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Three-year Performance of *Acacia auriculiformis* Provenances at Serdang, Malaysia

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ABSTRAK

Satu percubaan yang melibatkan 28 provenans Acacia auriculiformis *A. Cunn. ex Benth. diukur kemandirian dan pertumbuhan pada umur 6, 12, 18, 24 dan 36 bulan. Dari kesemua provenans ini, 7 berasal dari Queensland utara dan 15 dari Northern Territory, Australia, serta 6 dari Papua New Guinea. Kesemua provenans menunjuk kemandirian baik (>66%), tetapi mereka berbeza dengan bererti ($p < 0.01$) dari segi pertumbuhan selepas berumur melebihi 6 bulan. Separuh daripada jumlah provenans mempunyai lebih dari 50% pokok yang berbatang satu. Provenans dari Queensland pada amnya tumbuh lebih cepat daripada provenans dari Northern Territory dan Papua New Guinea. Untuk pengeluaran kayu, 4 provenans dari Queensland (Archer River, Coen River, Wenlock River dan Kings Plain), 3 dari Northern Territory (Noogoo Swamp, Douglas River dan E. Alligator River), dan satu dari Papua New Guinea (Old Tonda Village) dikenalpasti berpotensi baik.*

ABSTRACT

A trial consisting of 28 provenances of Acacia auriculiformis *A. Cunn. ex Benth. was measured for survival and growth at 6, 12, 18, 24 and 36 months. Tree form was also assessed at 18 months. Of the provenances, 7 were from northern Queensland and 15 from Northern Territory, Australia, and 6 from Papua New Guinea. All provenances survived well (> 66%) but they differed significantly ($p < 0.01$) in their growth performance after 6 months. Half of the provenances tested had more than 50% of their trees with single stems. Queensland provenances generally grew faster than those from Northern Territory and Papua New Guinea. For timber production, four Queensland provenances (Archer River, Coen River, Wenlock River and Kings Plain), three Northern Territory provenances (Noogoo Swamp, Douglas River and E. Alligator River), and a Papua New Guinean provenance (Old Tonda Village) were identified as promising.*

INTRODUCTION

Acacia auriculiformis A. Cunn. ex Benth., native to Australia, Papua New Guinea and Indonesia, is a tree that grows fast, fixes nitrogen, and adapts to a wide range of environmental conditions. It is suitable for rehabilitating difficult sites such as tin tailings (Mitchell 1957), sand dunes (Mitchell 1963), *Imperata cylindrica* grassland (Voogd 1948), eroded land (Ali 1986), wasteland (Jha 1987) and overburden mining areas (Prasad and Chadhar 1987). It grows well on acidic (Turnbull 1989), alkaline (Basappa 1983), or saline soils (Midgley *et al.* 1986), and in areas polluted by industrial gases (Agrawal *et al.* 1986; Kong 1988).

Since its introduction to Peninsular Malaysia in 1931 (Barnard and Beveridge 1957), *A. auriculiformis* has been commonly planted as an ornamental tree in parks, gardens, or along roadsides. However, it possesses wood properties which make it suitable for a wide range of uses, such as fuelwood (Brewbaker *et al.* 1983), plywood (Patanaprapapan 1980), carving (Rajan *et al.* 1979), flooring and furniture (Chomcharn *et al.* 1986), and pulp and paper (Logan 1981; Ku and Chen 1984). It is, therefore, a potential industrial species. But, the heavy branching and crooked stems commonly exhibited are often major drawbacks, which restrict its wider planting. These characteristics could be under genetic control, perhaps perpetuated from a narrow genetic base of the earlier introductions. However, there has been only limited work on improving this species in Malaysia (e.g. Zakaria Ibrahim 1991; Sim 1992).

In 1987, the Forestry/Fuelwood Research and Development (F/FRED) Project of Winrock International and the Australian Tree Seed Centre of Commonwealth Scientific and Industrial Research Organisation (CSIRO) jointly funded a range-wide seed collection of *A. auriculiformis* provenances in Papua New Guinea and northern Australia (Gunn *et al.* 1987). Following this, the F/FRED Project further collaborated with the Australian Centre for International Agricultural Research (ACIAR) to evaluate the provenances by establishing multilocational trials in 1989. The trials were established in Zimbabwe and seven other countries in Asia including Malaysia. This paper reports on the survival and growth up to 36 months of the trial established at Universiti Pertanian Malaysia (UPM), Serdang.

MATERIALS AND METHODS

Seedling Establishment

This trial used twenty-eight seedlots of *A. auriculiformis* provided by the Australian Tree Seed Centre (ATSC). The seeds were collected from three geographic regions of the species' natural distribution; viz. northern Queensland, Northern Territory, Australia, and Papua New Guinea. Table 1 provides details of the seed origins.

TABLE 1
Details of the 28 provenances of *Acacia auriculiformis*

No.	CSIRO seedlot No.	Provenance		Lat. (°'S)	Long. (°'E)	Alt. (m)	No. parents
1	15483	Archer River	QLD	12 26	142 57	100	5
2	15697	South Coen	QLD	14 7	143 16	160	10
3	15985	Mt Molloy,	QLD	16 41	145 17	380	10
4	16142	Coen River	QLD	13 53	143 3	170	7
5	16145	Wenlock River	QLD	13 6	142 56	130	20
6	16484	Morehead River	QLD	15 3	143 40	50	6
7	16485	Kings Plain	QLD	15 42	145 6	150	7
8	16147	Noogoo Swamp	NT	12 23	131 0	28	5
9	16148	Manton River	NT	12 50	131 7	100	10
10	16149	Douglas River	NT	13 51	131 9	70	10
11	16151	Mary River	NT	13 56	132 8	120	8
12	16152	East Alligator River	NT	12 17	132 55	10	10
13	16153	Cooper Creek	NT	12 6	133 11	40	5
14	16154	Goomadeer River	NT	12 8	133 41	50	9
15	16155	Mann River	NT	12 22	134 8	60	4
16	16156	Yarunga Creek	NT	12 18	134 48	50	6
17	16158	Gerowie Creek	NT	13 19	132 15	100	12
18	16160	South Alligator River	NT	13 16	132 19	100	10
19	16161	Howard Springs	NT	12 27	131 3	70	12

TABLE 1 (continued)

No.	CSIRO seedlot No.	Provenance		Lat. (°'S)	Long. (°'E)	Alt. (m)	No. parents
20	16162	Reynolds River	NT	13 32	130 52	150	10
21	16163	Elizabeth River	NT	12 36	131 4	40	9
22	16187	Melville Island	NT	11 55	130 50	1	7
23	16101	North Bensbach	PNG	8 50	141 15	20	16
24	16103	South Balamuk	PNG	9 0	141 15	10	7
25	16105	Balamuk	PNG	8 55	141 17	20	12
26	16106	North Mibini	PNG	8 49	141 38	40	35
27	16107	Old Tonda Village	PNG	8 55	141 33	40	19
28	16108	Mari Village	PNG	9 11	141 42	5	8

QLD - Queensland NT - Northern Territory
PNG - Papua New Guinea

Nursery establishment followed the guidelines provided in the manual for field operation (Boland and Pinyopusarerk 1988). The seeds were pretreated by soaking in hot water at 80°C for 30 sec and then in water at room temperature for 10 min. The procedure was repeated three times. The seeds were then air dried and sown in containers filled with washed river sand, and later transplanted into polythene bags. Inoculation with Rhizobium was not made in the nursery. The seedlings were about four months old when they were planted out.

Field Establishment

Field trial was established in January 1990 at the UPM Farm, Serdang (latitude 03°02'N, longitude 101° 42'E, altitude 32 m) representing a humid site which was under *Imperata cylindrica* grass. Mean annual rainfall is 2141 mm and mean annual temperature 26°C. The site experiences an average windspeed of 0.86m/sec., receiving a daily average of 5.8 hr of sunshine and an annual evaporation of 1527mm. The soil is fine-loamy, mixed, Typic Hapludults, isohyperthermic and udic, with a pH of 4.4. The site was fully cultivated before planting.

A randomised complete block design with six replicates was used. Each replicated plot consisted of 16 trees (4 x 4) spaced at 3m x 3m. Two buffer rows were planted surrounding the trial to minimise edge effects. The plots were weeded every three months during the first year, and less frequently thereafter. At 19 months, a light grass fire burned through the plots. An assessment indicated that the damage was slight, and all provenances were similarly affected (Nor Aini 1993).

Assessment and Analysis

Measurements of height, basal diameter at 10 cm above ground (BD), diameter at breast height (Dbh) and survival were made on all trees at 6, 12, 18, 24 and 36 months after planting. Geometric mean Dbh (square root of the sum of the squares of each individual stem diameter) was used for multi-stemmed trees. At 18 months, trees were also individually assessed for form, following three classes;

Class 1: Tree with one main leading stem up to the tip. Branches are small, having basal diameter less than 50% of the principal bole at the same height.

Class 2: Tree with more than one leading stem originating at a height above 50 cm from the ground. The branching bole is considered a stem if its basal diameter is equal to or greater than 50% of the diameter of the principal bole at the same height.

Class 3: Tree with more than one leading stem originating below a height of 50 cm from the ground. What is considered as branching bole in Class 2 also applies here.

The data at each age were analysed for variance among the provenances, between provenance regions, and among provenances within each region. Provenance means at 36 months were compared using standard error. MPTStat, a statistical package developed by F/FRED, was used for the analyses.

RESULTS

All the provenances survived very well initially, with percentage ranging 92-100% up to 18 months. The level of survival dropped by about 2 to 30% at 24 months following the fire. However, the differences recorded among the provenances at different ages were not significant (Table 2). But significant differences ($p < 0.001$) in survival were detected among the Papua New Guinea provenances up to 18 months, and between the provenance regions ($p<0.05$) after 18 months. At 36 months, the Queensland provenances had the highest survival and Northern Territory provenances the lowest (Table 3). Except for two provenances from Northern Territory (Elizabeth River and Melville Island), the provenances still recorded above 70% survival at this age (Table 4).

TABLE 2
Mean sums of squares for various characters

Source of variation	df	6 months	12 months	18 months	24 months	36 months
		Height (m)				
Replication	5	0.239	1.181	3.351	6.031	8.762
Provenances	27	0.128*	0.531**	1.291**	3.240**	6.285**
Geographic Regions	2	0.165	1.130**	2.811***	7.003***	16.126***
Queensland	6	0.092	0.375	1.051*	3.185***	5.651***
Northern Territory	14	0.158**	0.459*	1.098**	2.610***	4.046**
Papua New Guinea	5	0.071	0.696**	1.512**	3.565***	9.381***
Error	135	0.067	0.189	0.390	0.663	1.356
		Diameter at Breast Height (cm)				
Replication	5	0.158	1.302	2.408	3.098	4.492
Provenances	27	0.773	0.921**	2.619***	4.905***	7.005***
Geographic Regions	2	0.021	2.437***	5.491***	12.578***	18.614***
Queensland	6	0.050	0.727*	2.594***	5.921**	8.170***
Northern Terittory	14	0.111*	0.719**	2.069***	3.612**	4.212**
Papua New Guinea	5	0.040	1.114***	3.038***	4.237***	8.782***
Error	135	0.054	0.249	0.462	0.827	1.157
		Basal Diameter (cm)				
Replication	5	0.576	1.523	3.369	3.965	3.750
Provenances	27	0.499**	1.615**	4.325***	6.524***	11.828***
Geogaphic Regions	2	0.919**	1.969**	4.306***	9.080***	17.195***
Queensland	6	0.209	1.233**	3.768***	6.522***	12.433***
Northern Territory	14	0.572**	1.516	3.805***	5.440***	8.682**
Papua New Guinea	5	0.471**	2.207***	6.453***	8.591***	17.767***
Error	135	0.148	0.396	0.752	1.144	1.761
		Survival (%)				
Replication	5	26.5	52.5	39.3	1622.2	1349.6
Provenances	27	14.1	20.1	24.5	486.6	507.8
Geographic Regions	2	12.2	22.5	20.7	1392.7*	1426.4*
Queensland	6	6.2	8.9	13.4	515.4	505.5
Northern Territory	14	10.1	7.2	9.8	385.1	401.9
Papua New Guinea	5	36.3**	68.1***	80.6***	373.6	439.6
Error	135	11.3	14.0	16.1	398.5	374.5

Significance level: *$p < 0.05$ **$p < 0.01$ ***$p < 0.001$

TABLE 3
Performance of *A. auriculiformis* provenances by geographic regions

Geographic Region	6 months	12 months	18 months	24 months	36 months
			Height (m)		
Queensland	1.5	3.3	4.8	6.9	9.5
Northern Territory	1.4	3.2	4.5	6.5	8.6
Papua New Guinea	1.4	3.0	4.3	6.1	8.2
			Diameter at Breast Height (cm)		
Queensland	0.6	2.4	4.2	6.5	8.4
Northern Territory	0.6	2.1	3.7	5.8	7.5
Papua New Guinea	0.6	1.9	3.4	5.5	7.1
			Basal Diameter (cm)		
Queensland	2.0	4.0	6.2	9.0	11.8
Northern Territory	0.6	2.1	3.7	5.8	7.5
Papua New Guinea	0.6	1.9	3.4	5.5	7.1
			Survival (%)		
Queensland	99	98	98	90	90
Northern Territory	99	99	98	80	80
Papua New Guinea	98	97	97	85	84

TABLE 4
Performance of *A. auriculiformis* provenances at 36 months

Provenance	Height (m)	Dbh (cm)	Basal diameter (cm)	Survival (%)	C.Rank
Archer River,QLD	10.0	9.2	13.2	97	1
South Coen, QLD	9.4	7.8	11.4	93	11
Mt Molloy, QLD	7.6	6.2	8.9	72	27
Coen River, QLD	10.1	9.3	12.7	85	3
Wenlock River, QLD	8.9	8.6	11.9	92	8
Morehead River, QLD	10.4	8.5	11.6	97	4
Kings Plain, QLD	9.8	9.6	12.9	95	2
Noogoo Swamp, NT	9.1	8.9	12.7	96	5
Manton River, NT	7.6	8.2	11.7	82	15
Douglas River, NT	9.9	8.4	12.2	85	6
Mary River, NT	8.7	7.2	10.2	88	17
East Alligator River, NT	9.7	8.4	12.0	83	8
Cooper Creek, NT	9.1	7.9	11.4	77	15
Goomadeer River, NT	8.6	6.8	10.2	80	21
Mann River, NT	7.5	6.5	8.9	89	23
Yarunga Creek, NT	8.3	7.3	10.9	77	19
Gerowie, NT	9.0	8.2	11.7	80	13
South Alligator River, NT	7.8	6.9	9.8	85	20
Howard Springs, NT	9.9	8.1	11.5	75	12
Reynolds, NT	7.7	6.2	9.0	72	25
Elizabeth River,NT	7.9	6.6	9.3	66	24
Melville Island, NT	8.5	7.3	10.5	67	22
North Bensback, PNG	9.3	8.2	12.5	88	7

TABLE 4 (continued)

Provenance	Height (m)	Dbh (cm)	Basal diameter (m)	Survival (%)	C.Rank
South Balamuk, PNG	6.6	5.6	8.8	77	28
Balamuk, PNG	6.6	5.7	8.6	85	26
North Mibini, PNG	8.6	8.2	12.4	77	14
Old Tonda Village, PNG	9.2	7.8	11.2	99	10
Mari Village, PNG	8.9	7.3	10.6	81	18
Mean	8.7	7.7	8.7	83	
SE (±)	0.48	0.44	0.54	7.9	
CV (%)	13.3	14.1	12.1	23	

C. Rank = Composite ranking (Mean of ranks of ht, Dbh, basal diameter and survival)

The provenances, however, showed significant differences in their growth performance after 6 months (Table 2). Significant differences were detected between the provenance regions and among provenances within each region. Queensland provenances consistently outgrew those from the other two regions (Table 3). Five (Archer River, Coen River, Wenlock River, Morehead River, and Kings Plain) of the seven provenances tested from Queensland were among the top ten performers (Table 4). Although differences between provenances of Northern Territory and Papua New Guinea were small, those from Northern Territory appeared to have produced a greater volume of wood (Table 3). Three provenances (Noogoo Swamp, Douglas River, and E. Alligator River) from Northern Territory, and two (N. Bensbach and Old Tonda Village) from Papua New Guinea emerged as among the top ten performers. Based on composite ranking (mean of the ranks of survival, height, Dbh and BD), the ten best provenances in decreasing order were; Archer River, QLD, Kings Plain, QLD, Coen River, QLD, Morehead River, QLD, Noogoo Swamp, NT, Douglas River, NT, N. Bensbach, PNG, Wenlock River, QLD, E. Alligator River, NT, and Old Tonda Village, PNG (Table 4).

Tree form also differed markedly among the provenances (Table 5). Single stemmed trees (Class 1) and those branching above 50 cm (Class 2) were the most prominent. Fourteen of the provenances had over 50% of their trees in Class 1, and nine provenances had similar percentages in Class 2. Out of these fourteen provenances in Class 1, four (Archer River, Coen River, Wenlock River, Kings Plain) were from Queensland, eight (Noogoo Swamp, Manton River, Douglas River, Mary River, E. Alligator River, Cooper Creek, Mann River, and Melville Island) were from Northern Territory, and the other two (Balamuk and Old Tonda Village) were from Papua New Guinea. All the four provenances from Queensland, three from Northern Territory (Noogoo Swamp, Douglas River, and E. Alligator River), and one from Papua New Guinea (Old Tonda Village) were also among the top ten growth performers. Among the top ten provenances which had over 50% of their trees in Class 2 were Morehead River from Queensland and North Bensbach from Papua New Guinea.

TABLE 5
Percentage of trees according to tree from classes of various provenances

Provenance	Class 1	Class 2	Class 3
Archer River, QLD	60	40	0
South Coen, QLD	42	56	2
Mt Molloy, QLD	29	66	5
Coen River, QLD	56	36	8
Wenlock River, QLD	53	45	2
Morehead River, QLD	41	59	0
Kings Plain, QLD	68	29	3
Noogoo Swamp, NT	59	40	1
Manton River,NT	71	26	4
Douglas River, NT	67	33	0
Mary River, NT	51	48	1
East Alligator River, NT	72	26	1
Cooper Creek, NT	61	38	1
Goomadeer River, NT	32	58	10

TABLE 5 (continued)

Provenance	Class1	Class 2	Class 3
Mann River, NT	52	48	0
Yarunga Creek, NT	44	49	6
Gerowie, NT	42	49	9
South Alligator River, NT	39	55	6
Howard Springs, NT	33	56	11
Reynolds, NT	45	44	11
Elizabeth River, NT	30	63	7
Melville Island, NT	56	41	3
N. Bensback, PNG	43	53	4
South BAlamuk PNG	39	55	6
Balamuk, PNG	51	45	4
North Mibini, PNG	44	27	12
Old Tonda Village, PNG	54	36	11
Mari Village, PNG	43	49	8

Among the traits analysed at 36 months, BD was the least variable and survival was the most variable having coefficients of variation of 12% and 23% respectively. Fire partly contributed to the latter.

DISCUSSION

The results indicate that all provenances survived well with percentage ranging from 66 to 99%. But they differed markedly in their growth in terms of height, BD, Dbh, and tree form. These differences were associated with both inter- and intra-variations from the three main provenance regions; northern Queensland, Northern Territory and Papua New Guinea. Similar variations were reported for the same provenance trials at Sai Thong and Sakaerat in Thailand (Luangviriyasaeng *et al.* 1991).

Although the trial is only 36 months, the results provide sufficient basis for making a selection of the better provenances. The Queensland provenances are prime candidates because of the generally faster growth rates. However, based on composite ranking and straight tree form, eight provenances from within the three regions could be selected for further planting. They are four from Queenland (Archer River, Coen River, Wenlock River and Kings Plain), three from Northern Territory (Noogoo Swamp, Douglas River and E. Alligator River) and one from Papua New Guinea (Old Tonda Village). They would provide for genetic diversity and are particularly suited for timber production. Their growth rates are comparable to those reported for *A. mangium*, a species widely planted in Malaysia (Johari Baharudin and Chew 1987; Sim and Gan 1991).

However, if the species were to be planted for other purposes, such as fuelwood production, rehabilitation of degraded land, or ornamental planting, a different ideotype would have to be selected. Provenances with a combination of fast growth and Class 2 or 3 tree form would be a better choice. The results indicate that the Morehead River provenance from Queensland, and the North Bensbach provenance from Papua New Guinea have these combined traits.

The provenances evaluated in this trial have been reported to exhibit strong genotype x environment interaction effect (Luangviriyasaeng *et al.* 1991; Kamis Awang *et al.* in press). That is, the performance of a particular provenance with respect to the others is not the same across sites. Therefore, planting of the provenances recommended here should be restricted to the sites similar to the trial site. It also implies that further testing of selected promising provenances on other sites with different environmental conditions is needed.

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