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Biomass Accumulation in a Naturally Regenerating Lowland Secondary Forest and an *Acacia mangium* Stand in Sarawak

LIM MENG TSAI and MOHD. BASRI HAMZAH*
Faculty of Forestry,
Universiti Pertanian Malaysia,
Serdang, Selangor, Malaysia.

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ABSTRAK

Komposisi flora dan biojisim atas tanah satu kawasan pemulihan semulajadi dibandingkan dengan satu dirian Acacia mangium *yang berumur tiga setengah tahun. Kawasan pemulihan semulajadi mempunyai purata ketinggian 1.5 m; pada amnya mempunyai berbagai jenis tumbuhan yang dinaungi oleh* Imperata cylindrica, Dicranopteris linearis, Pteridium *sp. dan* Scleria *sp. sedangkan dirian* Acacia mangium *mempunyai purata ketinggian pokok dominan sekitar 15.5 m dan bilangan genera tumbuhan yang kurang (termasuk cocoa).* I. cylindrica *dan* D. linearis *juga terdapat di dirian* A. mangium *tetapi tumbesarannya kurang subur dan berkelompok. Terdapat 6.2 t/ha bahan organik hidup di kawasan pemulihan semulajadi dan sekitar 59.0 t/ha di dirian* A. mangium.

ABSTRACT

The floristic composition and the aboveground biomass of a naturally regenerating area and a three-and-a-half year-old Acacia mangium *stand are compared. The naturally regenerating area averages 1.5 m in height; generally has more variety of plants and is dominated by* Imperata cylindrica, Dicranopteris linearis, Pteridium *sp. and* Scleria *sp. whereas the* A. mangium *stand has a top height of 15.5 m and fewer genera of plants (including cocoa).* I. cylindrica *and* D. linearis *were also found in the* A. mangium *stand but grew less vigorously in isolated patches. There was 6.2 t/ha of live organic matter in the naturally regenerating area and approximately 59.0 t/ha in the* A. mangium *stand.*

INTRODUCTION

Shifting cultivation is a widespread form of agriculture in Sarawak. Hatch and Lim (1979) estimated that over 23% of the total land area of Sarawak is within the shifting cultivation cycle and up to 30,000 ha of primary forests and 30 – 60,000 ha secondary forests are cleared annually. Clearing of forests for shifting cultivation very often occurs immediately after logging, when new areas become more accessible and conditions are more open. When this happens, large areas of up to five hectares or more may be cleared, burnt and then planted with crops such as maize, rice, sugar-cane and vegetables.

Soil degradation during and after shifting cultivation is often severe, especially when the fallow period is shortened and successive cropping occurs in the same area (Hatch, 1981; Nye and Greenland, 1960). Depending on the fertility of the soil and the number of times the area has been previously cultivated, the rate of natural regrowth of vegetation and the build-up of organic matter can vary quite considerably (Ewel, Chai and Lim, 1983).

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*Key to author's names: M.T. Lim and H. Mohd. Basri.

Various steps have been taken to rehabilitate former shifting cultivation areas (Lee, 1981) and among these is the artificial reforestation of areas having a low or poor natural regenerative capacity. Various species such as *Acacia mangium, Pinus caribaea, Swietenia* sp., *Gmelina arborea, Eucalpytus deglupta* and *Paraserianthes falcataria* (formerly *Albizia falcata)* have been and are being used. Among these, *A. mangium* Willd. was found to have a high growth rate as well as the ability to overcome competition from weeds and lalang *(Imperata cylindrica)* (Tham, 1976).

In this study, a comparison is made of the accumulation of biomass in an area that has been left to regenerate naturally and one that has been planted with *A. mangium.*

SITE

The study was conducted in the Oya Road Forest Plantation (2° 30'N and 112° 01'E) located approximately 25 km N-NE of Sibu, Sarawak. Much of the plantation area is at different stages of fallow after shifting cultivation prior to 1964. The annual rainfall at Sibu at approximately 3200 mm with peak rainfall in December and January. The study site, over a loose and light sandy loam was located on the top of a low ridge between 10 and 20 m above sea-level.

The *Acacia mangium* plots (AMP) were located in a line-planting trial stand interplanted with cocoa *(Theobroma cacao).* The *Acacia mangium* originated from Sabah and were planted in January 1979 at a spacing of 3 m by 3 m as nurse (shade-providing) trees for the cocoa which was planted as a cash crop at about the same time. The acacia was not given any fertiliser apart from that at initial planting but the cocoa plants were given regular fertiliser treatment (approximately 125 g Nutrex Blue (NPK) per tree every six months) (Chai, pers. comm.).

The naturally regenerating area (NRA) was approximately 200 m north of the AMP but outside of the trial stand, on similar soils and topography. The vegetation averaged 1.5 m in height, except for a few scattered woody trees and saplings which grew above this level but did not exceed 3.0 m in height.

MATERIALS AND METHODS

In the NRA, three plots were randomly established along a 30 m north-south oriented baseline. The first measured 8 m by 8 m while the second and third, 7 m by 7 m each. Families of all living plants found within the plots were recorded. As the number of individuals in the herb and woody tree class was relatively low and small, the size and number of individuals were not recorded nor were they divided into climbers, herbs and woody trees as was done by Ewel *et al.* (1983). All living biomass within the plots were harvested to ground level and weighed. During the course of the harvest of each plot, three samples were taken for moisture content determinations. Gross weight of the fresh biomass was taken using a 25 ± 0.1 kg (Salter) spring balance while samples for moisture determination weighed with a 2100 ± 0.1 g (O'Haus) beam balance. Samples were oven-dried at 80°C for at least 72 hours and the weights determined to 0.1 g.

The AMP comprised six plots measuring 15 m by 15 m. The diameters at breast height (dbh) were measured and the heights of the two trees with the largest dbh (top height) in each plot were determined using a ranging pole which measures up to 20 m. Families of plants other than *A. mangium* and cocoa present within the plots were also recorded. Their biomass was however not determined. The biomass of the *A. mangium* trees was estimated using the Smalian formula, modified as follows: —

$$\begin{aligned}\text{Biomass} &= \text{volume of tree} \times \text{density}\\ &= 0.5 \times \text{BA} \times \text{height} \times \text{density}\end{aligned}$$

The height value used was the top-height (of 15.5 m) and the density was assumed to be 0.50 g/cc or 500 kg per m^3.

TABLE 1
Plants found in the naturally regenerating area and in the 5 year old *Acacia mangium* stand (plants marked* are over 1.5 m but below 3.0 in height)

Taxon	NRA	*A. mangium* stand
Pteridophyta		
Dicranopteris linearis	×	×
Pteridium sp	×	×
Lycopodium sp	×	
Cyperaceae		
Scleria sp	×	×
Graminae		
Imperata cylindrica	×	
Hypoxidaceae		
Curculigo sp	×	
Euphorbiaceae		
Macaranga sp	×*	
Mallotus sp	×*	
Others		×
Leguminosae		
Paraserianthes falcataria	×*	
Loganiaceae		
Fagraea sp	×*	
Melastomataceae		
Melastoma malabathricum	×	×
Moraceae		
Ficus sp	×*	×
Nepenthaceae		
Nepenthes	×	
Rubiaceae		
Nauclea sp	×*	
Theaceae		
Ploiarium sp	×	
Verbenaceae		
Vitex sp	×*	

RESULTS AND DISCUSSION

Naturally Regenerating Area

The community was dominated by *Imperata cylindrica, Dicranopteris linearis* (formerly *Gleichenia linearis), Pteridium* sp and *Scleria* sp and average 1.5 m in height. The woody trees/saplings that grew above 1.5 m were woody pioneer genera such as *Macaranga, Mallotus, Ficus* and *Vitex* (Table 1). The few isolated *Paraserianthes* trees found may have been planted but this could not be verified. An average of 6.2 tonnes/ha of above-ground living biomass was recorded in this area (Table 2).

TABLE 2
Fresh and oven-dry biomass of the naturally regenerating area (tonnes/ha)

Plot	Fresh weight	Oven-dry weight
1	11.73	5.61
2	17.33	5.12
3	15.33	7.92
Mean	14.80	6.22

Acacia mangium Plots

Apart from *A. mangium* and cocoa, *Imperata cylindrica, Dicranopteris linearis, Scleria* sp and some of the woody (tree) genera were also found (Table 1). These plants were however not widespread as in the NRA and were found in patches where the canopy was more open. Most of the woody species were also below 1.5 m in height.

The mean dbh of the 3.5 year old *Acacia mangium* was 12.5 cm and the top height averaged 15.5 m (Table 3). Individual dbh values were very variable and ranged from 3.7 cm to 19.4 cm. Density of the trees averaged 1089 stems/ha and the stand was observed to have generally reached the canopy-closure stage with a large proportion of the ground being relatively bare and covered only with litter. The growth of the cocoa under the acacia was also variable; most were below 1.5 m in height and had two or three branches, while very few had numerous (>6) branches. The above-ground biomass of the *A. mangium* was estimated to be 54.4 tonnes/ha.

TABLE 3
Plot characteristics and biomass of the *A. mangium* stand

Plot	Mean dbh (cm)	dbh range (cm)	Top height (cm)	No. of trees (per ha)	Biomass (tonnes/ha)
1	12.5	8.8 – 16.5	14.75	1111	54.63
2	12.7	3.7 – 16.2	16.35	1111	57.83
3	12.9	7.6 – 19.4	15.30	1022	54.89
4	12.7	7.0 – 17.2	16.05	1111	57.19
5	11.9	81. – 15.4	15.20	1067	47.56
6	12.5	7.6 – 17.7	15.55	1111	54.49
Mean or overall	12.5	3.7 – 19.4	15.53	1089	54.43

DISCUSSION

Although the actual age of the NRA community is not known it has been assumed to be similar to the AMP on the basis of the following: the area was probably cleared together with the AMP but was not planted due to insufficient planting material; observations a year after the study indicated that the plants had grown by between 0.3 and 0.5 m; the estimated age of 3.5 years thus seems commensurate with the observed height of the plants.

Most of the genera of woody plants found in the NRA are common secondary forest species and have been reported in various other studies (Ewel *et al.*, 1983 and Kochummen and Ng, 1979). Compared to these other studies, however, the number of families recorded is relatively fewer. This may be due to the dense and extensive growth of *Imperata cylindrica* and the ferns *Dicranopteris linearis* and *Pteridium* which form a dense tangle of ranchises through which few woody pioneer species can penetrate and establish themselves. This is probably similar to the dense *Melastoma-Gleichenia* community which according to Kochummen and Ng (1979) prevented other woody species from establishing themselves.

The biomass of 6.2 t/ha recorded is considerably lower than the biomass of 21 t/ha for a 4.5 year old upland slope in Sabal Forest Reserve (Ewel *et al.*, 1983) which, however, has a higher number of larger sized trees. The low biomass could be due to the excessive domination by *Imperata cylindrica/Dicranopteris linearis* and *Pteridium* as well as to the infertile sandy loam soils, a condition often indicated by the presence of the genera *Nepenthes* and *Ploiarium* and possibly resulting from severe degradation through past use.

The NRA has a greater variety of plant families and genera than the AMP. This is due mainly to the differences in environmental conditions under the acacia. Most pioneer/secondary forest species generally require strong if not direct light and only a few genera such as *Ficus* and *Macaranga* can survive under the shade of other trees. The poor growth of surviving individuals relative to individuals of similar species growing in the NRA, further suggests that they are being out-competed by *Acacia mangium.*

It seems obvious too that the cocoa has also been out-competed by the acacia. Cocoa plants of a similar age under more suitable conditions would have matured sufficiently to have started bearing flowers and fruits, whereas most of those in the AMP are generally below 1.5 m and none were flowering or fruiting. It seems likely also that the acacia is taking up a large proportion of the fertiliser applied around and meant for the cocoa.

Although the biomass of the cocoa and the other undergrowth plants in the AMP were not determined, they would probably amount to only an extra 4.0 to 5.0 tonnes/ha. This would bring the overall total above-ground biomass of the AMP to approximately 59 t/ha, which compares favourably with those estimated from open-grown *A. mangium* (Lim, 1985) as well as from plantations of other species such as *Albizia falcata* (Kawahara *et al.*, 1981), *Shorea robusta* and *Tectona grandis* (De Angelis *et al.*, 1981) (Table 4).

Compared to the NRA plots, the AMP has a biomass that is over 9 times higher. This can be attributed to the inherent capacity of *A. mangium* for rapid growth (Tham, 1976) as well as to the regular application of fertilisers (to the cocoa) in the AMP. When this difference in biomass is considered on the basis of usable wood, the difference becomes even more significant. The bulk of the 6.2 t/ha in the NRA is in the form of leaves, rachises and semi-woody stems of ferns, whereas at least 90 percent of the biomass in the AMP would consist of wood from the boles and branches.

Thus, even though the underlying soil is poor in nutrients and can only support a low biomass and little growth can be attained through natural regeneration, it can be made to support and produce as much as 9 – 10 times more organic matter by planting with suitable tree species. Furthermore, the organic matter produced can be channelled into more utilisable forms, namely wood. Associated with the production of wood are the other benefits of improved natural cover of the area, increased organic matter content in the soil and improved soil conditions. All these offer a strong case for the artificial reforestation of severely degraded forests.

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TABLE 4
Biomass and biomass production of some tropical trees/forests

Location (type)	Age (years)	Biomass (t/ha)	Mean annual production (t/ha/yr)	Reference
Secondary forest (NRA)	(not known but assumed to be 3.5)	6.2	1.8	this study
A. mangium (plantation)	3.5	54.4	15.5	this study
A. mangium (open-grown)	3.5	64.1	18.3	Lim, 1985
Mixed secondary forest (slope)	4.5	21.0	4.7	Ewel *et al.*, (1983)
Secondary forest (alluvium plain)	4.5	46.6	10.4	Ewel *et al.*, (1983)
Shorea robusta (plantation)	5.0	15.5	3.1	De Angelis *et al.*, (1981)
Tectona grandis (plantation)	5.0	49.6	9.9	De Angelis *et al.*, (1981)
Albizia falcata (plantation)	5.0	75.6	15.1	Kawahara *et al.*, (1981)

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