FIVE-YEAR GROWTH PERFORMANCE OF *ACACIA PEREGRINALIS, A. MIDGLEYI* AND *A. CELSA* AT KOLAPIS B IN EASTERN SABAH, MALAYSIA

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AJIK, M. & HARWOOD, C. E. 2003. Five-year growth performance of *Acacia peregrinalis, A. midgleyi* and *A. celsa* at Kolapis B in eastern Sabah, Malaysia. A provenance trial was planted at Kolapis B, in eastern Sabah, Malaysia in 1995, testing 21 *Acacia* provenances, at that time classified as *A. aulacocarpa.* Nineteen of the provenances, now classified as *A. peregrinalis,* were from the southern lowlands of New Guinea and the other two, one now classified as *A. midgleyi* and the other as *A. celsa,* were from north Queensland, Australia. The trial was assessed for survival and growth at five years of age. Survival was generally good, averaging 82% for the trial, with no significant differences among species or provenances. The three species differed significantly ($p < 0.001$) in their growth performance of height and diameter at breast height (dbh), with all *A. peregrinalis* provenances clearly outperforming *A. midgleyi* and *A. celsa.* Species mean height for *A. peregrinalis* was 18.0 m (provenance means ranged from 16.4 to 19.1 m), and mean dbh was 16.2 cm (provenance means ranged from 14.9 to 17.7 cm). Provenance differences in height and dbh were not statistically significant. *Acacia celsa,* had a mean height of 15.2 m and dbh 11.9 cm, while the corresponding figures for *A. midgleyi* were 13.2 and 9.4 cm. *Acacia peregrinalis* was also significantly ($p < 0.05$) superior to the other two species with respect to stem form, and appears to have good prospects as a plantation species in eastern Sabah.

Key words: Species and provenance - *Acacia aulacocarpa* - *Acacia celsa* - *Acacia midgleyi*

AJIK, M. & HARWOOD, C. E. 2003. Pertumbuhan lima tahun *Acacia peregrinalis, A. midgleyi* and *A. celsa* di Kolapis B di timur Sabah, Malaysia. Satu percubaan provenans telah ditubuhkan di Kolapis B yang terletak di bahagian timur Sabah, Malaysia pada tahun 1995. Percubaan ini menguji 21 provenans *Acacia* yang pada masa itu diklasifikasikan sebagai *A. aulacocarpa.* Sebanyak 19 provenans tersebut, yang kini diklasifikasikan sebagai *A. peregrinalis* berasal daripada kawasan tanah rendah di selatan New Guinea manakala dua provenans lagi yang diklasifikasikan sebagai *A. midgleyi* dan *A. celsa* berasal daripada bahagian utara Queensland, Australia. Pertumbuhan dan kemandirian pokok pada umur lima tahun dinilai. Umumnya kemandirian adalah tinggi dengan purata 82% dan tidak ada perbezaan ketara antara spesies atau provenans. Ketiga-tiga spesies berbeza dengan bererti ($p < 0.001$) bagi ketinggian dan diameter pada aras dada (dbh). Kesemua provenans *A. peregrinalis* menunjukkan prestasi pertumbuhan lebih baik berbanding *A. midgleyi* dan *A. celsa.*

Min ketinggian *A. peregrinalis* ialah 18.0 m (min provenans dalam julat 16.4 hingga 19.1 m) dan min dbh ialah 16.2 cm (min provenans dalam julat 14.9 hingga 17.7 cm). Dari segi statistik perbezaan provenans bagi ketinggian dan dbh adalah tidak bererti. Min ketinggian dan dbh bagi *A. celsa* adalah masing-masing 15.2 m dan 11.9 cm manakala bacaan untuk *A. midgleyi* adalah 13.2 m dan 9.4 cm. Keunggulan bentuk batang utama *A. peregrinalis* juga adalah bererti ($p < 0.05$) berbanding kedua-dua spesies yang lain, justeru memberikannya prospek yang baik dalam aktiviti perladangan hutan di bahagian timur Sabah.

Introduction

Several *Acacia* taxa, formerly described as *A. aulacocarpa*, occur naturally in subcoastal northern and north-eastern Australia and southern New Guinea over a latitudinal range of 6° to 31° S (Thomson 1994, McDonald & Maslin 2000). Recent taxonomic revision of the group (McDonald & Maslin 2000, 2002), supported by analysis of allozyme differentiation among populations (McGranahan *et al.* 1997), has led to the recognition of several distinct species. Populations in the southern lowlands of New Guinea are now classified as *A. peregrinalis*, whilst two species, *A. midgleyi* and *A. celsa*, have been described from the wet tropics region of north Queensland.

In its natural environment, *A. peregrinalis* can develop as a single-stemmed, straight-boled tree with maximum height and diameter at breast height (dbh) of 40 m and 100 cm respectively. *Acacia peregrinalis* displayed superior early growth compared with *A. mangium* on sites in western Sabah, Malaysia (Sim & Gan 1988). Twelve-year-old *A. celsa* from Kuranda, north Queensland, has a basic density of 598 kg m^{-3} and a kraft pulp yield of 55.4%, making it an attractive prospect for pulp production (Clark *et al.* 1991). Wood harvested from natural forests of *A. celsa* in north Queensland is also used for framing, weatherboards and joinery, and is an attractive timber for furniture and cabinet making (Anonymous 1983). The *A. aulacocarpa* species complex is of interest for plantation forestry in Sabah, with *A. peregrinalis* already being planted on an operational scale in western Sabah by Sabah Forest Industries Sdn. Bhd. (Sim, pers. comm.).

This paper reports on the survival, growth and stem form of *A. peregrinalis*, *A. midgleyi* and *A. celsa* provenances at five years of age in a trial in eastern Sabah.

Materials and methods

The trial site at Kolapis B, eastern Sabah (5° 50' N, 117° 55' E) is situated at 15 m asl and receives an annual rainfall of 3200 mm, with no clear dry season. The mean monthly rainfall of all months exceeds 100 mm. The mean annual temperature is 27 °C (Anonymous 2000). The soil is moderately acidic, with surface pH ranging from 4.7 to 5.6. Mudstone and sandstone form the parent materials and the soil texture is sandy-clay loam with a depth of around 1 m. Prior to planting, the trial site was covered in secondary scrub, which was cleared manually and the residues burned. The seedlings were six months old at planting, and had a height of approximately 30 cm.

Twenty-one seedlots provided by CSIRO's Australian Tree Seed Centre (ATSC) were used in the experiment. Details of the species and provenances are given in Table 1. Nineteen provenances of *A. peregrinalis* and one provenance each of *A. midgleyi* and *A. celsa* were tested. A randomised complete block design was used, with four replicates, six-tree line plots, and spacing of 3 × 3 m between trees. Replicates had a distance of 4 m from one another to allow easy access and establishment of fire breaks. No fertiliser was applied. Four times of ring-weedings (diameter 1 m) around all trees were carried out over the first two years after planting. The trial was assessed five years after planting. Height was measured with height poles to 0.1 m, and diameter at 1.3 m (dbh) was measured using a diameter tape to the nearest 0.1 cm. The dbh of multi-stemmed trees was calculated from the square root of the sum of the squares of individual stem diameters. Axis persistence was scored as one of six categories, following Luangviriyasaeng *et al.* (1998):

(1) tree forks at ground level,
(2) tree forks in first quarter of tree height,
(3) tree forks in second quarter of tree height,
(4) tree forks in third quarter of tree height,
(5) tree forks in fourth quarter of tree height, and
(6) single leader persists to top of tree,

Table 1 Details of the 21 provenances of *Acacia peregrinalis, A. midgleyi* and *A. celsa* tested at Kolapis B, eastern Sabah

CSIRO seedlot no.	No. of parent trees	Provenance	Species	Latitude (°S)	Longitude (°E)	Altitude (m)
17601	15	Serki PNG	*A. peregrinalis*	8° 25'	141° 49'	60
17600	25	Tokwa PNG	*A. peregrinalis*	8° 42'	141° 32'	30
16949	11	Duaba PNG	*A. peregrinalis*	8° 13'	142° 58'	25
16979	25	West of Wipim PNG	*A. peregrinalis*	8° 40'	142° 43'	40
16950	37	Wasua Pedeya PNG	*A. peregrinalis*	8° 17'	142° 52'	10
17560	30	Dimisisi PNG	*A. peregrinalis*	8° 31'	142° 13'	50
17627	15	Morehead District PNG	*A. peregrinalis*	8° 40'	141° 30'	20
16996	150	Bimadebun PNG	*A. peregrinalis*	8° 38'	142° 03'	40
16988	20	Pongaki PNG	*A. peregrinalis*	8° 40'	141° 51'	30
16976	50	Wipim PNG	*A. peregrinalis*	8° 47'	142° 52'	45
16981	15	Kapal PNG	*A. peregrinalis*	8° 37'	142° 47'	40
16995	150	Arufi E Morehead PNG	*A. peregrinalis*	8° 43'	141° 55'	25
17551	30	Bensbach-Balamuk PNG	*A. peregrinalis*	8° 53'	141° 17'	25
17629	20	Gamaewe PNG	*A. peregrinalis*	8° 58'	142° 53'	20
16982	20	Kuru PNG	*A. peregrinalis*	8° 52'	143° 05'	30
16989	20	Derideri PNG	*A. peregrinalis*	8° 40'	141° 50'	30
16947	18	Makapa PNG	*A. peregrinalis*	7° 56'	142° 35'	15
16948	20	Isago Arimia River PNG	*A. peregrinalis*	8° 01'	142° 41'	10
16946	63	Balimo District PNG	*A. peregrinalis*	8° 05'	142° 58'	12
18285	12	NNW Kuranda Qld	*A. celsa*	16° 40'	145° 31'	460
18358	8	Lockhart Qld	*A. midgleyi*	12° 50'	143° 18'	15

PNG: Papua New Guinea, Qld: Queensland

where forking was defined as having occurred if the diameter of a competing leader was more than half that of the main leader.

All data were checked and screened for outliers and verified prior to analysis. The statistical package Genstat 5.4 was used for analysis of variance of the plot means for percentage survival, height, dbh and axis persistence.

Results

Table 2 shows the survival, growth and axis persistence at age five years for the species and provenances tested. Survival was generally good, averaging 82% across the trial, and did not differ significantly between species or provenances. *Acacia peregrinalis* clearly outperformed the other two species in terms of height and dbh ($p < 0.001$). Differences among *A. peregrinalis* provenances for growth traits were non-significant; provenance mean height of this species ranged from 16.4 to 19.1 m and dbh from 14.9 to 17.9 cm, with a species mean height of 18.0 m and dbh of 16.2 cm. *Acacia celsa* averaged 15.2 m in height and 11.9 cm in dbh; the corresponding values for *A. midgleyi* were 13.2 m and 9.4 cm. *Acacia peregrinalis* also had significantly better ($p < 0.05$) stem form than the other two species. The axis persistence score averaged 3.33 for *A. peregrinalis*, 2.23 for *A. celsa* and 2.56 for *A. midgleyi*. Differences in axis persistence among provenances of *A. peregrinalis* were not significant.

Discussion

Our study showed that *A. peregrinalis* was clearly superior to *A. celsa* and *A. midgleyi* in terms of its growth and stem form. It should be noted that the design of the trial, with individual seedlots represented by line plots, tended to overestimate seedlot differences. This is because the plots of slower-growing seedlots were overtopped and suppressed by the adjacent faster-growing plots once competition had set in. Nonetheless, the results showed clearly that all 19 provenances of *A. peregrinalis* tested were superior to both *A. celsa* and *A. midgleyi*. It is possible that there are other provenances of *A. celsa* and *A. midgleyi* which are better than those tested in our trial, but it seems unlikely that even the best provenance of any of these species will have a performance comparable to that of *A. peregrinalis*.

Acacia peregrinalis attains a greater size in natural forests than do the other two species (Thomson 1994), so its better performance in Sabah may reflect an intrinsically greater growth potential. *Acacia celsa* and *A. midgleyi* occur naturally in north Queensland, Australia, south of latitude 12° S, and the climate there is seasonal, with a distinctly cooler dry season (Thomson 1994). For example, Lockhart River, the origin of the *A. midgleyi* provenance tested in this trial, receives only 161 mm of rain over the five-month period from June to October in an average year, and a mean annual rainfall of 2125 mm (Anonymous 1988). The climate of that part of Western Province, Papua New Guinea (latitude 8° to 9° S), where *A. peregrinalis* occurs naturally, is more similar to that of Sabah, with a

Table 2 Provenance and species means for height, dbh, axis persistence and survival at age five years in the trial at Kolapis B, eastern Sabah

Species and provenance	Height (m)	Dbh (cm)	Axis persistence score[1]	Survival (%)
A. peregrinalis				
Serki	18.2	16.5	3.19	79.2
Tokwa	17.2	15.8	3.37	66.7
Duaba	18.8	17.7	2.85	87.5
West of Wipim	18.6	17.5	2.65	91.7
Wasua Pedeya	18.2	17.4	2.69	75.0
Dimisisi	17.7	16.3	3.72	83.3
Morehead	17.9	17.4	3.15	75.0
Bimadebun	16.4	15.3	3.58	95.8
Pongaki	17.1	15.5	3.71	95.8
Wipim	18.2	17.3	3.08	79.2
Kapal	18.5	17.4	3.45	75.0
Arufi	17.4	15.8	4.00	83.3
Bensbach-Balamuk	18.4	16.0	3.12	87.5
Gamaewe	17.2	17.7	3.61	79.2
Kuru	19.1	17.6	3.19	70.8
Derideri	18.0	14.9	4.45	91.7
Makapa	18.6	17.9	2.71	83.3
Isago Arimia River	17.7	17.1	4.07	66.7
Balimo	18.3	17.2	2.65	83.3
Mean for *A. peregrinalis*	18.0	16.2	3.33	81.6
A. celsa				
NNW Kuranda	15.2	11.9	2.23	87.5
A. midgleyi				
Lockhart	13.2	9.4	2.56	79.2
Standard error of difference of means for species	0.8	1.18	0.58	13.1
Significance of difference between species	***	***	*	ns
Significance of difference between *A. peregrinalis* provenances	ns	ns	ns	ns

ns: Not significant, * : $p < 0.05$, *** : $p < 0.001$
[1]See text for explanation of axis persistence score

less pronounced cooler dry season (Thomson 1994). Balimo, the location of one of the *A. peregrinalis* provenances tested, receives an annual rainfall averaging 2476 mm, but with only one month having less than 100 mm. It is, therefore, expected that *A. peregrinalis* would be better adapted to the climate of Kolapis B, with its high annual rainfall and lack of a distinct dry, cool season. Differences among the 19 provenances of *A. peregrinalis* tested appeared to be relatively minor. The small sample size, with only four replicates of six-tree plots per provenance, made it difficult to establish statistical significance for any differences. In a larger, better-replicated trial in north-eastern Thailand, Luangviriyasaeng *et al.* (1998) found that *A. peregrinalis* provenances from south-east of the Fly River east of latitude 142° E, grew significantly faster than those from two other local regions (north of the Fly River and south-west of the Fly River west of longitude 142° E). Although provenance differences were not statistically significant in our trial, a similar trend was found, with seven of the ten faster-growing provenances coming from the region south-east of the Fly River.

Growth was substantially faster at Kolapis B than that reported by Luangviriyasaeng *et al.* (1998) from a study in Thailand. The authors obtained an overall mean height of 12.3 m and mean dbh of 17.7 cm at age six years for a set of *A. peregrinalis* provenances very similar to those we tested. The higher mean dbh obtained by these workers is attributable to their trial being selectively thinned to a stand density of 440 stems ha^{-1} at age two years, with four inferior trees being felled from each five-tree progeny plot.

The mean height of 18.0 m and dbh of 16.6 cm at age five years attained by *A. peregrinalis* in our trial compares favourably with growth rates of the established plantation species of *A. mangium*, given similar site-types and silviculture. For example, *A. mangium* had a mean height of 20.4 m and dbh of 17.4 cm at age five years in a trial in at Gum Gum, Sabah, a site having very similar climate and soil to Kolapis B (personal observation). In a species-provenance trial at Dong Ha in central Vietnam, a provenance of *A. peregrinalis* from Morehead, PNG reached a mean dbh of 7.5 cm and a height of 7.2 m in 52 months, compared with an overall mean dbh of 8.3 cm and mean height of 6.8 m for seven provenances of *A. mangium* in the same trial (Nghia & Kha 1998).

It is concluded that *A. peregrinalis* is a promising species for plantation forestry in eastern Sabah. Examination of the wood quality of plantation-grown trees from the trial reported here would be a logical next step in exploring the potential of *A. peregrinalis.*

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