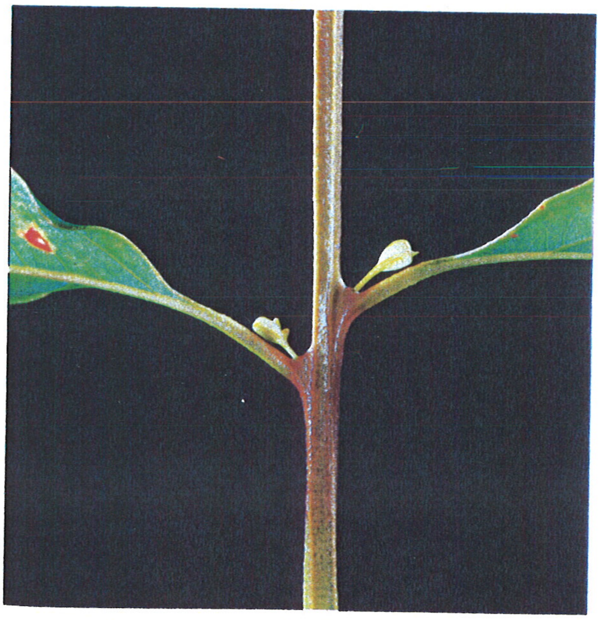


Photo C *Eucalyptus grandis* **x** *Eucalyptus nitens*

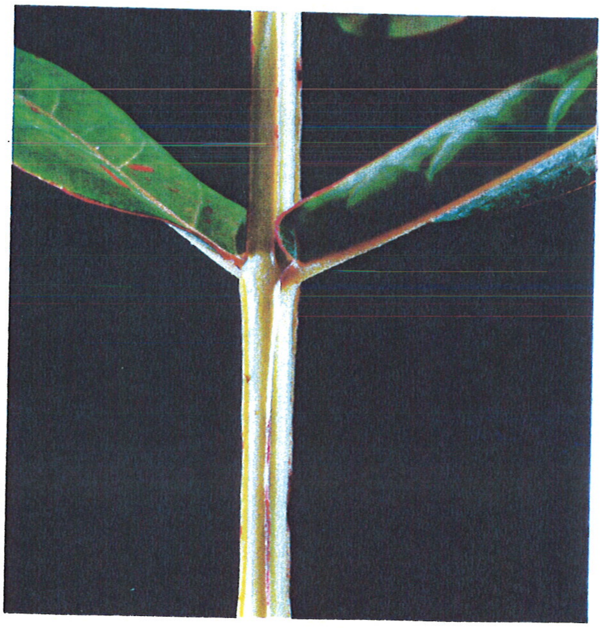
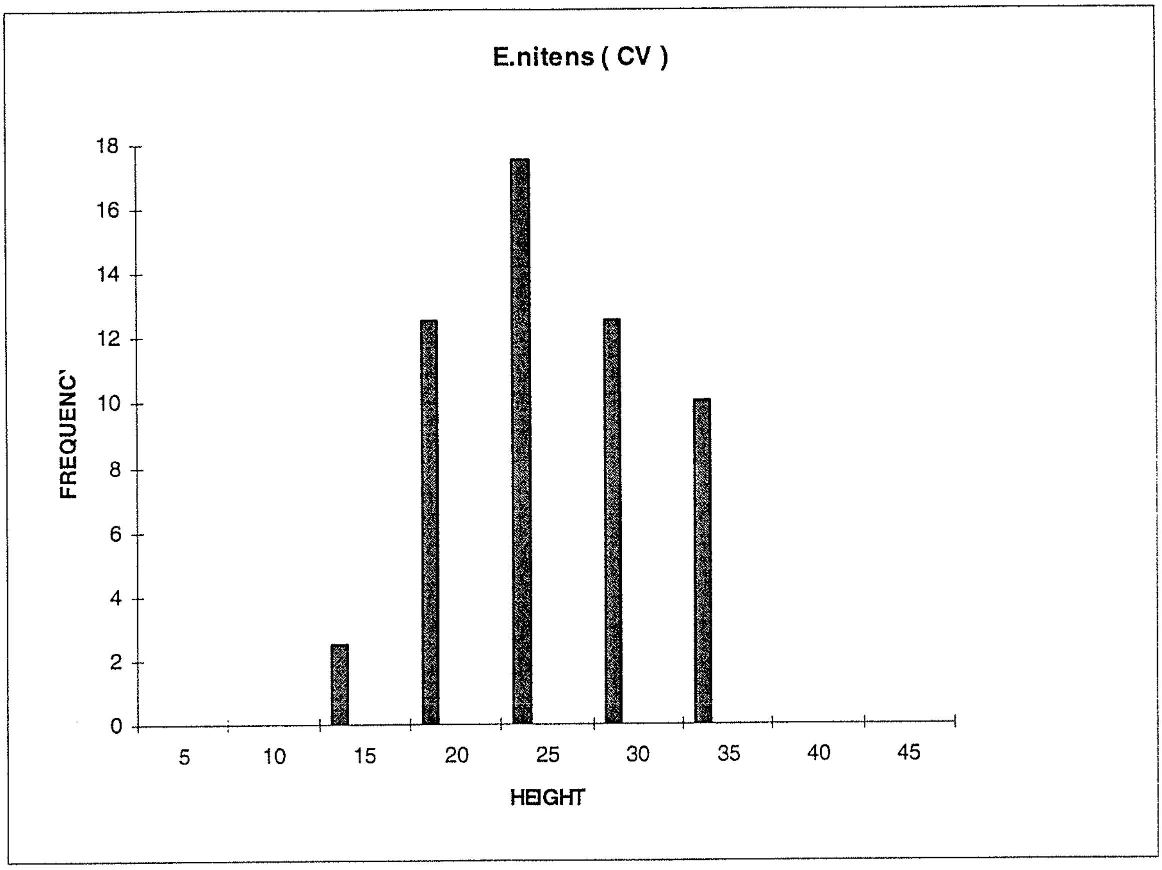


Photo D *Eucalyptus nitens*

Figure 2: Frequency Distribution, Te Teko Site



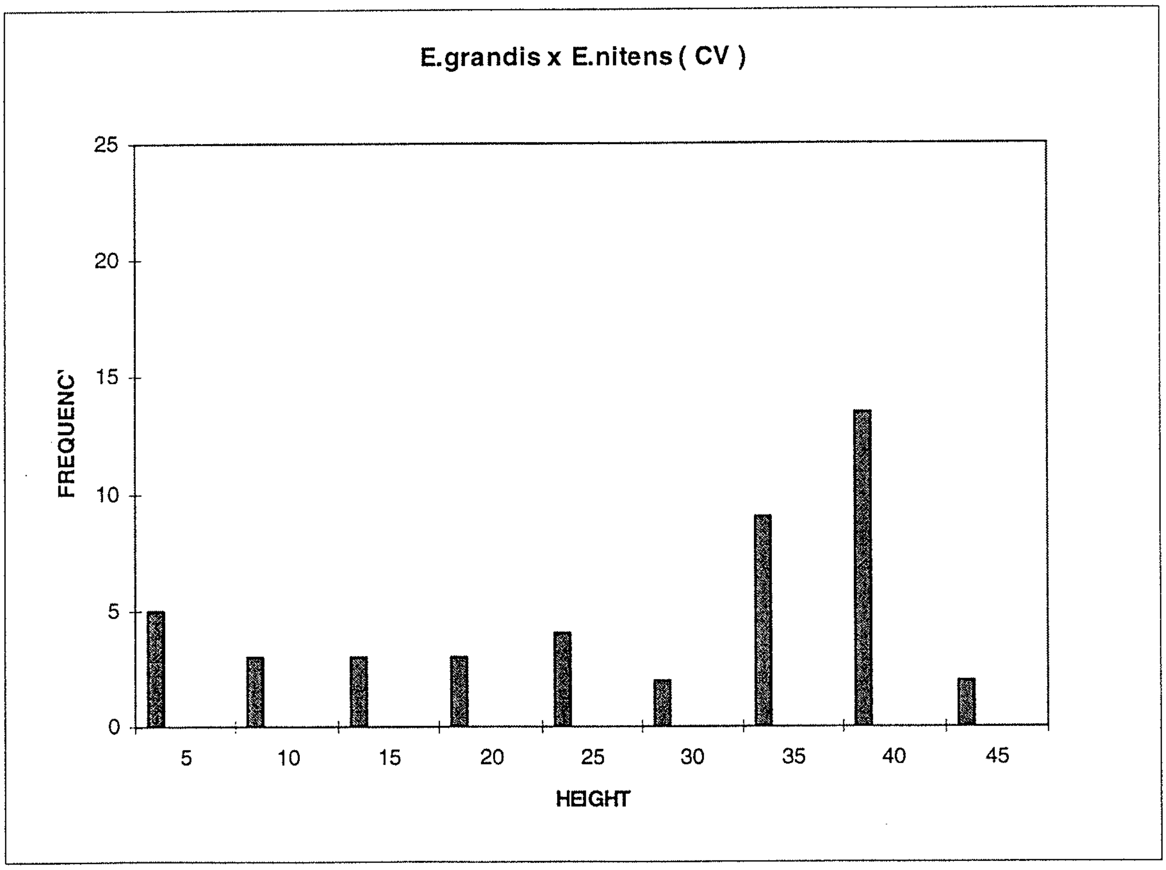


Table 1: Mating Design of *E. grandis* x *E. nitens* Hybrids

E. grandis **(Female Parents)**

		301	302	303	304	305	306	307	308	309
	401	101								
(Male Parents)	402		102							
	403			103						
E. nitens	404				104					
CV	405					105				
	406						106			
	407								108	
	408									109

		301	302	303	304	305	306	307	308	309
	501	201								
(Male Parents)	502		202							
	503			203						
E. nitens	504				204					
NSW	505					205				
	506						206			
	507							207		
	508									208

E. grandis		E. nitens (CV)		E. nitens (NSW)	
Code no.	**Ortet No.**	**Code No.**	**Ortet No.**	**Code No.**	**Ortet No.**
301	G58	401	890-042	501	892-003
302	G38	402	888-877	502	892-004
303	G17	403	888-854	503	892-005
304	G19	404	890-052	504	892-006
305	G74	405	890-055	505	892-007
306	G75	406	888-885	506	892-008
307	G101	407	890-045	507	892-009
308	G39	408	890-044	508	892-010
309	G97				

Table 2: Average values for each species group and Duncan's Multiple Range Test

Height (dm)

	Te Teko	Tairua	Awarua
E. grandis	26.3 A	15.3 A	4.6 C
Hybrid CV	30.9 A	15.8 A	4.2 BC
Hybrid NSW	25.8 A	13.5 B	4.1 BC
E. nitens CV	26.2 A	17.0 A	6.3 A
E. nitens NSW	19.8 B	12.5 B	5.2 B

Means with the same letter are not significantly different

Table 3: Average values of the best 5 trees in each species group

Height (dm)

	Te Teko	Tairua	Awarua
E. grandis	36.2	25.2	6.2
Hybrid CV	42.6	28.4	8.9
Hybrid NSW	38.4	21.8	6.7
E. nitens	35.0	25.2	9.4
E. nitens NSW	28.8	19.4	8.0

Table 4: Average values for each species group and Duncan's Multiple Range Test

Petiole Score

	Te Teko	Tairua	Awarua
E. grandis	5.0 A	4.9 A	4.8 A
Hybrid CV	3.9 B	4.2 B	3.3 B
Hybrid NSW	4.2 B	3.9 B	3.1 B
***E. nitens* CV**	1.0 C	1.0 C	1.1 C
***E. nitens* NSW**	1.0 C	1.0 C	1.1 C

Means with the same letter are not significantly different

Table 5: Average Values for each species group and Duncan's Multiple Range Test

Stem Shape Score

	Te Teko	Tairua	Awarua
E. grandis	4.9 A	4.7 A	4.7 A
Hybrid CV	1.7 C	1.3 C	3.4 B
Hybrid NSW	1.5 B	2.0 B	3.3 B
***E. nitens* CV**	1.0 D	1.0 C	1.4 C
***E. nitens* NSW**	1.0 D	1.0 C	1.4 C

Means with the same letter are not significantly different

Table 6: Average Values for each species group and Duncan's Multiple Range Test

Leaf Health

	Te Teko	Tairua	Awarua
E. grandis	2.3 A	2.6 B	1.5 C
Hybrid CV	1.7 B	2.7 B	2.5 B
Hybrid NSW	1.7 AB	2.7 B	2.4 B
***E. nitens* CV**	2.6 A	3.0 A	2.9 A
E. nitens NSW	2.6 A	2.9 A	2.9 A
Overall	2.2	2.8	2.4

Means with the same letter are not significantly different

Table 7: Average values for each species group and Duncan's Multiple Range Test

Malformation

	Te Teko	Tairua	Awarua
E. grandis	4.2 B	4.4 A	3.3 B
Hybrid CV	3.9 B	3.9 B	3.1 AB
Hybrid NSW	4.4 B	3.6 B	3.4 AB
E. nitens	4.8 A	4.4 A	3.8 A
***E. nitens* NSW**	4.1 B	4.2 A	3.6 A

Means with the same letter are not significantly different

Table 8: Average values for each species group

Survival (%)

	Te Teko	Tairua	Awarua
E. grandis	98.4	65.4	36.1
Hybrid CV	70.3	72.3	81.4
Hybrid NSW	65.6	66.7	83.9
***E. nitens* CV**	84.4	82.5	98.2
***E. nitens* NSW**	92.2	84.7	93.8

TABLE: 9a Analysis of variance of species, Awarua

General Linear Model Procedure (SAS)

Trait	Source	DF	Type III SS	Mean Square	F Value	Pr > F
Height	REP SPECIES	7 4	3109.241 3100.109	444.177 775.027	4.65 8.11	0.0016 0.0002
Petiole	REP SPECIES	7 4	0.812 78.367	0.116 19.592	1.14 191.77	0.3711 0.0001
Stem Shape	REP SPECIES	7 4	0.493 63.376	0.070 15.844	0.70 158.04	0.6697 0.0001
Leaf Health	REP SPECIES	7 4	0.382 10.309	0.055 2.577	1.43 67.64	0.2332 0.0001
Malformation	REP SPECIES	7 4	3.732 3.857	0.533 0.964	1.32 2.38	0.2812 0.0767

TABLE: 9b Analysis of variance of species, Tairua

General Linear Model Procedure (SAS)

Trait	Source	DF	Type III SS	Mean Square	F Value	Pr > F
Height	REP	8	114.412	14.302	2.87	0.0158
	SPECIES	4	142.865	35.716	7.17	0.0003
Petiole	REP	8	2.544	0.318	2.63	0.0247
	SPECIES	4	121.333	30.333	250.59	0.0001
Stem Shape	REP	8	4.894	0.612	1.98	0.0813
	SPECIES	4	87.669	21.917	71.02	0.0001
Leaf Health	REP	8	0.318	0.040	0.92	0.5126
	SPECIES	4	1.074	0.268	6.22	0.0008
Malformation	REP	8	5.584	0.700	3.65	0.0040
	SPECIES	4	4.487	1.122	5.86	0.0012

TABLE: 9c Analysis of variance of species, Te Teko

General Linear Model Procedure (SAS)

Trait	Source	DF	Type III SS	Mean Square	F Value	Pr > F
Height	REP	7	171.590	24.513	3.15	0.0138
	SPECIES	4	326.463	81.616	10.50	0.0001
Petiole	REP	7	0.836	0.119	1.60	0.1778
	SPECIES	4	114.589	28.647	382.91	0.0001
Stem Shape	REP	7	1.036	0.148	1.29	0.2909
	SPECIES	4	87.268	21.817	190.19	0.0001
Leaf Health	REP	7	1.064	0.152	0.92	0.5066
	SPECIES	4	3.557	0.889	5.38	0.0024
Malformation	REP	7	2.105	0.301	2.30	0.0550
	SPECIES	4	2.744	0.687	5.25	0.0028

TABLE: 10a Analysis of variance of families, Te Teko

General Linear Model Procedure (SAS)

Trait	Source	DF	Type III SS	Mean Square	F Value	Pr > F
Height	REP	7	1307.748	186.821	3.88	0.0005
	FAMILY	39	7650.580	196.169	4.07	0.0001
Petiole	REP	7	3.753	0.536	2.26	0.031
	FAMILY	39	831.031	21.308	89.98	0.000
Stem Shape	REP	7	4.134	0.591	1.35	0.2268
	FAMILY	39	753.649	19.324	44.28	0.0001
Leaf Health	REP	7	9.189	1.313	2.04	0.0515
	FAMILY	39	87.304	2.239	3.48	0.0001
Malformation	REP	7	16.526	2.361	3.01	0.0050
	FAMILY	39	59.179	1.517	1.93	0.0017

TABLE: 10b Analysis of variance of families, Tairua

General Linear Model Procedure (SAS)

Trait	Source	DF	Type III SS	Mean Square	F Value	Pr > F
Height	REP	8	421.211	52.651	1.84	0.0715
	FAMILY	39	2672.249	68.519	2.39	0.0001
Petiole	REP	8	9.478	1.185	3.34	0.0013
	FAMILY	39	730.589	18.733	52.85	0.0001
Stem Shape	REP	8	11.297	1.412	2.98	0.0035
	FAMILY	39	595.151	15.260	32.19	0.0001
Leaf Health	REP	8	0.980	0.123	0.63	0.7480
	FAMILY	39	21.744	0.558	2.89	0.0001
Malformation	REP	8	28.403	3.550	3.83	0.0003
	FAMILY	39	64.122	1.644	1.77	0.0060

TABLE: 10c Analysis of variance of families, Awarua

General Linear Model Procedure (SAS)

Trait	Source	DF	Type III SS	Mean Square	F Value	Pr > F
Height	REP	7	16364.688	2337.813	9.17	0.0001
	FAMILY	39	29598.310	758.931	2.98	0.0001
Petiole	REP	7	4.516	0.645	1.42	0.1984
	FAMILY	39	455.784	11.687	25.76	0.0001
Stem Shape	REP	7	2.518	0.360	1.05	0.3969
	FAMILY	39	371.668	9.530	27.85	0.0001
Leaf Health	REP	7	1.640	0.234	0.87	0.5302
	FAMILY	39	53.093	1.361	5.06	0.0001
Malformation	REP	7	15.732	2.247	1.50	0.1701
	FAMILY	39	64.770	1.661	1.11	0.3204