PERFORMANCE OF SOME AUSTRALASIAN ACACIAS 3.5 YEARS AFTER PLANTING AT MAKOKA, MALAWI

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MAGHEMBE, J.A., CHIRWA, P.W. & KWESIGA, F. 1997. Performance of some Australasian acacias 3.5 years after planting at Makoka, Malawi. Fifteen species and provenances of Australasian acacias selected by matching the climate of the planting site in Malawi and seed collection sites in Australia and Papua New Guinea were grown for 3.5 y at Makoka, Malawi. The climate at Makoka is sub-humid, with a unimodal rainfall regime (November-April) and annual total rainfall range between 850 and 1200 mm. The three provenances of *Acacia auriculiformis* tested were clearly superior to the rest of the species in growth and biomass production, producing a total biomass of 46-54 t ha^{-1} dry wt in 3.5 y. Other fast-growing species included *Acacia glaucocarpa*, (28.5 t ha^{-1}), *A. neriifolia*, (26.4 t ha^{-1}), *A. holosericea* (25.3 t ha^{-1}) and *A. aulacocarpa* (21.8 t ha^{-1}). The rest of the species grew poorly with below average production when compared to fast-growing multi-purpose trees (MPTs) in Southern Africa. The selection of *A. auriculiformis, A. holosericea, A. aulacocarpa, A. glaucocarpa, A. neriifolia, A. crassicarpa* and *A. difficilis* by climatic matching of seed sources and the planting site out-performed previous provenances tested at Makoka while in the other species it was not very successful. The use of this model for germplasm aquisition together with characterising the species special site requirements like obligate symbionts is recommended.

Keywords: *Acacias* - Australasian - germplasm - performance - biomass

MAGHEMBE, J.A., CHIRWA, P.W. & KWESIGA, F. 1997. Prestasi beberapa acacia Australasia 3.5 tahun selepas penanaman di Makoka, Malawi. Lima belas spesies dan provenans acacia Australasia yang dipilih melalui penyesuaian iklim di tapak penanaman di Malawi dan tapak pengutipan biji benih di Australia dan Papua New Guinea ditanam selama 3.5 tahun di Makoka, Malawi. Makoka beriklim sublembap, dengan regim hujan unimod (November-April) dan jumlah hujan tahunan berjulat di antara 850 dan 1200 mm. Tiga provenans *Acacia auriculiformis* yang diuji didapati superior kepada sebahagian lagi spesies dalam pertumbuhan dan pengeluaran biojisim, mengeluarkan biojisim berjumlah 46-54 t ha^{-1} berat kering dalam 3.5 tahun.

Lain-lain spesies yang cepat membesar termasuklah *Acacia glaucocarpa* (28.5 t ha^{-1}), *A. neriifolia* (26.4 t ha^{-1}), *A. holosericea* (25.3 t ha^{-1}) dan *A. aulacocarpa* (21.8 t ha^{-1}). Spesies yang lain tumbuh dengan perlahan dengan pengeluaran di bawah purata jika dibandingkan dengan pokok pelbagai guna yang cepat tumbuh (MPTs) di Afrika Utara. Pemilihan *A. auriculiformis, A. holosericea, A. aulacocarpa, A. glaucocarpa, A. neriifolia, A. crassicarpa* dan *A. difficilis* melalui penyesuaian iklim sumber-sumber biji benih dari tapak penanamannya daripada menunjukkan prestasi yang lebih baik daripada provenans terdahulu yang diuji di Makoka sementara spesies yang lain kurang berjaya. Penggunaan model ini untuk memperoleh germplasma bersama dengan mencirikan keperluan khusus tapak spesies seperti simbion obligat disyorkan.

Introduction

The artificial regeneration of *Acacia* species endemic to Australasia is a recent phenomenon (Boland & Turnbull 1981) due to their good performance in many sites in Southeast Asia and mainland China (Turnbull 1991), their potential for nitrogen fixation, lack of thorns in the majority of species (and associated easy management on farm), and expectation to grow fast in other foreign sites as demonstrated by Australasian *Eucalyptus* species abroad. In an initial trial at Makoka, of 18 Australasian acacias tested, only *Acacia auriculiformis* and *A. aulacocarpa* showed good survival and growth (Maghembe & Prins 1994). *Acacia shirleyi, A. julifera, A. burrowii* and *A. difficilis* showed good growth (height mean annual increment (MAI) >1.5 m), but generally poor survival. *Acacia victoriae, A. ampliceps, A. pachycarpa,* and *A. murrayana* failed to grow.

We noted that most of the Australasian germplasm we used originated from semi-arid environments where they may have developed special mechanisms and symbioses to cope with water stress, nutrient availability and environmental periodicity. These views were based on recent evaluations of mycorrhizal endophytes of native Australasian plants (Warcup 1980, Osonubi *et al.* 1991) and our experiences with the failure of pines to grow in East Africa until their obligate ectomycorrhizae endophytes were introduced (Mikola 1970, Maghembe & Redhead 1980).

However, discussions with Australian experts on tree introductions raised the possibility that the performance of Australasian *Acacia* species could be improved by selecting seed sources using new approaches of matching climatic conditions of introduction sites and seed sources in Australia (Booth *et al.* 1988). This climatic matching is based largely on new approaches in modelling climatic conditions in remote seed collection areas and test sites, the two located in distant positions on earth (Wahba & Wendeberger 1980). Seed sources of 15 Australasian acacia species/provenances based on this matching system were specifically selected for Makoka, Malawi (Booth *et al.* 1989). We present data on early survival, growth and production of the 15 Australasian acacias.

Materials and methods

The study area

The experimental area is located at Makoka Agricultural Research Station (15° 30' S, 35° 15' E; 1029 m a.s.l.), near Zomba, Malawi. The long term (over 20 years) total annual rainfall at Makoka varies from 850 to 1250 mm with a mean of 1044 mm. In recent years and during the experiment in 1992 and in 1994, the annual total rainfall was as low as 560 mm y^1. The rainfall is uni-modal lasting from November to April followed by a long dry season, May to October. The potential annual evapotranspiration is 1360 mm. The mean day time temperatures at Makoka vary from 16 to 24 °C with extremes of 11 °C in July and 30°C in November.

Experimental design and management

Fifteen Australasian acacias (Table 1) were planted in January 1990 in a randomised complete block design and replicated three times. Plots consisted of individual species/provenances arranged in two rows, each with 6 trees (12 trees/plot); planted at the spacing of 2.0 m within and 1.5 m between rows. Tree rows were on ridges made for erosion control. Throughout the trial period, tree plots were kept free from weeds by manual hoeing.

Table 1. Seed sources for Australasian acacias planted in Makoka in January 1990

Species name	Seed origin	Latitude	Longitude	Altitude (m)
Acacia auriculiformis	Cooper Creek, NT	12° 06' S	133° 11'E	40
Acacia auriculiformis	Morehead River, PNG*	8° 43'S	143° 36'E	18
Acacia auriculiformis	Morehead River, QLD*	15° 03'S	143° 40 E	50
Acacia aulacocarpa	Morehead River, PNG	8° 42'S	141° 34'E	30
Acacia crassicarpa	Bimadebun, PNG	8° 37'S	141° 55'E	25
Acacia difficilis	Anne Creek, NT*	13° 14'S	134° 45'E	60
Acacia flavescens	Lockhart, QLD	12° 47'S	143° 18'E	20
Acacia glaucocarpa	Gayndah, QLD	25° 32'S	151° 29'E	390
Acacia holosericea	Sedge Cattle Ranch, QLD	16° 46'S	145° 15'E	380
Acacia julifera	Mt. Garnet, QLD	18° 49'S	144° 35'E	640
Acacia leptocarpa	Lake Evella, NT	12° 26'S	135° 46'E	80
Acacia melanoxylon	Blibli, QLD	26° 37'S	153° 02'E	95
Acacia neriifolia	Toowoomba, QLD	27° 24'S	152° 00'E	500
Acacia plectocarpa	Roper River, NT	15° 20'S	135° 20'E	30
Acacia rothii	Han River, QLD	15° 10'S	143° 45'E	80

*PNG = Papua New Guinea, QLD = Queensland, NT = Northern Territory.

Data collection and analysis

The trial was assessed for survival, growth and production at 2 and 3.5 y after planting. Assessment for survival was based on a complete count of the trees originally planted in each plot and subjected to arcsine transformation prior to statistical analysis. Growth measurements included tree height, diameter at the root collar and crown spread.

Nitrogen was determined by the macro-Kjeldahl's procedure. For the determination of P and K, sub-samples of plant materials were ashed in a muffle furnace at 450 °C for 6 h and dissolved in 6 N HCl. Aliquots from this solution were used to determine P by colorimetry and K by flame photometry. All data were organised in data chain (Rodger & Muraya 1991) and analysed by Genstat for a randomised complete block design. Significant plot means were separated by the standard error of differences of means (SED).

Results and discussion

Survival and growth

The survival of the 15 accessions of Australasian acacias was generally better than the 18 acacia species from Australia tested in Makoka in 1988 (Maghembe & Prins 1994). The differences between species were barely significant ($p<0.055$). There were significant differences, however, in growth in height ($p<0.001$), diameter development ($p<0.001$) and crown spread ($p< 0.024$). At the early stage (Table 2), *Acacia glaucocarpa,* the three *A. auriculiformis* provenances, *A. neriifolia, A. crassicarpa, A. julifera,* and *A. plectocarpa* achieved height of more than 3.5 m in 2 y. The rest were generally slow growing when compared to other species of multipurpose trees planted at Makoka (Maghembe & Prins 1994) and in similar environments within the Miombo ecozone of Southern Africa (Gwaze 1993, Ngulube *et al.* 1993, Kamara & Maghembe 1994). At the end of 3.5 y, the same species maintained their lead both in height, root collar growth and crown spread (Table 3). However, their MAI for height (1.44 - 2.20 m) were generally lower than those of *Acrocarpus fraxinifolius, Calliandra calothyrsus, Senna siamea, Senna spectabilis* and *Sesbania sesban* grown in the same site (Maghembe & Prins 1994).

The good growth of provenances of *Acacia auriculiformis* shown here has also been demonstrated elsewhere in Southern and Southeast Asia (Turnbull 1991) as well as in Africa (Gwaze 1993, Ngulube *et al.* 1993, Maghembe & Prins 1994). This species has therefore been recommended for community forestry programmes to supply poles and fuelwood in Malawi in view of its fast growth and high basic density (Ngulube *et al.* 1993).

Table 2. Survival, growth and biomass production in 15 Australasian acacias 24 months after planting at Makoka, Malawi

Species	Survival %	Height (m)	Root collar diameter (cm)	Crown diameter (m)	Total biomass production (t ha^{-1})
A. auriculiformis, NT	97.2	3.57	7.02	2.57	18.31
A. auriculiformis, PNG	97.2	4.22	6.85	2.67	20.75
A. auriculiformis, QLD	100.0	3.10	6.15	2.42	14.92
A. aulacocarpa, PNG	97.2	2.51	5.50	2.04	8.93
A. crassicarpa, PNG	83.3	3.04	4.77	2.19	8.43
A. difficilis, NT	100.0	2.19	5.46	2.75	8.18
A. flavenscens, QLD	94.4	2.58	4.42	1.46	9.46
A. glaucocarpa, QLD	91.7	5.52	6.36	2.67	16.35
A. holosericea, QLD	91.7	2.80	4.81	2.25	16.54
A. julifera, QLD	100.0	3.14	4.80	2.57	8.18
A. leptocarpa, NT	94.4	2.39	4.10	1.54	2.80
A. melanoxylon, QLD	97.2	2.95	4.19	1.74	6.44
A. neriifolia, QLD	75.0	3.76	4.97	1.97	5.74
A. plectocarpa, NT	80.6	3.07	5.85	2.10	12.05
A. rothii, QLD	67.0	1.78	3.42	1.30	3.77
SED	11.4	0.65	1.15	0.41	8.28
CV %	14.4	21.40	22.10	19.40	55.10

Table 3. Growth and biomass production (dry weight basis) in 15 Australasian acacias 42 months after planting at Makoka, Malawi

Species	Height (m)	Root collar diameter (m)	Crown diameter (m)	*Total biomass production	
				t ha^{-1}	MAI
A. auriculiformis, NT	6.23	9.63	4.55	53.49	(15.28)
A. auriculiformis, PNG	5.37	9.83	4.10	44.52	(12.72)
A. auriculiformis, QLD	5.69	12.90	4.33	46.22	(13.20)
A. aulacocarpa, PNG	5.40	9.00	4.40	21.81	(6.23)
A. crassicarpa, PNG	3.37	5.97	2.69	15.48	(4.42)
A. difficilis, NT	3.09	5.67	3.43	15.05	(4.30)
A. flavenscens, QLD	3.91	7.20	2.15	15.55	(4.44)
A. glaucocarpa, QLD	5.71	10.40	3.73	28.52	(8.15)
A. holosericea, QLD	4.38	8.73	3.53	25.30	(7.23)
A. julifera, QLD	4.42	7.60	3.34	11.95	(3.42)
A. leptocarpa, NT	3.36	7.93	3.00	10.67	(3.05)
A. melanoxylon, QLD	5.62	4.17	2.22	16.78	(4.80)
A. neriifolia, QLD	7.70	10.23	3.09	26.41	(7.55)
A. plectocarpa, NT	3.54	6.20	3.06	16.21	(4.63)
A. rothii, QLD	3.88	6.40	2.75	5.48	(1.57)
SED	1.45	2.82	1.32		
CV %	31.5	35.6	39.6		

* The analysis of variance for biomass was based on single tree mean for each species.

Biomass production and nutrient content

At 24 months, only *A. auriculiformis* provenances, *A. glaucocarpa* and *A. holosericea* showed biomass production levels (8.90 - 14.80 t ha^{-1} y^{1}) comparable to average production of species at the same age in Makoka and in other sites in southern Africa (Table 2). Most of the other species showed very low production, the poorest being *A. leptocarpa, A. rothii, A. neriifolia* and *A. melanoxylon.*

At the end of 3.5 y, *Acacia auriculiformis* provenances were clearly the most superior species, in line with earlier findings (Gwaze 1993, Ngulube *et al.* 1993, Maghembe & Prins 1994). *Acacia neriifolia* with a slow start, however, produced 26.41 t ha^{-1} of standing biomass (MAI, 7.55 t ha^{-1} y^{1}). Other species showing good growth were *A. glaucocarpa* (28.5 t ha^{-1} y^{1}), *A. holosericea* (25.30 t ha^{-1}) and *A. aulacocarpa* (21.8 t ha^{-1}). The rest of the species were generally below average when compared to fast-growing MPTs in the Miombo ecological zone of southern Africa (Kamara & Maghembe 1994, Maghembe & Prins 1994). In addition, the coppicing ability, which was visually assessed, was very poor (less than 50%) in all the species and provenances studied.

Australasian acacias are known to coppice well in the humid tropics (Visaratana 1991), while coppicing under sub-humid conditions is satisfactory only when trees are cut in the rainy season and with one branch left uncut (Ngulube *et al.* 1993). These species are therefore unsuitable for agroforestry technologies based on coppice regeneration for the production of large volumes of green manures for soil improvement in sub-humid and semi-arid environments.

The contents of phosphorus and potassium in the seven best performing species and provenances were generally similar to those of *Calliandra calothyrsus, Gliricidia sepium* and *Sesbania sesban* at the same age in Makoka. However, the Australasian acacias showed lower nitrogen concentrations (Table 4). As N is the most limiting nutrient in soils of most of southern Africa, these results suggest further limitations for the choice of these species for green manure/mulch production. However, the high biomass production, especially with regard to *A. auriculiformis,* makes them a good choice for fuelwood and poles.

Table 4. Foliar nutrient concentrations (% dry weight) in some fast-growing Australasian acacias at 3.5 y after planting at Makoka, Malawi

	Nitrogen %	Phosphorus %	Potassium %
Acacia auriculiformis, NT	2.52	0.23	1.68
Acacia auriculiformis, PNG	2.45	0.22	1.68
Acacia auriculiformis, QLD	2.63	0.21	1.33
Acacia aulacocarpa, PNG	2.07	0.25	1.36
Acacia glaucocarpa, QLD	2.10	0.27	1.02
Acacia holosericea, QLD	2.20	0.24	1.48
Acacia neriifolia, QLD	1.75	0.29	1.16
**Calliandra calothyrsus*	2.60	0.21	0.51
**Gliricidia sepium*	3.70	0.25	1.05
**Sesbania sesban* (magoye)	3.80	0.23	-

* Grown at Makoka and given for comparison.

The accessions of *A. auriculiformis, A. holosericea, A. aulacocarpa, A. glaucocarpa, A. neriifolia, A. plectocarpa, A. crassicarpa* and *A. difficilis* selected by climatic matching of seed sources and the planting site (Booth *et al.* 1988) by far out-performed those planted in Makoka earlier (Maghembe & Prins 1994). This method of selecting seed sources for distantly placed planting sites is clearly valuable for some species and should be used when possible. However, the general expectation of excellent performance of Australasian acacias to match the growth of *Eucalyptus* abroad has to be revised at least for southern Africa. The selection model for seed sources used in this study (Booth *et al.* 1989) needs to be accompanied with closer studies on symbiotic relationships (Osonubi *et al.* 1991) conferring Australasian acacias special mechanisms to cope with environmental conditions within their natural range. In previous studies, simultaneous introductions of the test species with their obligate symbionts (Mikola 1970) allowed good performance of species introductions in Africa where earlier introductions had failed. This is especially important in view of the dismal performance of many of the Australasian acacia species in this and other studies in southern Africa (Gwaze 1993, Ngulube *et al.* 1993). Further studies like those of Warcup (1980) on key Australasian acacias are therefore necessary as a first step in the characterisation of these species for introduction to Africa and other distantly placed regions.

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