GROWTH OF THREE MULTIPURPOSE TREE SPECIES ON TIN TAILINGS IN MALAYSIA

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KAMIS AWANG. 1994. Growth of three multipurpose tree species on tin tailings in Malaysia. This study investigated the effect of tree management techniques (pollarding and pruning) on two genotypes each of *Acacia mangium*, *Acacia auriculiformis* and *Leucaena* sp. planted on a mixture of sand and slime tin tailings. Eighteen months growth was assessed. Survival was generally high for all the genotypes. The best growth was recorded in *A. auriculiformis*, followed by *A. mangium* and *Leucaena* sp.

Key words: Tin tailings - Malaysia - pollarding - pruning - *Acacia mangium* - *Acacia auriculiformis* - *Leucaena* - rehabilitation

KAMIS AWANG. 1994. Pertumbuhan tiga spesies pokok pelbagai guna pada hampas lombong di Malaysia. Kajian ini telah menyelidik kesan teknik-teknik pengurusan pokok (pangkas dan cantas) pada dua genotip *Acacia mangium, Acacia auriculiformis* dan *Leucaena* sp. yang ditanam pada campuran pasir dan selut hampas lombong. Pertumbuhan setelah lapan belas bulan dikaji. Survival didapati tinggi pada keseluruhannya untuk kesemua genotip. Pertumbuhan yang paling baik dicatat oleh *A. auriculiformis* diikuti oleh *A. mangium* dan *Leucaena* sp.

Introduction

The tin industry has been one of the mainstays of the Malaysian economy. Mining operations have left large tracts of land barren. In Peninsular Malaysia where most of the country's tin mining activities are concentrated, the extent of affected areas (called tin tailings) is estimated to be about 202 700 ha (Ang 1987). Although this represents only about 1.5% of the total land area, it involves a considerable amount of prime lowland that once supported highly productive forests. Besides the destruction of these original ecosystems, mining activities have been cited to cause siltation of river beds and drainage systems, and destruction of agricultural land (Shamsuddin *et al.* 1986).

Currently, only small pockets of tin tailings areas are used for productive purposes. These include settlement, recreational uses, vegetable farming and fruit growing. Fish culture is sometimes practiced in old mining pools, while some poultry and swine farming are integrated with fruits or fish. However, all these agricultural production systems require high inputs of capital and labour.

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Farming, for example, usually requires heavy fertilization (both organic and inorganic) and irrigation (Lim *et al.* 1981, Shamsuddin *et al.* 1986). According to Lai (1970), fertilizers constitute 57 - 95% of the input costs of vegetable cultivation on tin tailings in Kinta Valley.

Over the years, various field and controlled environment researches have been conducted to better utilize tin tailings for agriculture. Most of these efforts have focused on finding ways of ameliorating the physical and chemical status of the tailings (Lim & Maesschalck 1980, Lim *et al.* 1981). A wide range of materials, both inorganic and organic, have been tested. These include synthetic soil conditioners such as polyacrylamide and bitumen, sewage sludge, oil palm mill effluent, rice husks, composted sawdust, natural rubber skim latex, peat, chicken dung and fertilizers. Some of these materials can improve the physical and chemical properties of the tin tailings, and thus promote crop growth and yield.

Trees are known to have beneficial effects on soils (e.g., see Nair 1987). The prospect of using trees, especially those with known multiple uses, to rehabilitate tin tailings should be given serious consideration. Apart from the studies reported by Mitchell (1957) and Ang (1986), little has been done in this area. Since 1987, the Faculty of Forestry at the Universiti Pertanian Malaysia has initiated a number of studies involving species and provenance selection, establishment techniques and tree management. One of these studies was a trial established to investigate how tree management affects the performance of two genotypes each of three multipurpose tree species (MPTS). It was one of 11 sites involved in the MPTS Research Network trials supported by the Forestry/Fuelwood Research and Development (F/FRED) project of the Winrock International Institute for Agricultural Development. Eighteen months growth is reported here.

Materials and methods

The study site is in the Universiti Pertanian Malaysia's experimental farm, located at latitude 3° 2' N, longitude 101° 42' E and about 31 m above sea level. The area is flat. It was mined for tin more than 15 years ago, and has since been left unused. The soil in this tin tailing area is described as Entisol with udic moisture regime. The depth of the water table is about 160 cm and its drainage is somewhat poor. Texturally, the tailing is a mixture of sand and slime (clay and silt). The upper layers consist of sandy loam with the percentage of sand exceeding 60% to a depth of 108 cm. Below this, clay and silt constitute a greater proportion of the texture. The soil is low in C, N, P and exchangeable bases. The pH is about 5.1. Table 1 gives a detailed description of the soil profile.

Climatic data collected over 10 years (1977-1987) indicate that the site has a mean maximum annual temperature of 32.8 °C and a mean minimum annual temperature of 22 °C. The rainfall is of bimodal distribution with peak falls in March-May and September-November, and a mean annual total of 2140 mm. Weather information collected over the duration of the experiment is shown in Figure 1. The site experiences an average windspeed of 0.86 m/sec. and an annual evaporation of 1527 mm. It receives a daily average of 5.8 h of sunshine.

Table 1. Soil profile characteristics

Depth (cm)	Horizon	Percentage			Bulk density (g/cc)	Water content (%)	
		Clay	Silt	Sand		1/3 bar	15 bar
0 - 14	Ap	10.5	20.4	69.1	1.80	11.4	4.9
14 - 27	C1	6.1	14.6	79.3	1.71	6.7	2.2
27 - 38	C2	9.0	17.0	74.0	1.71	7.9	3.9
38 - 66	C3	11.3	27.1	61.6	1.82	11.6	5.3
66 - 108	C4	11.0	21.9	67.1	1.93	7.2	4.8
108 - 143	C5	43.0	27.4	29.6	-	-	17.4
143 - 200	C6 Gray	43.8	22.5	33.7	-	-	18.3
143 - 200	C6 Black	47.0	30.1	22.9	1.31	36.6	23.3

Depth (cm)	pH		Basic cation (NH_4OAC) Meg/100g					CEC (NH_4OAC)	N (%)	O.C. (%)	P (ppm)
	KCl	H_2O	Ca	Mg	Na	K	Sum				
0 - 14	4.6	5.6	2.1	0.2	0.1	0.1	2.5	3.3	.06	1.08	9.7
14 - 27	4.5	5.5	0.6	0.1	0.1	-	0.8	0.9	.01	0.14	10.8
27 - 38	4.3	5.3	0.6	0.1	0.1	-	0.8	1.6	.01	0.18	11.9
38 - 66	4.0	4.8	1.0	0.1	0.1	-	1.2	2.8	.04	0.62	25.3
66 - 108	3.9	4.7	0.5	0.2	0.2	-	0.9	1.7	.01	0.13	5.9
108 - 143	3.5	4.7	1.0	0.3	-	-	1.3	6.3	.03	0.33	4.3
143 - 200	3.7	4.8	0.9	0.3	0.2	0.1	1.5	1.5	.03	0.62	6.4
143 - 200	3.1	5.0	1.3	0.2	0.2	0.1	1.8	13.7	.09	2.40	11.2

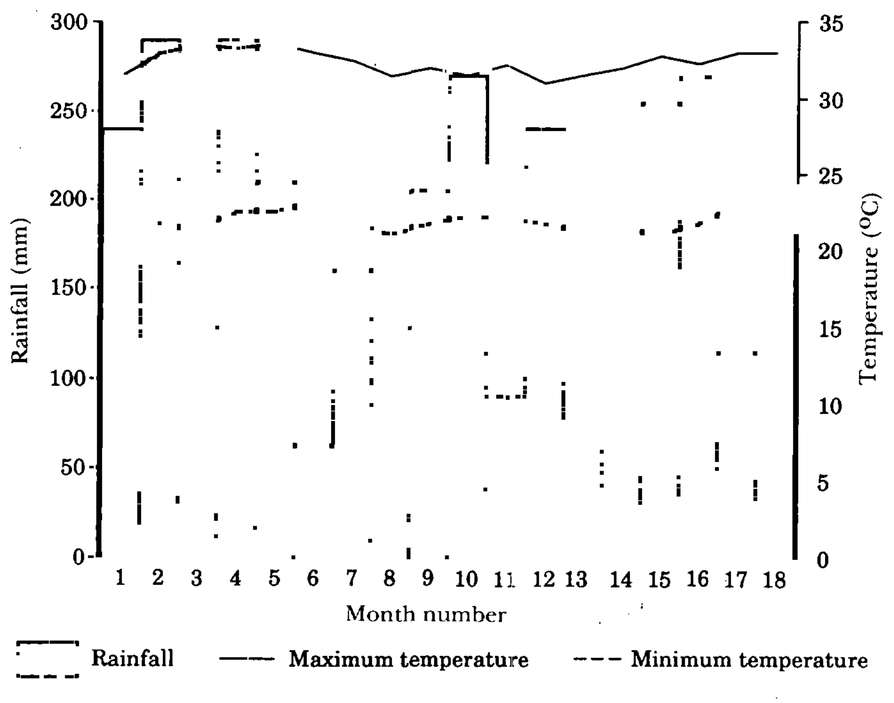

Figure 1. Rainfall and temperature at the study site during experiment

Experimental

This was one of F/FRED's multilocational trials using a standardised methodology. The experimental design was a randomized complete block with four replicates, comparing two genotypes each of three species, under three management practices. The term 'genotype' is used to describe the subspecies treatment level, as both provenances and a *Leucaena* hybrid were included. Genotypes were chosen for their potential benefits to the soil and small farmers. The species and genotypes used were:

Species	Provenance-seedlot
i. *Acacia auriculiformis*	1. Morehead, Queensland, CSIRO No. 15477
	2. Bensback Balamuk, Papua New Guinea, CSIRO No. 15648
ii. *Acacia mangium*	1. Iron Range, Queensland, CSIRO No. 15677
	2. Boite, Papua New Guinea, CSIRO No. 15642
iii. *Leucaena diversifolia*	1. Hawaii hybrid KX3
	2. Hawaii K 156

The three management practices were

- Pollarding at two meters at the age of 24 months
- Pruning up to 50% of the total stem height at the age of 18 months
- No cutting at all

Research conducted under the F/FRED Project is for the benefit of small farmers. The two cutting treatments selected were a general simulation of farmers' practices of managing trees on their farms.

The seedlings were planted at a spacing of 2 × 1 m in 7 × 14 m plots with 49 trees per plot. They were inoculated with rhizobia obtained from the Rubber Research Institute Malaysia. Before planting, the area which was covered with grass was disc ploughed to a 30 cm depth. It was then rotovated to a depth of 15 cm. Drainage was dug along the western and southern boundaries of the area. Weeds were controlled through herbicide (Roundup) applications at 3-4 month intervals. No fertilizer was applied. No fire problems were faced.

Measurements of survival, height, basal diameter (10 cm from the ground), diameter breast height (dbh), and above ground biomass were made every six months. Dimensional measurements were made on nine inner trees. Biomass measurements were made by sampling two trees from the outer rows each time.

Biomass was separated into three fractions: stem, foliage, and branches and twigs. Daily weather information was also recorded. The experiment lasted for three years, from December 1987 until December 1990.

For this paper, only eighteen months data were analyzed. All three management treatments were used as additional sources of replication since cutting management treatments had not yet begun. The data were analyzed for variance, and means were compared using the Studentized range test. FMOD, a statistical package developed by F/FRED, was used for the analysis.

Results and discussion

The results of the analysis of variance are given in Table 2. Genotypes differed significantly ($p < 0.01$) for all the parameters analyzed. A certain degree of caution must be used when evaluating the biomass differences. The data were very variable as indicated by the high (69.9%) coefficient of variation obtained (Table 3). The limited number of trees used in sampling probably accounted for most of this variability.

Table 2. Analysis of variance of survival, height, dbh and biomass

Source of variation	df	Survival		Height		Dbh		Biomass	
		MS	P-value,	MS	P-value,	MS	P-value,	MS	P-value,
Blocks	3	222.3	0.1349	4.34	0.0032	4.11	0.0004	15.99	0.0038
Genotypes	5	894.5	0.0000	13.55	0.0000	8.65	0.0000	21.41	0.0000
Residual	63	115.6		0.86		0.59		3.23	

Table 3. Survival and growth of the six genotypes at 18 months

Genotype	Survival (%)	Height (m)	Dbh (cm)	Biomass (kg)
A. auriculiformis (PNG)	98.3 a	5.2 a	3.4 a	4.0 a
A. auriculiformis	99.2 ab	5.6 ab	3.6 ab	3.2 ab
L. diversifolia (K156)	85.7 c	3.5 c	1.8 c	1.0
L. diversifolia hybrid (KX3)	76.6 d	2.9 c	2.0 c	0.8
A. mangium (PNG)	93.5 abcd	5.0 ab	3.8 ab	3.6 ab
A. mangium (QLD)	94.2 abcd	4.0 c	3.1 ab	2.7 ab
Mean	91.2	4.4	3.0	2.6
CV (%)	11.8	21.1	26.0	69.9

Means having the same letters are not significantly different at 5% level using Studentised range test.

Survival was generally high for all the genotypes, with the two acacias having greater than 93% (Table 3). The lowest survival percentage was recorded in *Leucaena* hybrid (KX3). In general, the best growth was recorded in *A. auriculiformis* followed by *A. mangium* and *Leucaena* sp. Differences between genotypes within each species were generally not statistically significant. However, the Queensland provenance tended to grow better than the Papua New Guinea provenance in the case of *A. auriculiformis*; this pattern was the reverse of *A. mangium*. *L. diversifolia* (K156) appeared to be better than its hybrid KX3.

The results indicate that the species tested are very promising, especially the two acacias. For these species the growth rates recorded were comparable to those recorded on undisturbed sites. For example, Sim and Gan (1991) reported mean annual increments of height of about 3.2 m for *A. mangium* and 3.5 m for *A. auriculiformis*, versus 3.0 m and 3.5 m respectively in this study. The poorer performance of *Leucaena* could be due to low pH and poor drainage, as reported elsewhere (Pound & Cairo 1983).

Natural recolonization of tin tailings does occur in certain areas, particularly those in the vicinity of natural vegetation. However, as reported by Mitchell (1959) the progress of natural recolonization by plants is extremely slow. There is a possibility of hastening this process by planting trees. MPTS, especially those with the ability to fix nitrogen and accumulate organic matter rapidly, are recommended. The two acacias used in this study deserve high priority.

Caution should be observed in applying these results to other areas of tin tailings. Tin tailings are known to be heterogeneous in their physical and chemical properties,and are generally classified into three types: slime, sand and a mixture of slime and sand. Slime consists of silt and clay, and on drying gives rise to a compact structure with low porosity, which often results in waterlogged conditions. Cation exchange capacity and organic matter content are higher than for the sand tailings (Palaniappan 1969). Sand tailings, in contrast, usually have low water-holding capacity, high porosity and hydraulic conductivity, low nutrient status and weak structural stability. Moreover, their cation exchange capacity is also extremely low. Soil temperature is generally high (40-50 °C) which in turn results in high evaporation (Lim *et al.* 1981, Tan & Khoo 1981).

As indicated in Table 1, the tailings where this study were conducted were a mixture of slime and sand. It is uncertain whether similar growth could be obtained on either slime or sand tailings alone. Further studies testing the same species and others, as well as different establishment techniques, should be undertaken on these other types of tailings.

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