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PROVENANCE TRIAL IN ACACIA

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ABSTRACT

The tropical acacias from Australia and Papua New Guinea are introduced to other tropical countries since early 1900s to afforest highly degraded, lateritic and infertile soils. Early introductions with very low genetic base led to severe inbreeding depression. Proper attention was also not given to introduce the appropriate seed sources. Such lapses led to stunted growth, poor tree form and susceptibility to diseases.

In this context, a research project was initiated to select the best species/provenances suited for Kerala with respect to growth and other characters. Provenance trial was conducted in three species of Acacia namely, *A.aulacocarpa. A.crassicarpa and A.mangium* with 8, 5 and 9 provenances respectively, all from Papua New Guinea. The growth of the provenances was monitored up to 12 months. The study showed that there were significant differences between provenances for growth in A. *aulacocarpa* and *A. mangium* but not in *A. crassicarpa* The genetic variations and heritability status for height and girth are found to be moderate to high in *A. aulacocarpa* and, a high genetic gain is expected by selecting the best provenance. In *A. mangium* genetic variations were moderate with low heritability and by selecting the best provenance, moderate genetic gain is expected. In *A.aulacocarpa* the best performers were Bensbach and Arufi whereas in *A. mangium* the best provenances were Bensbach. Wipim and Guram.

A species-cum-seed source trial also was conducted to select the best species/seed source for growth and other characters. Four species namely, *A. aulacocarpa. A. auriculiformis, A. crassicarpa* and *A. mangium* each with one provenance and a seed orchard source (improved seeds). were tested. The seedlings were monitored up to 20 months. The study showed that there were highly significant differences between species with respect to height, girth and number of branches. But within species there were no significant differences between seed sources with respect to these three characters. With regard to growth *A. auriculiformis* excelled others. especially the provenance Oriomo from Papua New Guinea. *A. mangium* had the least number of branches which is a desirable character and for this character provenance Oriomo was the best performer. The natural or artificial hybrids between these two species are reported to be highly promising and expressing hybrid vigour. Hence, hybrid production followed by selection for the best characters can be opted for genetically improving the growth and other characters. The best seed sources should be used for hybridization to exploit the maximum gain.

1. INTRODUCTION

The tropical acacias, native of eastern Indonesia. Papua New Guinea and northern Australia are introduced to other tropical countries since early 1900s. These species are reported to tolerate a wide variety of infertile sites including clayey soils with impeded drainage. highly degraded lateritic soil and mined lands and hence planted widely to afforest these types of sites.

Early introductions of acacias to other tropical countries showed severe inbreeding depression due to very low genetic base. *Acacia mangium* was introduced to Sabah, Malaysia in 1967 using a single tree collection from Mission Beach, Queensland. Thereafter many hectares of plantations were established in Sabah using the seeds from those single tree progenies. Generation after generation, the growth was diminished. indicating the inbreeding depression caused by the extremely low genetic base. In 1981, the need for a wider genetic base was felt strongly and new planting materials were brought from Queeensland (QLD), Papua New Guinea (PNG) and lndonesia to Malaysia. In Kerala also the genetic base is very narrow for *A.mangium* because most of the planting materials originated from the collections of the Bishop Palace compound , Trivandrum.

While more than 700 species are there for Acacia in Australia alone, the number of species tested is limited. However, *A. aulacocarpa. A. auriculiformis. A. crassicarpa* and *A. mangium* are the most widely tested species in other tropical countries. High potential of PNG provenances of *A. crassicarpa* and *A. mangium* and good potential of selected PNG and Queensland provenances of A.auriculiformis in terms of productivity were recognised widely (Otsamo *et al,* 1996). *A. aulacocarpa* was preferred for sawn timber production.

A. aulacocarpa is characterized as a hardy fast growing tree capable of tolerating a wide variety of infertile sites in the humid and sub-humid tropics. The wood is attractive for furniture and cabinet making and is a good fuel but frequently with fluted bole (Turnbull *et al.* 1986). It occurs in sub-coastal northern and north-eastern Australia and southern Papua New Guinea between 6^{o} and 31^{o} S latitude and from near sea level to 950 m altitude (Thomson. 1994). There are 5 subspecies of *A. aulacocarpa* and the one that is found in Papua New Guinea and lrian Jaya is subspecies B. This subspecies grows up to 15-40 m height. typically single boled and 30-110 cm dbh at maturity, with narrow crown and vertically branching to spreading depending on habitat. It is reported to be adapted to acidic and strongly acidic (pH 3.5-6) soils of varying fertility. Heartwood is reddish brown.

hard. heavy (600-800 kg/m^3) moderately durable and tough. It is suitable for a wide range of sawn timber end-uses including decorative purposes.

A.auriculiformis has been introduced and grown in several parts of Asia for fuelwood. afforestation as well as an ornamental tree. It is known to be adaptive to a wide range of soils, degraded infertile soils and environmental conditions (Pinyopusarerk. 1990). *A.auriculiformis* from PNG exhibited excellent pulpwood potential, at least as good as some of the commercially accepted high quality eucalypts (Logan. 19871. It was reported to be highly suitable for pulp and paper, plywood and medium density fibreboard. However, this species is well known for its very poor form and high occurrence of forking in the lower part.

Acacia crassicarpa is a fast growing tree coming up on a wide variety of soils including deep siliceous sand and clay with impeded drainage. It is generally seen in between 8^0 and 20^o S latitude and between sea level and 450 m altitude. It tolerates fire. salt-laden winds, weed competition and low soil fertility (Turnbull et *al.*. 19861. It tolerates poorer site conditions than *A. mangium* and *A. aulacocarpa* (Turnbull, 1982). It is reported to be adapted to acidic and strongly acidic infertile sandy podzolics. Rapid growth rate, ability to suppress weed growth and the abundant Rhizobium nodulation give *A. crassicarpa* outstanding potential for soil improvement and land rehabilitation for a wide range of degraded sites in the sub-humid and humid tropics. Its sapwood is susceptible to rapid fungal decay in moist environments and attack by *Lyctus* borers. The heartwood is pinkish or deep reddish brown. attractively marked, hard, moderately durable and tough. It is suitable for a very wide range of sawn timber end-uses. including light structural and decorative purposes (Thomson, 1994). The stem form of *A. crassicarpa* is considered acceptable although it has a propensity to bend at the nodes and have larger branches than *A. auriculiformis* and *A. aulacocarpa* (Turnbull, 1988)

A.mangium also has been introduced to many tropical countries to rehabilitate degraded lands and also for pulp. It prefers slightly higher drier sites. Experience in China shows that this species grows slowly when the mean monthly temperature is below 17^oC and grows faster when the temperature is more than 20^o C (Zhigang and Minquan, 1987). It possesses a fairly good form with a well defined, relatively straight bole and good crown to clear bole ratio. But it has also some unfavourable traits such as large branches and fluted stem. It is well suited for pulp and paper. plywood and medium density fibre board. However, pulpwood productivity is higher in *A. auriculiformis* (234-305 kg/m3) than *A. mangium* (179 – 268 kg/m3)(Clark *et al,* 19911.

The wide ecological and geographic ranges of some of the acacias should have led to marked genetic variations. In *A. aulacocarpa.* Keru provenance from PNG was

growing 4 to 6 times the rate on wood volume basis than North Queensland provenances (Turnbull, 1988)when they were tested.

in Thailand. Likewise. the two and a half years growth of provenance Wipim (PNG) of *A. mangium* was reported to be 70-80% greater than that of the provenance Subanjeriji (Indonesia). when they were tested at South Kalimantan. Indonesia (Turvey. 1996). Differences of this magnitude indicates the absolute necessity of provenance testing before establishing large scale plantations.

Performance of different species and provenances of acacia in various tropical and sub-tropical countries was reported by scientists and foresters. But on analysis of these reports. it can be seen that the ranking of provenances and species, with respect to growth, changes from experimental site to site. The performance of species, provenance and even improved seeds differ depending upon the sites. seed sources as well as interaction. Hence, to select the species or provenances suitable for Kerala. it is better to field test the sources here itself. Hence. this project was initiated with the objective of selecting the best species/provenances of acacias for growth and other morphological characters.

2. MATERIALS AND METHODS

Two separate experiments were conducted to study the performance of different species and provenances. First experiment was a provenance trial where. various provenances of three different species were tested for their growth performance. while the second one was a species-cum-seed source trial where, one of the good provenances was compared with a seed orchard source in each of the four acacia species.

a) ***Provenance trial (Experiment No.1)***

The first experiment was conducted using various provenances of *A.aulacocarpa*, *A.crassicarpa* and *A.mangium* received from the Forest Research Institute. Lae. Papua New Guinea. The details of these provenances and their origin are given in Table 1. All the provenances were from Papua New Guinea. Separate trial was conducted for each of the three species. Each trial was carried out in a randomized complete block design with 3 blocks and several provenances. *A.aulacocarpa* had 8 provenances. *A.crassicarpa* 5 and *A.mangium* 9 provenances.

The seeds were pretreated by immersing in boiling water for one minute and then soaking in water for overnight. They were sown in raised nursery beds . When the seedlings were 3 months old they were polypotted. In the nursery measurements were taken on the seedling height when they were 6 and 9 months old and girth at 12 cm height above ground at 9 months.

When the seedlings were 9 months old they were transplanted to field at Palappilly Field Research station of KFRI. The latitude and longitude of the experimental site are l0º26 N and 76º24'E respectively. The area is at an altitude of 40 m which receives an annual rain fall of 3000 mm. In each block the number of plants per provenance was 16 for *A.aulacocarpa* and 7 for *A. crassicarpa* A spacing of 3 m was given between plants. In *A.aulacocarpa* the field trial extended to an area of 1.25 ha with a total of 384 experimental plants (8 provenances x 3 blocks x 16 plants) and 290 border plants. In *A. crassicarpa*, a total of 105 experimental plants (5 provenances x 3 blocks x 7 plants) along with its border plants occupied an area of 0.25 ha. In *A. mangium* some of the provenances had only few seedlings while in others more number of seedlings were available for planting. Hence. number of seedlings planted in each block was unequal which varied from 5 to 15 per provenance. In this species a total of 0.3 ha was occupied by 210 experimental plants and its border plants. When the seedlings were 12 months old. height and girth at 12 cm above ground were taken.

Table 1. Materials used for provenance trial in Acacia spp.

Seed lot No.	Locality of provenance	Latitude (S)	Longitude (N)	Altitude (m)
Acacia aulacocarpa				
16947	Makapa	7°56'	142°35'	15
16946	Balimo	8°05'	142°58'	12
16996	Bimadebum	8°38'	142°03'	40
16949	Duaba	8°13'	142°58'	25
16950	Wasau	8°17'	142°52'	10
16998	Oriomo	8°53'	142°52'	10
17551	Bensbach	8°53'	141°17'	25
16995	Arufi	8°43'	141°55'	25
A. crassicarpa				
05	Buisio	7°11'	146°39'	700-2000
16956	Oriomo	8°49	143°06'	10
16552	Bensbach	8°53	141°17'	25
16948	Isago Arimu	8°01'	142°42'	10
16977	Wipim	8°49	142°48	45
A. mangium				
16994	Arufi	8°43	141°55'	24
16971	Wipim	8°48'	142°48'	45
17550	Bensbach	8°53'	141°17'	25
16991	Guram	8°37'	141°54'	25
16938	Kini	8°05	142°58'	12
16690	Deri Deri	8°40	141°50'	30
207	Oriomo	8°52'	143°08'	20
209	lokwa	4°25	144°49'	25
210	Balamuk	4°25'	144°49'	25

The statistical analysis was done separately for each species with respect to mean height and mean girth since the aim of the project was to select the best provenances of each species. Since the number of plants survived per block was

unequal. mean height and girth for each provenance per block were estimated and used for the analysis. As the analysis showed significant differences between provenances in two species for growth. cluster analyses were done to group similar provenances with respect to height and girth in such species. Clustering was done using Non hierarchical Euclidean' algorithm. After grouping, the clusters were ranked as best, moderate and poor based on their mean height and girth.

From the ANOVA table. the derived variance components were used to estimate the phenotypic and genotypic coefficients of variation (PCV and GCV), provenance heritability (H^2) and genetic gain or genetic advance (GA) to understand the amount of phenotypic and genotypic variations present among the provenances, how the characters would be inherited and also to estimate the extent of gain expected if we select at 5% level.

b) ***Species-cum-seed source trial (Experiment N0.2)***

The species-cum-seed source. trial comprised of four species namely. A.aulacocarpa, A.auriculiformis. A.crassicarpa and A.mangium For each species seeds from two sources mere included in the trial viz.. a good provenance and a seed orchard. Hence. a total of 8 seed sources (4 species x 2 seed sources) received from Australian Tree Seed Centre, Australia were tested for growth and other characters. The details of the seed sources are given in Table 2.

Table 2. Materials used for the species-cum-seed source trial

Seed lot No.	Name of provenance	Latitude	Longitude	Altitude (m)
A. aulacocarpa				
17629	Gameve W.P.. PNG	8°58	142°53'	20
19301	PNG prov. Seed orchard, Fiji	18°00'	178°00'	Sea level
A. auriculiformis				
19267	Oriomo. PNG	8°50	143°05 '	10
19305	N.QLD prov.Seed orchard Fiji	18°00'	178°00'	Sea level
A. crassicarpa				
19304	PNG Prov.seed orchard, Fiji	18° 00'	178° 00'	Sea level
19389	Wipim. Oriomo area.Wp. PNG	8°49	142° 54'	45
A. mangium				
19286	Seed orchard, QLD	18°16'	146° 02'	80
19387	Oriomo RWP. PNG	8°50	143° 05'	10

The number of seeds present in 10 g of each seed lot was estimated for all the seed sources. The seeds were sown in nursery beds in a randomized block design with 3 replications as a species-cum-seed source trial. The germination percentage was estimated after 2 months in the nursery. The seedlings were field planted at Nilambur in a randomized complete block design with three blocks in an area of 0.7 ha. The latitude and longitude of the experimental site are 11^0 N and 76^0 E respectively. The area is at an altitude of 36 m which receives an annual rain fall of 2600mm. In each block 40 seedlings per provenance were planted. At the age of 20 months, the seedlings were measured for height and girth at 12cm above ground. The number of branches were also counted. Nested analysis was out separately for each character.

3. RESULTS AND DISCUSSION

a) Provenance trial (Experiment No. 1)

The mean performance of the provenances of the three species of Acacia namely. *A.aulacocarpa. A.crassicarpa* and *A.mangium* at different ages is given in Table 3. It can be seen that in general, *A.mangium* is performing better compared to other two species. Provenances within species also differ from each other with respect to growth [Table 3 and Plate

Table 3. Mean performance of Acacia provenances at different ages

No.	Provenance	Height (cm)			Girth (cm)	
		6 months	9 months	12 months	9 months	12 months
A. Aulacocarpa						
1	Makapa	12.17	18.87	20.67	0.23	0.27
2	Balimo	14.50	23.03	24.83	0.33	0.40
3	Bimadebum	16.60	28.37	30.17	0.43	0.50
4	Duaba	12.87	20.27	22.60	0.23	0.33
5	Wasau	17.60	28.07	29.67	0.43	0.50
6	Oriomo	19.60	29.93	29.83	0.47	0.53
7	Bensbach	20.53	32.83	34.83	0.53	0.63
8	Arufi	23.37	34.40	36.57	0.57	0.63
A. crassicarpa						
1	Buisio	19.87	31.20	33.33	0.50	0.63
2	Oriomo	17.27	25.33	27.60	0.37	0.47
3	Bensbach	17.83	26.70	29.17	0.40	0.47
4	lsago Arimu	21.33	30.92	32.83	0.48	0.60
5	Wipim	14.80	20.40	22.00	0.27	0.33
A. mangium						
1	Arufi	20.10	29.70	31.33	0.47	0.53
2	Wipim	22.80	34.73	36.83	0.60	0.67
3	Bensbach	23.77	34.53	36.50	0.63	0.67
4	Guram	20.27	31.93	33.60	0.60	0.67
5	Kini	21.50	30.33	32.17	0.50	0.53
6	Deri Deri	18.20	26.00	27.83	0.40	0.43
7	Oriomo	14.33	22.60	24.47	0.27	0.30
8	Iokwa	15.93	23.17	25.00	0.33	0.37
9	Balamuk	17.20	19.43	24.47	0.30	0.33

In the species *A. aulacocarpa.* provenances 7 and 8 namely, Bensbach and Arufi were the best performers while. provenances 1 and 4, Makapa and Duaba were with poor growth. Among *A.crassicarpa.* provenances 1 and 4. Buisio and Isago Arimu were growing fast whereas, provenance 5,Wipim was the slowest growing one. In the case of *A.mangium,* nos. 2 and 3, namely Wipim and Bensbach were the fastest growing provenances while, nos. 7 and 9. Den Den and Balamuk were the most undesirable provenances.

The analysis of variance showed that in *A.aulacocarpa.* provenances significantly differed with respect to height and girth at different ages. In *A.crassicarpa.* provenances are not significantly different. But the studies in China showed that there were significant differences in growth between provenances as well as between families in *A.crassicarpa* (Zhang and Yang. 1996). It was also reported that the growth variation between families was larger than between provenances. The lack of significant difference between provenances could be due to the close relationship between the limited number of provenances tested in the present study. In *A.mangium.* provenances were significantly different at 5% level for 9 months height and at nearly 5% level for height at 6 and 12 months height and for 9 months girth (Table 4).

Table 4. ANOVA for Height and girth in different provenances

Source	d.f.	Height at			Girth at	
		6 months	9 months	12 months	9 months	12 months
A. aulacocarpa						
Replication	2	1.67 0.20)	13.95 (0.60)	5.47 (0.30)	0.0004 (0.06)	0.004 (0.23)
Provenance	7	45.77 (5.48**)	97.55 (4.17*)	94..52 (5.12**)	0.048 (7.27**)	0.053 (3.29*)
Error	14	8.35	23.373	18.45	0.007	0.016
A. crassicarpa						
Replication	2	25.44 (1.46)	69.11 (1.14)	70.53 (1.16)	0.027 (0.94)	0.018 (0.37)
Provenance	4	18.87 (1.09)	59.53 (0.98)	63.34 (1.04)	0.027 (0.93)	0.043 (0.89)
Error	8	17.39	60.45	60.77	0.029	0.048
A. mangium						
Replication	2	26.31 (2.06)	81.79 (2.34)	141.96 (4.56*)	0.121 5.04*)	0.143 3.91')
Provenance	8	30.08 (2.35)	90.64 (2.59*)	74.54 (2.40)	0.058 (2.39)	0.066 (1.80)
Error	16	12.80	35.03	31.11	0.024	0.037

Figures in parentheses are F values **. * significant at 1 % and 5 % level respectively

Cluster analysis done for A.aulacocarpa and A.mangium showed three distinct groups among provenances. Based on the mean height and girth these groups were ranked as best, average and poor (Table 5). Since. A.crassicarpa provenances did not differ significantly, they were not grouped.

Table 5. Cluster formation in *A.aulacocarpa* and *A.mangium* with regard height and girth

Cluster	Provenance number & name	
	A. aulacocarpa	*A. mangium*
Best	7, 8 - Bensbach and Arufi	2, 3. 4– Wipim. Bensbach and Guram
Average	3, 5, 6– Bimadebum,Wasau and Oriomo	1. 5. 6 – Arufi. Kini and Deri Deri
Poor	1, 2. 4- Makapa. Balimo and Duaba	7, 8. 9 – Oriomo. lokwa and Balamuk

In *A.aulacocarpa* Bensbach and Arufi were the best performers whereas. in *A.mangium* Bensbach Wipim and Guram were the best provenances (Figs.1 and *2).* While Oriomo was one of the provenances with poor growth in our trial. it was one of the most promising provenances when tested in Brazil (Silva *et al.*. 1996). Multilocational provenance trials with 9 provenances of *A.mangium* at Philippines revealed that there were significant variations between provenances, site and provenance-site interaction (Faizuddin and Dalmacio. 1996). Pinyopusarerk and Puriyakorn (1987) also noted that provenance ranking within species differed from site to site. The international provenance trials of *A.mangium* at 19 trial sites in Southeast and South Asia, Australia and Fiji with 24 local provenances from five provenance regions, PNG (2). QLD (19). Far North QLD (1). Ceram (1) and lriyan Jaya (1) showed that for growth, there were highly significant dillerences between experimental sites, between provenance regions and among the local provenances within regions (Hanwood and Williams, 1992). They also reported that growth was generally faster at near equatorial trial sites and slower at sites farther from the equator and that PNG provenances were consistently best performers closely followed by Claudie River provenance from Far North QLD. In *A.crassicarpa* also PNG provenances excelled others as reported by Pan *et* al.(1988) from China. In A.aulacocarpa and A.crassicarpa. provenances from PNG were reported to be taller than those from North QLD (Pinyopusarerk and Puriyakorn. 1987). According to Otsamo *et al* (1996) PNG provenances of *A.crassicarpa* and *A.mangium* have high potential whereas in A.auriculiformis PNG and QLD provenances have good potential.

Highly significant correlations were seen between height at different ages as well as between height and girth in all the species. Hence, for large scale plantations. the best provenances mentioned above can be used.

Fig. 1 Growth performance of *A. aulacocarpa* provenances

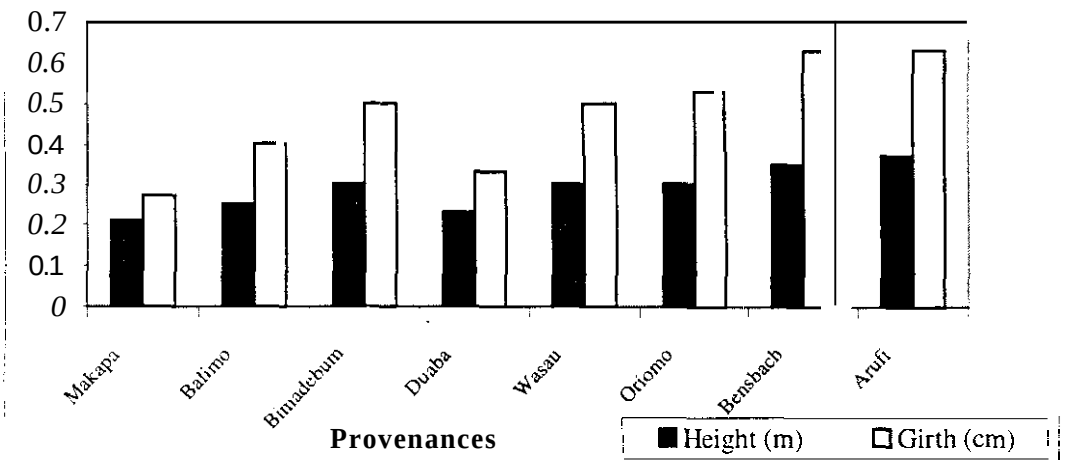
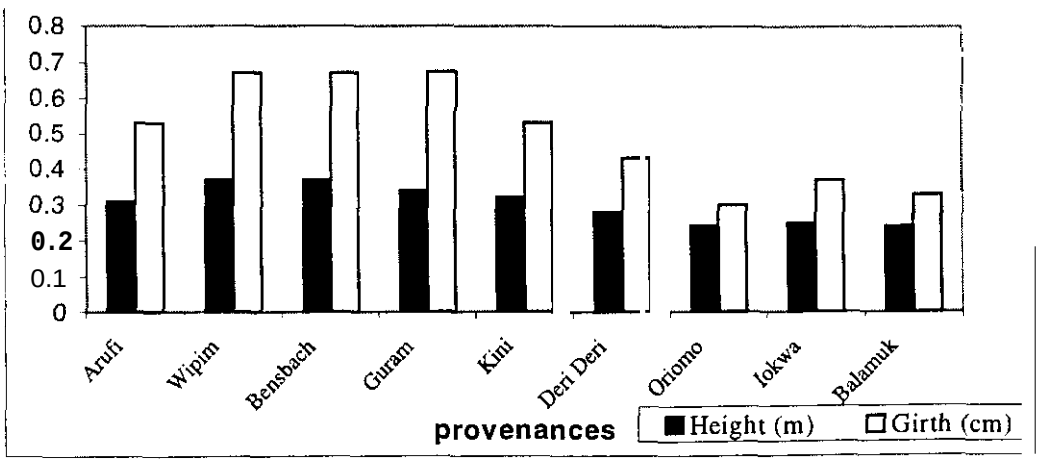


Fig. 2 Growth performance of A. *mangium* provenances



The phenotypic and genotypic coefficients of variation, heritability and genetic gain as percentage of mean are estimated (Table 6) for height and girth at different ages which will be useful in improving the characters genetically. From the estimates it can be seen that in A.aulacocarpa, phenotypic coefficients of variation (PCW for all the observed characters were high while genotypic coefficients of variation (GCW were moderate to high. The early results from the trials at Thailand support the view that in A.aulacocarpa marked genetic variations are expected due to its wide ecological and geographic range (Turnbull. 1988). Our observations also agree with this. Heritability also was moderate to high. By selecting the best provenance. high genetic gain can be expected.

Table 6. Variation, heritability and genetic gain for height and girth in Acacia provenances

Character	PCV (%)	GCV (%)	Heritability	GA (k =2.06 at 5% level)	GA as % mean
A. aulacocarpa					
Height at 6 months	26.60	20.59	0.599	5.63	32.83
Height at 9 months	25.71	18.44	0.514	7.34	27.22
Height at 12 months	23.10	17.58	0.579	7.89	27.54
Girth at 9 months	35.35	29.08	0.676	0.20	49.50
Girth at 12 months	35.51	23.37	0.433	0.15	31.58
A. crassicarpa					
Height at 6 months	23.21	3.85	0.028	0.24	1.32
Height at 9 months	28.89	0.12	0.000	0.00	0.00
Height at 12 months	27.08	3.19	0.014	0.22	0.76
Girth at 9 months	42.82	7.84	0.034	0.01	2.48
Girth at 12 months	44.65	6.32	0.020	0.01	2.00
A. mangium					
Height at 6 months	22.27	12.41	0.310	2.75	14.22
Height at 9 months	26.09	15.35	0.346	5.22	18.61
Height at 12 months	22.32	12.58	0.318	4.42	14.61
Girth at 9 months	41.18	23.19	0.317	0.12	26.34
Girth at 12 months	43.08	19.72	0.210	0.09	18.00

In A. crassicarpa though only 5 provenances were tested, the PCV were high but GCV were extremely low. So also was the case of heritability with very low values. From the analysis of variance it could be seen that there were no significant differences between provenances and hence, there is no scope for selection from among the provenances tested.

In A. mangium high PCV were expressed while GCV were generally moderate when 9 provenances were tested. Heritability were generally low for the growth

characters. By selecting the best provenance, moderate genetic advance can be expected.

b) Species- cum-seed source trial (Experiment No.2)

The mean performance of the seed sources, belonging to the 4 species is shown in Table 7 and the result of analysis of variance in Table 8.

Table 7. Mean performance of seed sources of Acacia at the age of 20 months

No.	Seed source	Number of seeds/ 10g	Germi-nation percent	Height (cm)	Girth (cm)	Number of branches per sapling
A. aulacocarpa						
1	Gamaeve WP, PNG	705	12.5	68.20	0.93	1.73
2	PNG prov.seed orchard, Fiji	598	46.5	69.68	0.90	1.62
A. auriculiformis						
3	Oriomo, PNG	608	34.0	132.39	1.32	2.61
4	N.QLD. Prov.seed orchard, Fiji	603	9.5	98.60	1.20	1.67
A. crassicarpa						
5	PNG prov.seed orchard, Fiji	477	41.5	84.67	0.98	0.62
6	Wipim, Oriomo area WP, PNG	521	57.0	97.93	0.93	0.96
A. mangium						
7	Prov.seed orchard, QLD	**776**	**86.0**	**86.46**	**0.81**	**0.68**
8	Oriomo RWP. PNG	**876**	**78.0**	**83.37**	**0.66**	**0.40**

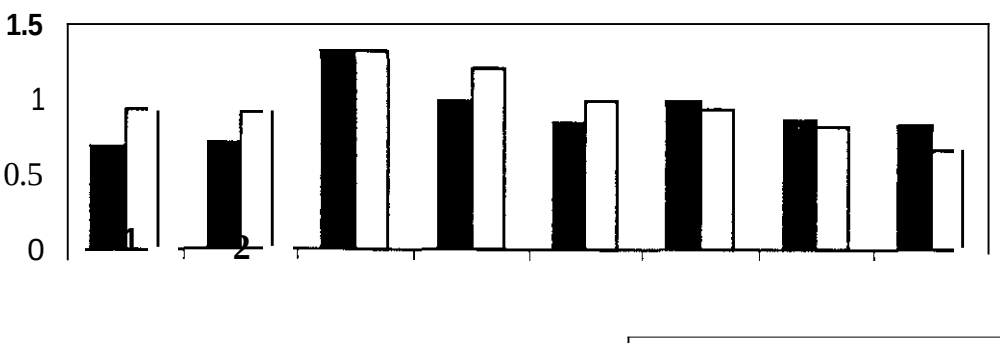
Table 8. ANOVA for growth characters in different seed sources of Acacia

Source	d.f.	Mean Sum Squares & F		
		Height	Girth	No. of branches
Replication	2	125.0 (0.71)	0.032 (0.69)	0.446 (2.51)
Species	3	2246.5 (12.81**)	0.287 (6.12**)	3.417 (19.21**)
Seed source within species	4	498.58 (2.84)	0.015 (0.32)	0.397 (2.23)
Within cell error	14	175.4	0.047	0.178

Figures In parentheses are Fvalues ** Significant at 1% level

It can be seen that *A.crassicarpa* is having smaller seeds and *A.mangium* the biggest seeds while, other two species having the medium. The analysis of variance showed that there were highly significant differences between species with respect to height, girth and number of branches. But within species there were no significant differences between seed sources (Table ***8)***. From the results it can be seen that *A.auriculiformis* is the fast growing species but, it is having more number of branches which is an undesirable character (Fig.3). For height, *A.aulacocarpa* was having the least value and for girth *A.mangium* was the poor species. But number of branches was less in *A.mangium* followed by *A.crassicarpa* which is a desirable character (Fig.4).The F1 hybrids between *A.mangium* and *A.auriculiformis* are reported to be highly promising showing hybrid vigour (Pinso and Nasi. 1992, Harwood. C.E. Pers. comm.). Selections from these hybrids exploiting heterosis for growth as well as other good qualities of both the parents will genetically improve the planting material appreciably. With regard to the seed sources, Oriomo provenance of *A.auriculiformis* from Papua New Guinea excelled all other seed sources for growth and Oriomo provenance of *A.mangium* from PNG was the best provenance for less number of branches. Inter specific hybridization between the above two provenances can be attempted to increase the productivity and to improve the tree form.

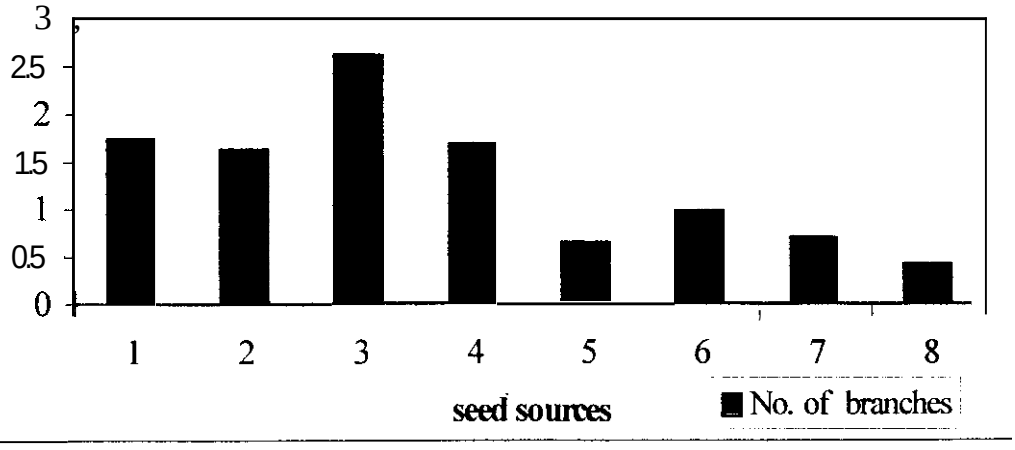
Fig. 3 Growth performance inAcacia seed sources



The species tests in various countries show different results. On testing 15 species and their provenances of Australasian acacias by matching the climate of the planting site in Malawi showed that for growth all the 3 provenances of *A.auriculiformis* were clearly superior to the rest of the species each with one provenance (Maghembe *et al,* 1997). In Laos, the performance of species with

regard to tree volume was in the order of *A. mangium* > *A. crassicarpa* > *A.aulacocarpa* > *A.auriculiformis* (Pinyopusarerk *et al,* 1996) but in Vietnam, *A.auriculiformis, A.mangium* and *A.crassicarpa* were reported to be the most

Fig. 4 Number of branches in *Acacia seed* sources



Seed sources 1 & 2 – *A.aulacocarpa* 3 & 4 –*A.auriculiformis*
5 & 6 --*A.crassicarpa* 7 & 8 –*A.mangium*

Plate 1. Variation in growth performance between provenancesof *Acacia*

promising species for growth (Nguyen and Le. 1996). In South Kalimantan. Indonesia, the order of excellence with regard to volume was *A.mangium* > *A.crassicarpa* > *A.auriculiformis* > *A.aulacocarpa* (Otsamo *et al.*. 1996) while in China 3 year old species-cum-provenance trial shows A.crassicarpa as the fastest growing species compared to *A.aulacocarpa, A.auriculiformis. A.cincinnata* and *A.leptocarpa* (Pan *et al.*, 1988). The reasons for this type of variation must be due to the differences in ecological and other site conditions.

4. CONCLUSIONS

The provenance trial conducted at Palappilly Field Research Centre of KFRI on three species of Acacia namely, *A. aulacocarpa, A. crassicarpa* and *A. mangium* showed that there were significant differences between provenances for height and girth except in *A. crassicarpa* when initial 12 months growth was measured. The genetic variations and heritability for growth are found to be moderate to high in *A. aulacocarpa* and, a high genetic gain is expected by selecting the best provenance. In *A. mangium* genetic variation was moderate with low heritability and by selecting the best provenance, moderate genetic gain is expected. In *A. aulacocarpa* the best performers were Bensbach and Arufi whereas in *A. mangium* the best provenances were Bensbach. Wipim and Guram.

The species-cum-seed source trial having four species namely, *A. aulacocarpa A. auriculiformis, A. crassicarpa* and *A.mangium* each with one provenance and a seed orchard source (improved seeds) showed that there were highly significant differences between species with respect to height, girth and number of branches when they were monitored at an age of 20 months. But within species there were no significant differences between seed sources with respect to these characters. It was seen that *A. auriculiformis* was the fastest growing species among the four but it was also having the largest number of branches. *A. mangium* was the species with least number of branches which is quite desirable. In *A. auriculiformis.* provenance Oriomo was the best performer for growth character. In *A.mangium* also, Oriomo was the best provenance when less number of branches are taken into consideration. The natural or artificial hybrids between these two species are reported to be highly promising and expressing hybrid vigour. Hence, hybrid production followed by selection for the best characters can be opted to genetically improve the growth and other characters. The best seed sources should be used for hybridization to exploit the maximum gain.

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