



UNIVERSITI PUTRA MALAYSIA

**GROWTH PERFORMANCE AND GENETIC VARIATION OF FOUR
ACACIA SPECIES PLANTED IN PAHANG, MALAYSIA**

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**GROWTH PERFORMANCE AND GENETIC VARIATION OF FOUR *ACACIA*
SPECIES PLANTED IN PAHANG, MALAYSIA**

By

MOHD NOOR MAHAT

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in
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Acacia mangium Willd, *Acacia auriculiformis* A. Cunn. ex Benth., *Acacia crassicarpa* A. Cunn. ex Benth. and *Acacia aulacocarpa* A. Cunn. ex Benth. are the four fast-growing tropical acacias which have received high priority for genetic assessment and improvement in the Asian region. Despite their rapid early growth and tolerance to a wide range of environmental conditions, only *A. mangium* has been widely planted in the Compensatory Forest Plantation Programme in Malaysia. The seed sources utilised in the plantation were however, unselected and originated from a narrow genetic base. Therefore, this study was conducted at Kampung Aur Gading, Kuala Lipis, Pahang to evaluate the genetic variation and growth performance of a base breeding populations of *Acacia* species in terms of their quantitative and qualitative growth characteristics. Estimates of some parameters such as genetic correlation and heritability were also made. Twenty progenies each of the species were collected from two geographic regions namely Queensland and Papua New Guinea were used in this study. This trial was laid out in a randomized complete block design with four replications.



Generally all species adapted and performed well in local condition and their growth performances were significantly different ($P < 0.05$) between species, provenance and family. *A. mangium* was the best performer in almost all of the traits tested, followed by *A. crassicarpa*, *A. auriculiformis* and *A. aulacocarpa*. Concurrently, all species exhibited high intra species variation for all the traits assessed. There were also significant genetic variation between regions, between provenances within region and between families within the provenances exists in the quantitative traits assessed for all species. The populations collected from Papua New Guinea, generally, outperformed those from Queensland in quantitative growth traits except for stem quality which appeared otherwise. The progenies in the family also exhibit high genetic variability with variance component ranging from 39% to 93.7% of the total variance. Out of these, few individuals were found to be exceptionally good performer, even from the poor families such as JSL3777 of *A. mangium*, MHL14 of *A. crassicarpa*, BH14068 of *A. auriculiformis* and GB100 of *A. aulacocarpa*. Among the top performing families were KN097, CG1853 and JSL380 of *A. mangium*, BVG2609 and MHL13A of *A. crassicarpa*, GB098, MM1016 and AR10 of *A. aulacocarpa* and BH14607 and JSL363 of *A. auriculiformis*.

There were significant differences between species (at $P < 0.05$) for selected wood properties tested. *A. aulacocarpa* gave the highest wood density of 0.59 g/cm^3 , followed by *A. auriculiformis* (0.54 g/cm^3), *Acacia crassicarpa* (0.51 g/cm^3) and *A. mangium* (0.43 g/cm^3). On the contrary, the order of ranking differed in fiber length where, *A. crassicarpa* produced the longest fiber length (0.91mm), followed by *A. mangium* (0.85mm), *A. aulacocarpa* (0.83mm) and *A. auriculiformis* (0.83mm).

The study found that all species were efficient in their photosynthetic capabilities since they produced F_v/F_m values above 0.80 and were not significantly different.

Generally the heritability estimates were variable between traits and between species. The heritability estimates of quantitative growth traits for *A. aulacocarpa* were found to be almost consistent for all traits ranging from 0.36 to 0.40. Similarly, *A. mangium* gave estimates ranging from 0.30 to 0.36. On the contrary *A. auriculiformis* gave comparatively more variable estimates ranging from 0.23 to 0.37. *A. crassicaarpa* recorded comparatively lower estimates ranging from 0.20 to 0.30. The heritability estimates for the qualitative traits were however, low with majority of them estimating narrow sense heritabilities below 0.20. The heritability estimates for wood properties and chlorophyll fluorescence varied significantly from none (0.0) to moderate (0.32) for families of all species tested. The phenotypic and genetic correlations varied widely ranging from 0.0 to 0.96 for the former and from 0.0 to 0.83 for the latter, respectively. Generally, these correlations were found to vary between traits as well as between species. The correlations between growth traits and stem qualitative traits were generally moderate (0.4 –0.6) to high (above 0.6). The correlations between quantitative traits and other traits were found to be generally low (below 0.4) whereas correlations between physiological traits and wood properties and with other traits were generally very low (below 0.1) or even not correlated at all. This study indicated that further improvement could still be done on this base breeding population by employing further selection on a few selected traits at a time for the development of advanced breeding or even for the production populations.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi untuk keperluan ijazah Doktor Falsafah

**PRESTASI PERTUMBUHAN DAN VARIASI GENETIK EMPAT SPESIES
ACACIA DI TANAM DI PAHANG, MALAYSIA**

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Acacia mangium Willd, *Acacia auriculiformis* A. Cunn. ex Benth, *Acacia crassicaarpa* A. Cunn ex Benth dan *Acacia aulacocarpa* A. Cunn ex Benth merupakan empat spesies Acacia tropika yang cepat tumbuh yang mendapat penilaian utama penilaian genetik dan penambahbaikan di kawasan Asia. Walaupun mempunyai kadar pertumbuhan awal yang cepat dan toleransi terhadap pelbagai keadaan persekitaran, hanya *Acacia mangium* yang ditanam secara meluas di bawah Program Kompensatori Hutan Ladang di Malaysia. Sumber biji benih yang digunakan dalam program ini walau bagaimanapun, tidak dipilih dan berasal daripada asas genetik yang kecil. Oleh yang demikian, kajian ini dijalankan di Kampung Aur Gading, Kuala Lipis, Pahang untuk menilai variasi genetik dan prestasi ciri-ciri pertumbuhan populasi pembiakan asas genotip Acacia dari sudut kuantitatif dan kualitatif. Di samping itu anggaran terhadap beberapa parameter seperti korelasi genetik dan keterwarisan juga dibuat. Sebanyak 20 progeneri setiap spesies dari dua kawasan geografi iaitu Queensland dan Papua New Guinea digunakan dalam kajian ini. Kajian spesies, provenan dan progeneri dijalankan menggunakan reka bentuk blok rawak lengkap.

Secara umum, kesemua spesies berupaya menyesuaikan dan tumbuh dengan baik di Malaysia dan menunjukkan kadar pertumbuhan yang berbeza secara bererti ($P < 0.05$) antara spesies, provenan dan famili. *A. mangium* menunjukkan pertumbuhan yang terbaik diikuti dengan *A. crassicarpa*, *A. auriculiformis* and *A. aulacocarpa*. Pada masa yang sama kesemua spesies mempamerkan variasi intra-spesifik yang tinggi bagi setiap ciri yang dinilai. Variasi genetik juga didapati ketara antara kawasan geografi, antara provenan dari kawasan yang sama, dan antara famili daripada provenans yang sama dalam kesemua ciri yang dikaji daripada keempat-empat spesies. Populasi yang berasal dari Papua New Guinea pada umumnya menunjukkan prestasi yang lebih baik berbanding Queensland dalam semua ciri pertumbuhan kuantitatif kecuali kualiti batang. Progeni-progeni dalam famili juga menunjukkan variasi genetik yang tinggi dengan varians antara 39% ke 93.7%. Beberapa individu didapati menunjukkan kadar pertumbuhan yang begitu baik walaupun berasal daripada famili yang inferior seperti *Acacia mangium* JSL3777, *A. crassicarpa* MHL14, *A. auriculiformis* BH14068 dan *A. aulacocarpa* GB100. Antara famili terbaik ialah *A. mangium* KN097, CG1853 dan JSL380, *A. crassicarpa* BVG2609 dan MHL13A, *A. aulacocarpa* GB098, MM1016 dan AR10, dan *A. auriculiformis* BH14607 dan JSL363. Terdapat juga perbezaan secara bererti ($P < 0.05$) untuk beberapa sifat-sifat kayu yang diuji. *A. aulacocarpa* memberikan ketumpatan kayu tertinggi iaitu 0.59 g/cm^3 , diikuti dengan *A. auriculiformis* (0.54 g/cm^3), *A. crassicarpa* (0.51 g/cm^3) dan *A. mangium* (0.43 g/cm^3). Berbeza pula dengan saiz gentian di mana *A. crassicarpa* menghasilkan gentian terpanjang (0.91 mm), diikuti dengan *A. mangium* (0.85 mm), *A. aulacocarpa* (0.83 mm) dan *A. auriculiformis* (0.83 mm). Kajian ini juga mendapati



semua spesies mempunyai keupayaan fotosintesis yang efisien kerana menghasilkan nilai F_v/F_m melebihi 0.80 dan tidak berbeza secara bererti.

Pada umumnya, anggaran keterwarisan berbeza antara ciri dan antara spesies. Anggaran keterwarisan ciri pertumbuhan kuantitatif *A. aulacocarpa* didapati hampir konsisten bagi semua ciri iaitu antara 0.36 ke 0.40. *A. mangium* juga menunjukkan anggaran yang agak konsisten antara 0.30 ke 0.36. Sebaliknya, *A. auriculiformis* memberikan anggaran yang lebih tidak sekata iaitu antara 0.23 ke 0.37. *A. crassicarpa* pula merekodkan anggaran yang jauh lebih rendah antara 0.20 ke 0.30. Anggaran keterwarisan untuk ciri-ciri kualitatif walau bagaimanapun rendah dengan majoriti di bawah 0.20. Anggaran keterwarisan untuk sifat-sifat kayu dan pendarfluor klorofil berbeza dengan bererti daripada tiada (0.0) ke sederhana (0.32) untuk kesemua famili yang diuji. Korelasi fenotip dan genetik pula mempunyai perbezaan yang jelas dengan julat 0.0 ke 0.96 untuk korelasi fenotip dan 0.0 ke 0.83 untuk korelasi genetik. Secara umum, korelasi-korelasi ini didapati berbeza antara ciri dan juga antara spesies. Korelasi antara ciri pertumbuhan dan ciri kualitatif batang adalah sederhana (0.4 – 0.6) ke tinggi (melebihi 0.6). Korelasi antara ciri kuantitatif dan ciri-ciri yang lain pada dasarnya didapati lebih rendah (di bawah 0.4), manakala korelasi antara ciri fisiologi dan sifat-sifat kayu dengan ciri-ciri yang lain adalah sangat rendah (di bawah 0.1) atau tidak ada korelasi. Kajian ini menunjukkan bahawa kualiti populasi pembiakan asas ini mampu dipertingkatkan dengan melakukan pemilihan berterusan pada ciri-ciri terpilih dan juga boleh digunakan sebagai populasi pengeluaran bahan tanaman.

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I certify that an Examination Committee has met on 5th October 2007 conduct the final examination of Mohd Noor Mahat on her Doctor of Philosophy thesis entitled “Growth Performance and Genetic Variation of Four *Acacia* Species Planted in Pahang, Malaysia” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommended that the candidate be awarded the degree of Doctor of Philosophy.

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DECLARATION

I declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

MOHD NOOR MAHAT

Date: 1 January 2008



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