TWO-YEAR PERFORMANCE OF *ACACIA* AND *EUCALYPTUS* SPECIES IN A PROVENANCE TRIAL IN LAO P.D.R.

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PINYOPUSARERK, K., LUANGVIRIYASAENG, V. & RATTANASAVANH, D. 1996. Two-year performance of *Acacia* and *Eucalyptus* species in a provenance trial in Lao P.D.R. A species and provenance trial consisting of four eucalypts (*Eucalyptus camaldulensis, E. tereticornis, E. pellita* and *E. urophylla*) and four acacias (*Acacia aulacocarpa, A. auriculiformis, A. crassicarpa* and *A. mangium*) was established near Vientiane, Lao P.D.R. to screen suitability of species that might be grown commercially in plantations. Each species was represented by 6 - 8 provenances, a total of 55 provenances in all. Results up to two years of age showed considerable differences between species, and between provenances within species. A ranking of the species in order of magnitude based on tree volume was *E. camaldulensis, E. urophylla, A. mangium, E. tereticornis, A. crassicarpa, A. aulacocarpa, E. pellita* and *A. auriculiformis.* The results have implications for selection of most potential species and provenances for further detailed investigation. Future studies would desirably include yield estimation involving more sites, larger plots and alternative management regimes.

Key words: Species/provenance trial - *Acacia aulacocarpa* - *A. auriculiformis* - *A. crassicarpa* - *A. mangium* - *Eucalyptus camaldulensis* - *E. tereticornis* - *E. pellita* - *E. urophylla.*

PINYOPUSARERK, K., LUANGVIRIYASAENG, V. & RATTANASAVANH, D. 1996. Prestasi dua tahun spesies *Acacia* dan *Eucalyptus* di sebuah percubaan provenan di Lao P.D.R. Satu spesies dan percubaan provenan yang mengandungi empat eucalypts (*Eucalyptus camaldulensis, E. tereticornis, E. pellita* dan *E. urophylla*) dan empat acacia (*Acacia aulacocarpa, A. auriculiformis, A. crassicarpa* dan *A. mangium*) telah ditubuhkan berhampiran Vientiane, Lao P.D.R. untuk melihat kesesuaian spesies yang mungkin dapat ditanam secara komersial di ladang. Setiap spesies diwakili oleh 6 - 8 provenans, sejumlah 55 provenans kesemuanya. Keputusan sehingga umur dua tahun menunjukkan perbezaan-perbezaan yang besar di antara spesies, dan di antara provenans di dalam spesies. Satu susunan spesies dari segi magnitud berdasarkan isipadu kayu ialah *E. camaldulensis, E. urophylla, A. mangium, E. tereticornis, A. crassicarpa,* *A. aulacocarpa, E. pellita* dan *A. auriculiformis*. Keputusan mempengaruhi pemilihan spesies dan provenans yang paling berpotensi untuk penyelidikan lebih lanjut. Kajian pada masa depan sepatutnya menyertakan anggaran hasil yang melibatkan tapak kawasan yang lebih luas, plot-plot yang lebih besar dan regim-regim pengurusan alternatif.

Introduction

Many tropical species of the genera *Acacia* and *Eucalyptus* are fast growing and have great potential for plantation forestry (Turnbull 1986). Some species such as *A. auriculiformis, A. mangium, E. camaldulensis* and *E. urophylla* have been planted extensively for pulp and other wood products in many countries in the seasonally dry tropics. Others such as *A. aulacocarpa, A. crassicarpa* and *E. pellita* have also shown promise as important plantation species in recent years (Boland 1989, Pinyopusarerk 1992).

In Lao P.D.R., *E. camaldulensis* has become an important plantation species especially for woodchip export while *A. auriculiformis* has been used extensively in ornamental and shelterbelt plantings but the area of commercial plantation is very small. Some of the *Eucalyptus* and *Acacia* species mentioned above have recently been introduced to Lao P.D.R. but their performance is not well documented. In order to screen the suitability of a range of species and provenances with potential for national tree planting programmes, a provenance trial of selected *Eucalyptus* and *Acacia* species was established in 1992 at the Nam Souang Silvicultural Research Centre near Vientiane. The trial was established as part of a collaborative research project between the Lao Department of Forestry and Division of Forestry and Forest Products of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) with financial support from the Australian Centre for International Agricultural Research (ACIAR). This paper describes and compares relative growth performance up to two years of age of species and provenances in this trial.

Materials and methods

Species and provenances

Four species each of *Eucalyptus* (*E. camaldulensis, E. pellita, E. tereticornis* and *E. urophylla*) and *Acacia* (*A. aulacocarpa, A. auriculiformis, A. crassicarpa* and *A. mangium*) were included in the trial. There were 55 seedlots in total with each species being represented by six to eight provenances. Details of the species and provenances are given in Table 1. These species and some of their provenances were selected based on their satisfactory performance in a suite of field trials in Thailand (Pinyopusarerk 1989 , Chittachumnonk & Sirilak 1991).

Seed and seedlings

Bulked seedlots for the provenances were supplied by CSIRO Australian Tree Seed Centre. Seedlings were raised in a nursery for about four months and were approximately 20-25 cm high at the time of planting in July 1992. The seedlings were not inoculated with *Rhizobium* or ectomycorrhizal fungi.

Table 1. Details of seed origin of *Acacia* and *Eucalyptus* species in the species and provenance trial in Lao P.D.R.
NT = Northern Territory, QLD = Queensland, WA = Western Australia, IND = Indonesia, PNG = Papua New Guinea

Species	CSIRO Seedlot No.	Provenance	Latitude (° 'S)	Longitude (° 'E)	Altitude (m)	Number of parent trees
A. aulacocarpa	16948	Isago, Arimia River, PNG	8 01	142 41	10	20
	16981	Kapal, NW of Wipim, PNG	8 37	142 47	40	15
	17551	Bensback-Balamuk, PNG	8 53	141 17	25	30
	17560	Dimisisi, PNG	8 31	141 13	50	30
	17628	Keru Village, PNG	8 33	141 45	30	50
	17873	Wipim-Oriomo, PNG	8 49	142 54	45	10
A. auriculiformis	16145	WenlockRiver, QLD	13 06	142 56	130	20
	16485	Kings Plains, QLD	15 42	145 06	100	7
	16729	15 km WNW Coen,QLD	13 53	143 03	175	10
	17966	Boggy Creek QLD	15 52	144 53	240	10
	16148	Manton River,NT	12 50	131 07	100	10
	16155	Mann River, NT	12 22	134 08	60	4
	18090	Morehead River, PNG	8 43	141 36	20	10
	18102	Mibini, PNG	8 50	141 38	18	8
A. crassicarpa	16128	Jardine River, QLD	11 02	142 22	20	15
	17944	Claudie River,QLD	12 48	143 18	20	4
	17948	Chilli Beach, QLD	12 38	143 23	3	10
	16598	Bimadebun Village, PNG	8 37	141 55	25	230
	16977	Wipim District, PNG	8 49	142 48	45	20
	17871	Wipim-Oriomo, PNG	8 49	142 54	45	20
A. mangium	15357	Cardwell, QLD	18 21	146 05	12	24
	15681	Heathlands, CapeYork,QLD	11 41	142 42	110	3
	17946	Claudie River, QLD	12 48	143 18	20	60
	16592	Mai Kussa River, PNG	8 59	142 15	25	2
	16938	Kini WP, PNG	8 05	142 58	12	70
	18058	Wipim, PNG	8 49	142 54	45	150
	18088	Oriomo, PNG	8 55	143 10	20	20
E.camaldulensis	13694	N of Normanton,QLD	17 28	141 10	30	5
	14338	E of Petford, QLD	17 17	145 03	500	129
	14781	SE Wrotham Park, QLD	16 49	144 10	240	1
	13941	Victoria River, NT	16 20	131 07	100	5
	17635	Katherine River, NT	14 25	132 18	120	11
	14514	Ord River, WA	17 29	127 51	300	15
	14537	Isdell River, WA	16 56	125 35	315	10
	15051	Lennard River, WA	16 30	124 30	50	50

continued

Table 1. (continued)

E. tereticornis	13666	SW of Mt Garnet, QLD	18 30	144 45	265	24
	14212	Helenvale, QLD	15 45	145 15	500	25
	14424	Ravenshoe,QLD	17 39	145 21	700	30
	14802	Kennedy River, QLD	15 34	144 02	140	25
	14858	W Mareeba, QLD	16 46	145 15	380	75
	16349	Atherton Wongabel, QLD	17 19	145 28	780	6
E. pellita	12162	5 km S Helenvale, QLD	15 45	145 15	152	12
	14339	14.6 km NE Coen,QLD	13 53	143 17	580	18
	17859	NW Kuranda, QLD	16 39	145 33	440	73
	17874	Lankelly Creek,QLD	13 53	143 16	500	10
	18149	SE Cardwell, QLD	18 21	146 04	15	27
	17854	Bupal-Muting, IND	7 21	140 36	40	17
E. urophylla	12898	Mt Boleng, Adonara, IND	8 21	123 15	890	16
	14531	Mt Egon, Flores, IND	8 38	122 27	515	50
	14532	Mt Lewotobi, Flores, IND	8 31	122 45	398	31
	17831	N of Ilwaki, Wetar, IND	7 52	126 27	515	17
	17832	N of Arnau, Wetar, IND	7 49	126 10	315	25
	17839	SE of Apui, Alor, IND	8 17	124 40	1115	16
	17840	Wai Wai, Central Alor, IND	8 14	124 44	540	10
	17842	Mt Dalaki, SE Pantar, IND	8 31	124 05	440	9

Trial establishment

The trial site was formerly a secondary mixed deciduous forest which had been cleared for agricultural purposes. The area which is 200 m above sea level receives average annual rainfall of 1650 mm and has a dry season lasting 5 - 6 months. The mean minimum and mean maximum temperatures are 20.6 °C and 30.8 °C respectively, with an annual mean temperature of 25.2 °C. The soils are of low fertility, sandy in texture and with a kaolinitic hard pan layer lying between 30 and 120 cm below the soil surface. The soil pH is around 5.

A nested design consisting of four replicates was used, with provenance sub-plots being within species plots. Each unit plot comprised 25 (5 × 5) trees, spaced at 3 × 3 m. There was a 6 m space between main plots to allow access of machinery and to reduce the risk of fire damage. Species were randomly allocated at the main plot level. Likewise, provenances of the same species were randomly allocated to sub-plots within each main plot.

The trial site was fully cultivated to a depth of 50 cm prior to planting and an initial application of 100 g per tree of NPK fertiliser was applied at one month after planting.

Assessment

Height (H, m) of the tallest stem was measured on all trees at 6, 12 and 24 months and diameter over bark at 1.3 m height (DBH, cm) at 12 and 24 months after planting. Survival was generally high (> 90%) for most seedlots and was, therefore, not addressed here. Conical volume (V, dm^3 per tree) was calculated for all trees at the 24-month measure using the equation: $V = 1/3 * 7\pi * (DBH/2)2 * H$. For trees with multiple stems, DBH was measured on all stems where forking or multiple leaders originated less than 1.3 m above the ground. The diameter, equivalent to that of a single stem with the same across-sectional area, was calculated using the formula:

$$DBH = (d_1^2 + d_2^2 + ... d_n^2)^{1/2}$$

where d_1, d_2, d_n are the diameters of the stems taken at 1.3 m from the ground.

Data analysis

Data were screened for unusual outliers before they were subjected to analysis of variance of plot means. The statistical package Genstat 5 (Payne *et al.* 1987) was used for the analyses. The following linear model was fitted to plot mean data:

$$Y_{ijk} = \mu + P_i + A_j + \eta_{ij} + A.B_{jk} + \varepsilon_{ijk}$$

where Y_{ijk} = plot mean, μ = overall mean, P_i = replicate effect, A_j = main plot (species) effect, η_{ij} = main-plot residual, $A.B_{jk}$ = species.provenance effect, ε_{ijk} = sub-plot residual.

Note that in the model the provenances are nested within species.

Results

Species differences

There were highly significant differences ($p < .001$) between species for all growth parameters measured at 6, 12 and 24 months after planting (Table 2). *Eucalyptus camaldulensis* and *E. urophylla* were most outstanding and between them had eight seedlots placed in the top ten out of the total 55 seedlots in terms of volume growth at 24 months. The bottom ten seedlots comprised *A. auriculiformis* (4 seedlots), *A. aulacocarpa* (3 seedlots), *E. pellita* (2 seedlots) and *A. crassicarpa* (1 seedlot). Overall species ranking based on tree volume was in the following order: *E. camaldulensis, E. urophylla, A. mangium, E. tereticornis, A. crassicarpa, A. aulacocarpa, E. pellita* and *A. auriculiformis* (Table 3).

Of the *Acacia* species, *A. mangium* and *A. crassicarpa* started slowly, being the shortest at 6 months, while *A. auriculiformis* was the tallest and *A. aulacocarpa* was intermediary (Table 3). This trend, however, changed with age. At 24 months, *A. mangium* was clearly the fastest growing. of the acacias. It was followed by *A.*

crassicarpa, *A. aulacocarpa* and *A. auriculiformis* which among them did not differ substantially.

Of the *Eucalyptus* species, *E. camaldulensis* and *E. tereticornis* grew faster than *E. pellita* and *E. urophylla* at 6 months (Table 3). While *E. camaldulensis* maintained its growth rate, *E. tereticornis* appeared to have slowed down at later stages. In contrast, *E. urophylla* which was slow initially caught up with *E. tereticornis* at 12 months and was as productive as *E. camaldulensis* in volume growth at 24 months, based on species average. *E. pellita* was consistently the slowest growing among the *Eucalyptus* species as evident from the provenance means in Table 3.

Provenance within species differences

Differences between provenances within species were highly significant ($p \leq =.001$) for all growth parameters at 6, 12 and 24 months (Table 2). Variance of height, diameter and volume was also analysed (data not shown here) and there were no significant differences between provenances within species. The growth data shown in Table 3 indicate that, in most cases, ranking of the provenances within each species changed with age. To simplify the comparison between provenances within each species, therefore, the tree volume data at 24 months have been used (Table 3).

Table 2. Summarised results of analysis of variance of mean height, diameter and volume per tree of the *Acacia* and *Eucalyptus* species/provenance trial in Lao P.D.R.

Source	d.f.	6 months		12 months		24 months	
		m.s.	*F*	m.s.	*F*	m.s.	*F*
Mean height							
Replicate	3	0.155		0.864		4.677	
Species	7	2.281	< .001	12.625	< .001	20.932	< .001
Main plot residual	21	0.030		0.103		1.930	
Species.Provenance	47	0.057	< .001	0.296	< .001	0.767	< .001
Sub-plot residual	145	0.015		0.074		0.231	
Mean diameter							
Replicate	3			3.737		2.813	
Species	7			10.325	< .001	16.022	< .001
Main plot residual	21			0.226		1.705	
Species.Provenance	47			0.293	< .001	0.940	< .001
Sub-plot residual	145			0.092		0.318	
Mean volume per tree							
Replicate	3					27.463	
Species	7					207.861	< .001
Main plot residual	21					16.739	
Species.Provenance	47					10.953	< .001
Sub-plot residual	145					4.071	

Table 3. Mean height (*H*, m), diameter at breast height (*DBH*, cm) and volume per tree (dm^3) of *Acacia* and *Eucalyptus* species in a provenance trial in Lao P.D.R. NT = Northern Territory, QLD = Queensland, WA = Western Australla, IND = Indonesia, PNG = Papua New Guinea

Species	CSIRO Seedlot No.	Provenance	6 months	12 months		24 months		
			H	*H*	*DBH*	*H*	*DBH*	*Volume*
A. aulacocarpa	17628	Keru Viliage, PNG	0.93	2.18	1.79	5.49	6.45	6.98
	16981	Kapal, NW of Wipim, PNG	1.02	2.21	1.80	5.52	6.25	6.18
	17551	Bensback-Balamuk, PNG	0.98	2.04	1.69	5.15	6.05	5.66
	17560	Dimisisi, PNG	0.86	2.03	1.65	5.23	5.66	4.85
	17873	Wipim,Oriomo, PNG	0.77	1.94	1.50	5.03	5.69	4.81
	16948	Isago, Arimia River, PNG	0.80	2.04	1.41	4.88	5.32	4.30
	Mean		0.90	2.14	1.76	5.39	5.92	5.48
A.auriculiformis	16729	15 km WNW Coen, QLD	1.23	2.66	1.96	6.15	6.00	6.68
	18102	Mibini, PNG	1.26	2.50	2.20	5.66	6.28	6.44
	16148	Manton River, NT	1.21	2.41	1.82	5.47	5.53	5.01
	16155	Mann River, NT	1.24	2.50	1.69	5.55	5.53	4.97
	16485	Kings Plains, QLD	1.11	2.37	1.68	5.49	5.52	4.83
	16145	Wenlock River, QLD	0.94	2.23	1.55	5.28	5.55	4.62
	18090	Morehead River,PNG	1.21	2.21	1.64	5.11	5.46	4.55
	17966	Boggy Creek, QLD	1.16	2.20	1.75	4.98	4.82	3.48
	Mean		1.16	2.39	1.76	5.46	5.53	4.98
A. crassicarpa	17871	Wipim,Oriomo, PNG	0.93	2.47	2.04	6.19	6.26	7.15
	17944	Claudie River, QLD	0.65	2.30	1.85	5.92	6.49	7.13
	16598	Bimadebun Village, PNG	0.84	2.32	1.93	5.91	6.23	7.09
	17948	Chilli Beach, QLD	0.98	2.55	2.04	5.80	6.15	6.57
	16977	Wipim District, PNG	0.81	2.36	1.77	5.73	5.74	5.72
	16128	Jardine River, QLD	0.48	1.88	1.96	5.12	5.42	4.41
	Mean		0.78	2.32	1.93	5.76	6.04	5.50
A. mangium	18056	Wipim, PNG	0.85	2.50	2.65	6.69	7.51	10.85
	18088	Oriomo, PNG	0.84	2.82	2.70	6.87	7.51	10.82
	15681	Heathlands, Cape York, QLD	0.63	2.21	2.09	6.58	7.45	10.41
	16938	Kini WP, PNG	0.74	2.08	2.18	7.03	6.80	9.55
	17946	Claudie River, QLD	0.68	2.44	2.20	6.25	7.23	9.16
	16592	Mai Kussa Rivcr, PNG	0.77	2.44	2.30	6.34	6.55	7.74
	15357	Cardwell, QLD	0.77	2.37	2.14	6.41	6.49	7.72
	Mean		0.75	2.42	2.31	6.52	7.08	9.35
E. camaldulensis	14781	SE Wrotham Park, QLD	1.64	4.39	3.80	8.88	7.87	15.40
	13694	N of Normanton,QLD	1.51	3.93	3.47	7.71	7.68	12.92
	17635	Katherine River, NT	1.63	4.09	3.55	7.69	7.60	12.53
	14338	E of Petford, QLD	1.68	4.22	3.17	8.25	7.14	12.07
	14537	Isdell River, WA	1.54	3.99	3.36	7.41	7.20	10.74
	13941	Victoria River, NT	1.30	3.92	3.13	7.06	7.17	10.18
	14514	Ord River,WA	1.48	3.88	3.22	7.13	6.45	8.29
	15051	Lennard River, WA	1.63	3.71	3.09	6.56	6.32	7.57
	Mean		1.54	4.03	3.35	7.66	7.21	11.37

continued

Table 3. (continued)

E. tereticornis	14212	Helenvale,QLD	1.32	3.12	2.92	6.69	7.45	11.82
	14802	Kennedy River, QLD	1.70	4.33	3.71	7.19	7.36	11.40
	13666	SW of Mt Garnet, QLD	1.39	3.43	3.08	6.71	6.93	9.80
	14424	Ravenshoe, QLD	1.33	3.12	2.81	6.22	6.58	8.27
	16349	Atherton Wongabel, QLD	1.29	2.70	2.24	5.70	5.81	6.67
	14856	W of Mareeba,QLD	1.36	2.80	2.38	5.67	5.91	6.13
	Mean		1.39	3.23	2.84	6.38	6.71	8.96
E. pellita	14339	14.6 km NE Coen,QLD	1.08	3.00	2.51	5.93	5.75	6.07
	17854	Bupal-Muting, IND	1.06	2.80	2.33	5.70	5.96	6.01
	17859	NW Kuranda, QLD	0.99	2.72	2.35	6.09	5.57	5.85
	12162	5 km S Helenvale, QLD	0.91	2.71	2.32	5.61	5.69	5.45
	17874	Lankelly Creek, QLD	0.93	2.56	2.13	5.15	5.09	4.44
	18149	SE Cardwell QLD	1.07	2.58	1.97	5.20	5.09	4.35
	Mean		1.01	2.74	2.27	5.61	5.52	5.37
E. urophylla	14531	Mt Egon, Flores, IND	1.08	3.33	2.88	7.20	7.58	12.88
	17839	SE of Apui, Alor, IND	1.03	3.20	2.67	6.99	7.74	12.31
	17840	Wai Wai, Central Alor, IND	1.00	3.20	2.59	6.95	7.77	12.26
	17842	Mt Dalaki, SE Pantar, IND	1.07	3.15	2.50	6.99	7.07	11.04
	14532	Mt Lewotobi, Flores, IND	1.17	3.66	3.09	7.24	7.30	11.03
	17831	N of Ilwaki,Wetar, IND	1.10	3.13	2.56	6.91	7.04	10.69
	12898	Mt Boleng, Adonara, IND	1.09	3.00	2.39	6.92	6.87	10.01
	17832	N of Arnau, Wetar, IND	1.28	3.38	2.92	7.40	6.82	9.80
	Mean		1.11	3.28	2.73	7.08	7.29	11.28
	Overall mean		1.10	2.85	2.38	6.25	6.44	8.00
	l.s.d. (p<.05) species		0.09	0.17	0.25	0.72	0.68	2.13
	l.s.d. (p<.05) provenances within species		0.17	0.38	0.04	0.67	0.34	2.80

A. aulacocarpa: Provenance differences were evident despite the fact that all provenances tested came from a limited geographic zone of Papua New Guinea. The best two provenances, i.e. Keru (17628) and Kapal (16981) were 35 - 40% more productive than the poorest provenance from Isago, Arimia River (16948).

A. auriculiformis: Significant differences were evident between provenances. There did not appear to be a clear pattern of the variation as provenance ranking overlapped between regions. Coen provenance from Queensland (16729) and Mibini provenance from Papua New Guinea (18102) were most outstanding for the species.

A. crassicarpa: Of the total six provenances compared, two from Papua New Guinea (Bimadebun Village, 16598 and Wipim-Oriomo, 17871) and one from Queensland (Claudie River, 17944) ranked in the top three. Sardine River provenance (16128) from Queensland was the poorest.

A. mangium: As for other *Acacia* species, there were mixed results in regard to ranking of the seven provenances from Queensland and Papua New Guinea. While two Papua New Guinea seedlots [Wipim (18056) and Oriomo (18088)] were the top two performers, their counterpart from Mai Kussa River (16592) was in the bottom group with a Queensland provenance from Cardwell (15357). Heathlands provenance (15681) in Cape York was the best for Queensland and ranked third for the species.

E. camaldulensis: Growth was very highly variable between the eight provenances from Queensland, the Northern Territory and Western Australia, with the tree volume ranging from 7.57 to 15.4 dm^3. All three Queensland provenances were growing well, especially Wrotham Park (14781) which was the most productive (producing 15.4 dm^3 volume per tree) not only for the species but also for the whole trial. Two provenances from the Northern Territory, viz. Katherine River (17635) and Victoria River (13941) and one from Western Australia, viz. Isdell River (14537) also grew well. The poorest performer was Lennard River (15051) from Western Australia, producing 7.57 dm^3 of tree volume.

E. tereticornis : Provenances from Queensland only were tested and there were marked differences between them. Mean volume per tree ranged from 6.13 dm^3 for Mareeba (14856) to 11.82 dm^3 for Helenvale (14212).

E. pellita : All the provenances tested grew slowly and variation between provenances was not as conspicuous as that observed for *E.camaldulensis* and *E. tereticornis*. The only provenance from Irian Jaya, Indonesia (17854) was comparable to the best of Queensland provenances, i.e. Coen (14339).

E. urophylla: All provenances grew well, with material from Flores, i.e. Mt Egon (14531), and provenances from Alor, i.e. Apui (17839) and Wai Wai (17840), recording similar growth rate (12.26 - 12.88 dm^3). The least productive provenance, i.e. Arnau, Wetar (17832), still recorded a creditable 9.8 dm^3 tree volume.

Discussion

The results show considerable differences in the growth rates between different species of *Acacia* and *Eucalyptus*. Differences between provenances within species were also evident despite the fact that the majority of provenances selected to represent the species were known to have given better-than-average growth in earlier field trials elsewhere. These differences could be detected as early as 6 months and continued on to 24 months after planting. The species can be separated into two groups; the first consisting of *E. camaldulensis, E. urophylla, E. tereticornis* and *A. mangium* and the second consisting of *A. crassicarpa, A. aulacocarpa, A. auriculiformis* and *E. pellita*. The differences between them were so great that all provenances of the species in the second group were below the overall mean.

While the good performance of *E. camaldulensis* and *E. urophylla* was not surprising, the poor performance of most *Acacia* species especially *A. crassicarpa* was unexpected. Trials involving these *Acacia* species in Thailand showed a considerably better growth performance of *A. crassicarpa* than *A. auriculiformis, A. aulacocarpa* and *A. mangium* (Pinyopusarerk 1989). *Acacia crassicarpa* has also been found to grow equally well, if not better, than *A. aulacocarpa* and *A. mangium* in southern China (Yang *et al.* 1989), Malaysia (Sim & Gan 1 991) and Vietnam (Le & Nguyen 1991). Seedlings were not inoculated in the nursery and it is possible that *A. crassicarpa* which was relatively new to the area had yet to associate itself with effective local micro-organisms.

In comparison with *E. camaldulensis* or *E. tereticornis, E. urophylla* is lesser known in Lao P.D.R. although it is one of the best eucalypts for planting in the seasonally dry tropics (Eldridge *et al.* 1993). The species has certainly shown great potential for plantation forestry in Lao P.D.R. judging from the most consistent and outstanding performance in the trial. Of the eight seedlots of *E. urophylla* planted, four were in the top 10 out of a total of 55 seedlots and another four in the top 20. In contrast, *E. pellita,* a closely related species to *E. urophylla,* was consistently the poorest of the four *Eucalyptus* species tested. *E. pellita* (Bupul-Muting provenance) has been reported to have a very low outcrossing rate, i.e. 0.44 (A. House 1995, pers. comm.) which is much lower than that of *E. camaldulensis* (0.96) (P. Butcher 1995, pers. comm.) and many other eucalypts (Eldridge *et al.* 1993). It is likely that plants derived from natural provenances of *E. pellita* have a high proportion, relative to other eucalypt species, of inbred trees which are slow growing. In this situation, use of seed from selected superior phenotypes in seed orchards or derived plantations of broad genetic base has the potential to substantially improve the productivity because the level of selfing will have been reduced (Sedgley & Griffin 1989).

Provenance variation was evident in most species. *Eucalyptus camaldulensis* and *E. tereticornis,* while growing well, appeared to be more variable than others. The differences between the best and the poorest seedlots were approximately 50% for both species. Within *E. camaldulensis* all three Queensland provenances grew well which complements the results obtained elsewhere in the tropics, e.g. India (Ghosh *et al.* 1977), Nigeria (Otegbeye 1985), Tanzania (Sabas & Nshubemuki 1988) and Thailand (Pinyopusarerk *et al.* 1995). Two out of three seedlots from Western Australia, Ord (14514) and Lennard Rivers (15051), were less productive. The remarkable performance of Wrotham Park provenance (14781) is noteworthy. Not only was it the most productive provenance for *E. camaldulensis* but it was also the best for the whole trial. The second best seedlot in the trial, *E. camaldulensis* from Normanton, Queensland (13694), produced 16% less wood volume per tree than Wrotham Park. It should be noted, however, that Wrotham Park provenance was represented by only one tree which could incidentally be an elite parent.

Large provenance variation in the growth of *E. tereticornis* has been reported and the top two seedlots for the species here, Helenvale (14212) and Kennedy River (14802), have also been found to perform well in many early trials (Martin 1978, Davidson & Das 1985, Otegbeye 1990). There was no clear pattern of geographic variation although Helenvale and Kennedy River came from more northerly latitudes. Kennedy River provenance of *E. tereticornis* is now recognised as *E. camaldulensis* because of their camaldulensis-like floral bud traits and seed and progeny morphology (Doran & Burgess 1993).

Provenances from Papua New Guinea are generally more vigorous than provenances from Queensland or Northern Territory for a number of *Acacia* species including *A. auriculiformis, A. crassicarpa* and *A. mangium* (Chittachumnonk & Sirilak 1991, Harwood *et al.* 1991, Harwood & Williams 1992). While it is also true for the trial reported here, some Queensland provenances were comparable to Papua New Guinea provenances. The reason for this is that most of the provenances selected to represent the species were based on knowledge and past experience with these species and the very poorly-performing Queensland provenances were not included.

The field design used for this trial in Lao P.D.R. allows it to last up to 3 - 4 years duration, by which time, however, the suitability of species and provenances can be judged. The range of provenances included ensures that no species which does have potential will be discarded. Foliar fungi have recently been observed on some species in the trial (S. Midgley 1995, pers. comm.). Future assessments should, therefore, include state of health in addition to growth traits.

Conclusions

The present results, although preliminary, are of considerable importance as they have demonstrated the species that have potential for planting in Lao P.D.R. in regions of similar conditions to the test site. The species showing most promise at this stage are *E. camaldulensis, E. tereticornis, E. urophylla* and *A. mangium.* The early ranking of provenances for each species was consistent with longer-term results elsewhere with Queensland provenances of *E. camaldulensis* and *E. tereticornis,* Flores and Alor Island sources of *E. urophylla,* and Papua New Guinea and Cape York provenances of *A. mangium* showing most promise. It would be prudent to test wider range of provenances of the most attractive species on sites where large scale plantations are planned. Any future studies would desirably include yield estimation involving more sites, larger plots and alternative management regimes.

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