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Provenance Trial in Eucalyptus grandis and its Implication to Forestry Programmes

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Summary

A provenance trial involving 17 exotic provenances from Australia and one local (Valparai) seed source of *Eucalyptus grandis* was undertaken to identify suitable provenances for a general plantation programme. The study revealed the presence of significant variation among the provenances. The provenances Paluma, Ravenshoe, Gadgara and Herberton were found to be the best. It is suggested that the local provenance of *E. grandis* which has till now been used for plantation forestry in the region should be replaced with the fast-growing provenance, Paluma. This may also be used as the population for the genetic improvement of *E. grandis*, if undertaken.

Key words: *Eucalyptus grandis*, provenance, variability, correlation.

Introduction

Selection of the best provenances of the best species for a given site or region is necessary for achieving maximum productivity both in plantation forestry and with agroforestry systems. The concept of provenance testing has been well established and demonstrated through nationally or internationally conducted co-ordinated provenance trials. *Eucalyptus grandis*, an exotic species, is being introduced to India for its high value for fuel, pulp, paper and timber and is the most sought-after species for paper production. It is also resistant to "pink disease" and grows well at high altitude in Tamil Nadu and Kerala (SHYAM SUNDAR, 1979). Information on the amount of provenance variation in growth rate and on selection of superior provenance of this species for commercial planting is meagre. A trial was therefore established so that suitable provenances of *Eucalyptus grandis* could be recommended for general and agroforestry plantation programmes.

Materials and Methods

The experimental materials consisted of 17 Australian provenances of *Eucalyptus grandis* received from CSIRO, Australia and one local seed source (*Table 1*). The provenance trial was planted in 1981 at Valparai which is a hill station, and at 1066 metres a. m. s. l. The provenances were planted in a randomized block design with four replications. Sixteen plants were planted in each plot at an espacement of 2 metres x 2 metres. Height and girth were measured annually. At the final assessment at age 9 years, height, clear bole height, girth and diameter at breast height (dbh) and basal area were measured. Growth parameters at the age of 7 and 9 years form the basis of this paper. The data were subjected to analysis of variance using plot means and correlation coefficients between characters were calculated at the plot mean level.

Results

Significant differences among the provenances were shown in the analysis of variance for all the characters under study (*Table 2*).

Provenance means for different characters are presented in *table 3*. All the provenances except S. of Tyalgum, northern N. S. W., Port Stephens and Eungella were superior to the Valparai local seed source for height which ranged from 17.8 m (Port Stephens) to 25.5 m (Paluma) at the age of 7 years. However, at the age of 9 all the Australian provenances were growing better than the Valparai local source. Of the 17 provenances, 11 showed 25% better growth in height than control. Mean height ranged from 26.2 m (Valparei local) to 44.0 m (Paluma). The correlation between heights at the ages of 7 and 9 years was positive and significant ($r = 0.7188$). Clear bole height measured at the age of 9 years was higher in all Australian provenances than the Valparai local and ranged from 10.3 m (Valparai local) to 26.1 m (Paluma).

12 and 7 provenances respectively had higher girth at the age of 7 and 9 years than the Valparei local. While Paluma showed the highest girth (82.0 cm), the Port Stephens provenance recorded the lowest girth (48.2 cm). The correlation between the girths at 7 and 9 years of age was positive and significant ($r = 0.9089$).

Mean values for dbh ranged from 13.5 cm (Port Stephens) to 23.6 cm (Paluma). 11 provenances had better diameter growth rate than the local plantation.

11 out of 17 provenances recorded higher mean basal area than the Valparai local and the values ranged from 143.9 cm^2 (Port Stephens) to 446.3 cm^2 (Paluma). 6 provenances showed 50% increased basal area over Valparai local. However, interplot competetion is likely to be exaggerating differences between poor-performing and good-performing provenances.

Table 1. — List of provenances of E. grandis.

Sl.No	Provenance	CSIRO Seed lot No.
1	Gillies Highway	12426
2	Gadgara	12422
3	Herberton area	12383
4	Wondella area	12381
5	Ravenshoe area	12409
6	Tully falls area	12382
7	West of Paluma	12462
8	Kenilworth	10695
9	Bellthorpe	10696
10	S. of Tyalgum, Northern N.S.W.	11243
11	N. of COFFS. Harbour, Northern N.S.W.	7823
12	N. of Bulahdelah	7810
13	Port Stephens	11587
14	Davis Creek road	12428
15	Eungella	13028
16	Gympie	13023
17	Wbian Wbian S.F. Lismers	13021
18	Valparai local (E. grandis)	

Tree height showed significant, positive correlations with all other characters measured at the age of 9 years (*Table 4*).

Discussion

Large and statistically significant differences observed among the Australian provenances of *E. grandis* indicated the presence of considerable genetic diversity in growth rate. These provenance differences can be exploited by selecting the best provenances and using these in future plantations.

The Paluma provenance emerged as the best provenance of all. It showed uniformly good growth rate during the whole assessment period, and the early superior growth rate was maintained during later stages of growth. Thus, it may be possible to use earlier results than at age nine to predict relative performance of provenances at older ages. Apart from Paluma, a few more provenances viz., Ravenshoe, Gadgara and Herberton also showed superior growth rates.

Positive correlations between height and other characters suggest that height or diameter at breast height may be

Table 2. — Analysis of variance for different characters in *E. grandis*.

Source	Mean Squares							
		At age of 7years (1988)		At age of 9 years (1990)				
	df	Height	Girth	Height	Clearbole height	Girth	Diameter	Basal area
Replication	3	14.4713	95.6391	319.8776	187.0326	94.9271	10.0163	10479.67
Treatment	17	68.2925**	226.1850**	83.7886*	54.8756*	411.5625**	39.1738**	34909.35**
Error	51	9.5152	47.2883	40.3033	26.1920	139.8548	13.4078	13244.11

*),**) = Significant at 5% and 1% levels, respectively

Table 3. — Mean performance of provenances of *E. grandis* for different characters.

Provenance	At age 7 years Height (m)	At age 7 years Girth (cm)	At age 9 years Height (m)	At age 9 years Clearbole height (m)	At age 9 years Girth (cm)	At age 9 years Diameter (cm)	At age 9 years Basal area (cm^2)
Gillies highway	23.0	48.1	36.0	18.8	68.7	19.7	311.1
Gadgara	21.7	48.3	38.2	20.7	78.0	22.4	396.6
Herberton area	23.1	49.3	36.4	16.7	71.4	20.4	339.7
Wondella area	21.8	44.9	34.3	19.5	63.6	17.3	237.7
Ravenshoe area	24.2	51.8	39.5	23.1	73.9	21.3	376.5
Tilly falls area	21.4	45.5	33.7	16.8	66.2	18.7	322.1
West of Paluma	25.5	53.2	44.0	26.1	82.0	23.6	446.3
Kenilworth	20.6	38.2	30.1	17.6	49.3	13.6	144.8
Bellthorpe	24.4	46.0	39.4	23.4	60.6	17.0	250.4
S. of Tyalgum, Northern N.S.W.	19.2	38.1	28.2	16.1	51.2	14.1	159.7
N. of COFFS Harbour, Northern (N.S.W.)	22.7	43.4	33.9	19.8	54.7	15.0	196.6
N. of Bulahdelah	23.2	38.9	35.4	23.3	56.1	15.9	205.4
Port Stephens	17.8	34.2	30.6	19.4	48.2	13.5	143.9
Davis Creek read	23.8	47.7	29.3	14.9	65.8	18.3	272.4
Eungella	19.0	38.7	30.2	16.7	49.9	13.6	147.9
Gympie	23.9	43.2	34.6	20.9	56.2	14.9	178.0
Wbian Wbian S.F. Lismore	23.4	47.3	31.0	20.5	58.3	16.3	213.7
Valparai local	19.5	39.3	26.2	10.3	56.0	15.6	198.5
SEM	1.54	3.44	3.17	2.56	5.91	1.83	57.54

Table 4. — Correlation[a]) coefficients among different characters in *E. grandis*.

Character	Clear bole height	Girth	dbh	Basal area
Height	0.8382**	0.5189*	0.5623*	0.5268*
Clear bole height		0.2449	0.2744	0.2209
Girth			0.9902**	0.9759**
dbh				0.9870**

*),**) = Significant at 5% and 1% levels, respectively
a) = Correlation values are based on plots means

used as criteria for selection among provenances (*Table 4*). However, height is a much more costly trait to measure after the first two years than dbh. Diameter at breast height could therefore, equally be used, and is better correlated with tree volume, which is economically more important trait. Although the correlation of height with girth, dbh and basal area were not high, they were positive and statistically significant.

It was concluded that the provenances Paluma, Ravenshoe, Gadgara and Herberton were superior in volume growth. The Valparai local seed source of *E. grandis* has so far been used for afforestation programmes in the region and as this seedlot has been shown to be quite slow growing, sub-optimal productivity must be expected from the plantations raised from this source. Provenances from Australia such as Paluma should, in future, be used for general plantation programmes for Valparei and areas having similar eco-climates. The future selective breeding of *E. grandis* should utilize Paluma and other provenances as a source of breeding population for selections. The inferiority in performance of the Valparei local seed source may be due to inbreeding because the original population may have been established from seed from a small number of parent trees.

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Genetic Control of Fifth Year Traits in Pinus patula Schiede and Deppe

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(Received 12th September 1991)

Summary

Polycross, factorial and diallel mating designs were used in the genetic improvement programme for *Pinus patula* SCHIEDE and DEPPE in ZIMBABWE. Their function was to elucidate genetic structure and control in economically important traits, to investigate genotype-environment interaction, to identify the best general combiners and to provide information on the efficiency of mating and experimental designs. Productivity, stem straightness and crown traits were measured in the fifth year from planting in the field. Analysis of the data showed that all traits were under multigenic control with practically insignificant contributions from dominance, maternal or reciprocal effects. Family heritability estimates were highest for the branch traits (up to 0.85, 0.80, 0.91 and 0.91 for branch basal area, total number and number per whorl and internode length respectively) but also high for stem volume (up to 0.82) and moderate for stem straightness (up to 0.67). Genotype-environment (locality) interaction could be of practical value for stem volume but was absent for stem straightness and the branch traits. There was no genotype-year interaction. Sub-blocking made no practical contribution to the precision of ranking the families but use of the lattice design might mean that the same precision of comparison could be achieved for some traits in some environments with experimental plantings that were up to 25% smaller. The assumption of half-sib relationship within families in the polycross was shown to be valid and the test was an efficient one to rank parents for general combining ability. The only adverse genetic correlation was a positive one between the amount of sinuosity in the upper stem in the second year and stem volume in the fifth year. Otherwise there were very strong genetic correlations between height and diameter in the second year and the same traits in the fifth year (0.94 (s.e. 0.06) and 0.94 (s.e. 0.09) respectively); and the same applied to the branch traits, internode length and total number of branches (0.85 (s.e. 0.11) and 0.91 (s.e. 0.06) respectively). The conclusion is that in the fifth year after planting, there are still strong indications that substantial and rapid genetic gain should be available for *P. patula* through early selection for general combining ability using conventional breeding methods.

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Key words: Progeny tests, diallel, factorial mating design, polycross test, genetic correlations, juvenile-mature correlations, triple lattice design, genotype-environment interaction, general combining ability, specific combining ability.

Introduction

The genetic improvement programme for *Pinus patula* SCHIEDE and DEPPE in Zimbabwe (then Rhodesia) started in 1958. It included the use of polycross, factorial and reciprocal mating designs for progeny testing and estimating genetic parameters in the first generation of plus trees selected from unimproved plantations. The aim was to identify parents with high general combining ability (*gca*) and to provide genetic information on the local population (BURLEY et al., 1966). Controlled crosses for this plan were completed in 1967 and progeny tests were planted between 1967 and 1972 (BARNES, 1973). Nursery assessments were made and the data analysed and published (BARNES and SCHWEPPENHAUSER, 1978) as were the data from extensive assessments made at 1.5 years after planting in the field (BARNES and SCHWEPPENHAUSER, 1979). In this paper we report on results of analyses of growth, stem and branch form traits measured at 4.5 years including estimates of juvenile-mature correlations.

Materials and Methods

The plus tree population, mating design, progeny test localities and environmental design of the experiments have been fully described previously (see BURLEY *et al.*, 1966; BARNES, 1973; BARNES and SCHWEPPENHAUSER, 1978 and 1979). For easy reference the mating design is repeated here in *figure 1.* Basic environmental design was randomized complete block, with superimposed lattice at the principle localities, with three replications of 10-tree line plots at 2.44 m square spacing. The polycross (controlled crosses between the seed parent and a 20-pollen mix) was repeated over two years at two localities and in each case was a double triple lattice. The factorial (controlled crosses between 9 seed parents and 5 pollen testers) was planted at the same two localities in one year as single triple lattices. The diallel (controlled crosses among five parents with reciprocals but without selfs) was planted as