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Comparative Growth of 11 Year old *Acacia aulacocarpa* A. CUNN. EX Benth from Four Provenances

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ABSTRACT

The aim of this study was to evaluate the growth potential of *Acacia aulacocarpa* A. Cunn. Ex Benth in four provenances of Malaysia. A field trial was established in Kampung Aur Gading, Kuala Lipis and Pahang using a Completely Randomized Block Design (RCBD) with four replications. The seeds used were from the Papua New Guinea and Queensland regions. Survival, total height and diameter at breast height (dbh) were assessed. There were significant differences at $p < 0.05$ found between regions and provenances for survival, height and dbh. Arufi East Morehead WP (PNG) and West Morehead (PNG) provenances perform better than the ones from Queensland region.

Key words: Region, provenances, growth performance, adaptability

INTRODUCTION

Forest cover slightly less than one third of the total land area of the Asia and the Pacific region. Based on estimated data from FAO (2011), the region's forested area was 740 million hectares in 2010; Southeast Asia contained 214 million hectares of the forest area. Since year 2000, rising demand of wood and wood products has resulted in the depletion of forest resources in the tropics and Malaysia is not an exception. Indiscriminate logging activities in the country are expected to create a timber shortage in the future. Therefore, there is an urgent need to look for other alternative wood sources. Currently plantation forestry appears to be the best alternative to overcome the anticipated timber shortage and alleviate the pressures for logging the natural forest. Forest plantations are generally more efficient in producing timber than natural forest (20 m³/year in plantations and 4 m³/year in natural forest). Malaysia targeted of 365,000 ha for growing hardwood forest plantations but until end of year 2000, Malaysia had established only 114,535 ha. In Sabah, a commercial forest plantation of fast-growing species totals at least 56,100 ha and focuses mainly on *Acacia mangium*. However, the issues of plantation forestry in the country are on this particular species i.e., problems of heart-rot, poor form and an unsuitable species for fulfilling the objectives for saw log production. Another problem is multiple leaders and its unsuitability for saw log and plywood. Perhaps, such problems arise because of no adherence to standard scientific procedures for choosing species for large scale plantations establishment, In Malaysia especially, no species chosen by researcher have been successful as forest plantations. Moreover, a few researches have been conducted in Malaysia to evaluate which species suitable for

forest plantations especially *A. aulacocarpa* species. A high productivity and better stem quality of the future plantations of these species can be assured only if improved seeds and superior planting material are used for their establishment. However, judicious planning ought to be made for rising successful plantations.

Acacia species which are exotic to Malaysia have shown great potential for forest plantations. Based on species introduction trial and large scale plantations, *A. aulacocarpa*, *A. auriculiformis*, *A. crassicarpa* and *A. mangium* have been identified as best adapted to the humid/sub humid tropics. These species grown fast, large and most suited for wood production (chips, pulp and sawn timber) (Pinyopusarerk, 1992). In recent years, *A. crassicarpa* and *A. aulacocarpa* have also assumed importance for the production of sawn timber and paper pulp in the Asia-Pacific region (Thompson, 1994; Turnbull *et al.*, 1998; McDonald and Maslin, 2000). *A. aulacocarpa* is a typical pioneer species of humid and sub-humid tropical zone and one of the largest acacias, reaching a height of 35 m with a diameter in excess of 1 m on moist sites associated with tropical rainforest. On dry sites it occurs as a shrub or small tree with 4-10 m in height. It occurs mainly in lowlands from sea-level to about 900 m a.s.l. It has a fragmented distribution (5°57'-28°50' S, 125°12'-152°25' E) which stretches from the coastal districts of central New South Wales through eastern Queensland to the northern part of Northern Territory and southern Papua New Guinea. It can withstand high temperatures exceeding 32 to 38°C and the average rainfall in its native habitat ranges from 900-4000 mm.

In Malaysia, planting *A. aulacocarpa* as a plantation was never introduced widely. A few researches have been conducted in Malaysia to evaluate the growth performance especially on this species. Early reports on the evaluation of several *A. aulacocarpa* provenances indicate that their growth is at least as good as *A. mangium* and *A. auriculiformis* in Thailand (Pinyopusarerk and Puriyakorn, 1986). These provenance trials of *A. aulacocarpa* have also demonstrated the superior vigor of provenances from Arufi East Morehead and West Morehead, PNG and the best stem form over those from QLD (Senin *et al.*, 2007; Mat *et al.*, 2009), fiber length (0.83 mm) (Mahat, 2007) and wood density (0.59 g cm⁻³) (Mat *et al.*, 2009). However, caution must be accorded in promoting the planting of this species at the moment, where there is very little information on this species especially on its site and genetic background of the material being planted is not well established. Understanding the growth performance of forest tree species and provenances is the basic for on appropriate utilization of forest plantation. Knowledge pertaining to growth characteristic between and within provenances of a species is important for the selection strategy in a forest plantation. The choice of tree species in any plantation program requires proper and intensive selection and it's usually done via species or provenances or progeny trial. Provenances regions screening and testing before planting is the first necessary step for the successful introduction for exotic in plantation establishment and productivity. The objective of this study was to determine the potential provenances/regions of *A. aulacocarpa* tree species that offer promising productivity for industrial wood production and reforestation.

MATERIALS AND METHODS

Plant material and side location: Seeds were supplied by ACIAR through Commonwealth Scientific and Industrial Research Organization (CSIRO). It was recommended that to obtain reliable assessment information on provenances regions which could help indicate which provenances should be promoted to the forest plantation industry. Details of the seed sources are given in Table 1.

Table 1: Details of the geographical and genetic information of the provenances used

Seed lot No.	Provenance	Origin	Lat. (° S)	Long. (° E)	Alt (m)	No. parents
17739	3 K South Mt Larcom	QLD	23 50	151 00	70	11
17891	Samford	QLD	27 17	152 51	50	5
16112	West Morehead	PNG	84 02	141 34	30	14
16995	Arufi East Morehead WP	PNG	84 03	141 55	25	150

Note: QLD-Queensland/PNG-Papua New Guinea

A field trial was established at Kampung Aur Gading, Kuala Lipis which is located in the northern part of the states Pahang, peninsular Malaysia (latitude 4°20' N and longitude 101°59' E, altitude approximately 91 m a.s.l.). Formerly the estate was planted with rubber trees. The soils of the site were deep series which are brownish yellow to yellowish brown fine sandy loam. The area has a rather uniform topography with the side ranging from 0° to 8° at the southern side and 20° at the Northern side. Mean annual rainfall is 2,211 mm and mean annual temperature is 27°C. The site experiences an average wind speed of 0.88 m sec⁻¹, receiving a daily average of 5.8 h of sunshine and an annual evaporation of 1,527 mm.

Experimental design and analysis: A randomized complete block design with four replicates (block) was used. Each block is made up of 80 lines. The provenances were assigned randomly to these line plots. Each line is made up of 16 trees spaced 3 m a part. Growth performance was measured on total height, diameter at breast height (dbh) and survival percentage. All measurements were analyzed statistically using SAS 6.2. The ANOVA/GLM SAS procedure was used and Duncan's New Multiple Range Test was further used to evaluate the multiple comparisons or mean separation.

RESULTS

Generally, the results showed that there were significant differences of all parameters measure in terms of regions and provenances (Table 2).

The growth performance based on regions and provenances are given in Table 3 and 4, respectively. In term of survival, the PNG region recorded the highest survival at 61.10% compared with the QLD region at 43.33%. The Arufi East Morehead provenance from PNG recorded the highest mean survival rate at 65.45% between all provenances followed by West Morehead provenance from PNG at 56.50% and 3K South Mt. Larcom provenance, QLD (48.93%). However, Samford provenance, QLD recorded the lowest survival rate at 38.65%. The overall average provenances survival percentage was 52.38% (Table 4).

Statistically significant differences were detected in term of height growth between regions and provenances (Table 3). The PNG region showed significantly mean height growth at 17.72 m compared to QLD region at 7.67 m. Meanwhile, the provenance showed significant differences between them, in height growth. The provenance from Arufi East Morehead WP, PNG recorded the best height growth at 18.20 m followed by the provenance from West Morehead, PNG at 17.17 m. However, provenance from Samford and 3 K South Mt. Larcom, QLD recorded the lowest height growth at 8.33 and 7.10 m, respectively (Table 4). The mean total height of the provenances ranged from 18.20 to 7.10 m. The overall mean height was 12.70 m (Table 4).

The results showed significant differences in dbh at ($p < 0.05$) between regions and provenances (Table 2). The PNG region produced significantly bigger diameter growth at 19.80 cm compared to QLD (7.78 cm) (Table 3).

Table 2: ANOVA for height, dbh and survival of *A. aulacocarpa*

Source	df	Height (m)		DBH (cm)		Survival (%)	
		MS	F-value	Ms	F-value	MS	F-value
Provenance	3	4095.14	227.39*	5855.04	114.69*	2370.65	20.52*
Region	1	12128.26	664.76*	17364.17	338.87*	5507.26	47.67*
Mean		14.03		15.38		52.72	

Note: *Significant at $p < 0.05$

Table 3: Mean height, dbh and survival of regions of *A. aulacocarpa*

Regions	Height (m)	Dbh (cm)	Survival (%)
Papua New Guinea	17.72±8.5 ^a	19.80±8.44 ^a	61.10 ^a
Queensland	7.67±6.54 ^b	7.78±6.54 ^b	43.33 ^b

Note: Means with the same letters are not significantly different from each other (ANOVA, $p > 0.05$). Standard errors (±) of means within regions

Table 4: Mean height, dbh and survival of provenance of *A. aulacocarpa*

Code	Provenances	Ht (m)	DBH (cm)	Survival (%)	Region	CR
P14	Arufi E Morehead WP	18.20±5.85 ^a	19.27±5.81 ^a	65.45 ^a	PNG	1
P13	W Morehead	17.17±5.38 ^a	20.40±5.25 ^a	56.50 ^b	PNG	2
P15	3K S Mt Larcom	7.10±4.57 ^c	7.11± 4.57 ^b	48.99 ^c	QLD	3
P16	Samford	8.33±4.17 ^b	8.54±4.16 ^b	38.65 ^d	QLD	4

PNG: Papua New Guinea and QLD: Queensland. Means with the same letters are not significantly different from each other (ANOVA, $p > 0.05$). Standard errors (±) of means within provenances

The four provenances also showed significant differences between them in dbh. The provenance from West Morehead, PNG recorded the biggest dbh at 20.40 cm, while provenance from 3 K South Mt. Larcom, QLD produced the smallest at 7.11 cm. The diameter ranged from 20.40 to 7.11 cm with the overall mean dbh was 13.83 cm (Table 4).

DISCUSSION

One of the most problems occur in forest plantation is the low survival rate. However, in this study showed that all provenances were moderate adapted to the environmental condition of the trial site in Aur Gading, Pahang. The results indicate that survival percentage ranging from 39 to 66% of the four provenances could be attributed to many factors including damage caused by heavy winds and drought especially at the early stage of the trial immediately after planting. Similar results have been reported for provenance trials in different regions (Minquan *et al.*, 1989; Casey, 1993; Thompson, 1993). Results of the present study indicate that *A. mangium* and *A. crassicaarpa* were most susceptible to wind fall compared to *A. auriculiformis* and *A. aulacocarpa*. Moreover, the genetic background (genotype) is one of the main factors influencing the growth and development of tropical trees. Moreover, characters used to identify the inherent adaptive variation related to the ecological variability between species and between provenances depend on the materials utilized (Van Wyk, 1978; Keiding *et al.*, 1984). In this study, growth performance was assessed in terms of survival, height and diameter. The results indicated a wide variation in growth among the regions and provenances for survival, total height and dbh. These differences were associated with both inter and intra-variation between provenances and two geographical regions.

Variation between regions: Generally, the materials from PNG region consistently recorded superior growth compared to the QLD region, for all growth traits (Senin *et al.*, 2007; Mahat, 2007; Mat *et al.*, 2009). Simultaneously, Ganeson (1989) grew 30 provenances from Australia, PNG and Thailand regions under glasshouse conditions and found that PNG region were the most vigorous in their growth. Pinyopusarek (1990) also reported that the PNG region performed better than the Thailand region in Thailand. Therefore, selection for further improvement should consider variation in between regions as well.

Variation between provenances: The results of this study indicated that all provenances differed significantly in survival, height and diameter. Such variation offers an opportunity for further improvement following provenance selection. Based on composite ranking, provenance from Arufi East Morehead WP, PNG and West Morehead, PNG were good performed. However, provenance from Samford, QLD performed poorly. Similar variation was also reported from provenance trials at Sai Thong and Sakaerat in Thailand (Luanviriyasaeng *et al.*, 1991). On the other hand, the results showed inconsistent behavior of the provenances at the two sites especially those from PNG. At Sai Thong, provenance from QLD (Wenlock, South Coen, Kings Plain and Morehead) and one provenance from Northern Territory (Mann) grew faster while the PNG provenances performed poorly in their overall performance. The results obtained by Miquan and Yutian (1994) from five provenance trials on Hainan Island showed that there were significant differences between provenances only for diameter at four years old. Results of these trials showed that QLD provenances recorded the overall best growth followed by the PNG provenances. The NT provenances were generally the poorest performers. However, Zobel and Talbert (1984) mentioned that provenances can sometime contain quite large differences related to differing sites and these are not genetically fixed and only represent the effects of varied environments on the growth and development of the trees. Moreover, the provenances adapted to alternating but heavy winds and light depressions may be unable to achieve continuous growth, thus exhibiting only moderate growth performances.

Adaptability: Generally, among the provenances planted under this study, the adaptability of the regions and provenances at any specified site could be judged based on composite ranking where PNG region were more adapted compared to QLD region. Report on the performance of 23 seed lots of 12 *Acacia* species planted in six trials throughout Thailand, *A. aulacocarpa* from PNG provenances grew much faster than those from north QLD and have many single stemmed trees strong apical dominance (Chittachumnonk and Sirilak, 1991; Pinyopusarek, 1993). According to the results of the composite ranking of the present study, it can be concluded that Arufi East Morehead WP, PNG is the most adapted provenance to the environmental condition of the trial sites followed by West Morehead, PNG. On the other hand, it revealed that Arufi East Morehead WP, PNG was most adapted of all the provenances tested (Rank 1) and followed by West Morehead, PNG (Rank 2) while provenance from Samford, QLD was the least adapted provenance and low in mean yield (Rank 4). The differences in the growth rate of might also result from the trees stress caused by trees crown competition for demanding light intensity may still have affected the growth results. Moreover, species and provenances screening and testing is the first necessary step for the successful introduction of exotics in new areas. The need to use the best-adapted sources of seeds and provenances was recognized in the early years of the history of exotic plantations (Zobel *et al.*, 1987). Meanwhile, site conditions, provenances and regions have to be carefully

matched to ensure successful establishment and yield of tree plantations. However, considering the management objective of the plantation to be established, different ideotypes could be selected for different management purposes and end used including sawn timber from among the best performers in height, dbh and survival while other genotypes could be selected for pulp and paper or fuel wood depending on quality and quantity of the produce.

CONCLUSION

The results of this study provided some useful information which are a prerequisite for establishment of plantations and the basis for a selection strategy for subsequent breeding and improvement of provenances examined. The PNG region has repeatedly had superior growth over the QLD in numerous provenances trials, attempts at finding out those climatic factors which determine adaptation of provenances to different environments. Based on the findings, the provenances of PNG region showed better survival, height and diameter growth. Based on composite ranking, provenance from Arufi East Morehead WP, PNG and West Morehead, PNG were the best growth performer and satisfactory for establishment of plantations and base populations for tree improvement purposes in the low latitude tropical lowlands. While provenance from Samford (QLD) sources showed the poorest growth and should be avoided. The study found that in addition to *A. mangium*, the *A. aulacocarpa* species also can be introduced for tree plantations and reforestation in Malaysia. The fast-growing tree species like *A. aulacocarpa* can be used at the farm level for fuel wood and for household construction and at the industrial level as solid timber, reconstituted wood and for pulp and paper production. Hence, planting *A. aulacocarpa* could alleviate the shortage of wood and fuel wood supply. Moreover, *A. aulacocarpa* have a positive impact on the environment and soil fertility can be sustained from planting as they are a nitrogen-fixing species. In this respect, benefits generated from this study accrue to the public.

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