GROWTH OF *ACACIA MANGIUM* PLANTED ON WINDROW SITES

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PANITZ, E. & ADZMI YAACOB. 1992. Growth of *Acacia mangium* planted on windrow sites. This study was conducted to test the difference in growth performance of *Acacia mangium* on rich and poor sites created by windrowing as the usual site preparation method for large scale plantations. The experimental plots were laid out in Ulu Sedili Forest Reserve in a one-year-old plantation. Soil samples were analyzed and trees were measured in 1985 and 1989. Basal area development and volume increment as well as timber production were calculated. After one year as well as after five years planting there was a significant difference between dimensions of trees of both sites.

Key words: *Acacia mangium* - site preparation - windrow effect - soil development - growth rates

Introduction

Under the Compensatory Forest Plantation Programme in Peninsular Malaysia, some 188,000 *ha* will be planted with fast- growing tropical hardwoods principally *Acacia mangium* (Yong 1984). It grows well over a wide range of site conditions including poor or degraded soils and has an expected rotation of 15 to 20 years.

Land clearing and site preparation are done either manually or semi - mechanically. In both methods the remnant vegetation is felled by chain saw, and is broadcast burnt. In semi-mechanical land clearing which is carried out only if the first burning is insufficient, bulldozers are used to stack the unburnt material into windrows before second burning is carried out. In both methods the remnant vegetation is felled by chain saw and is broadcast burnt. In semi-mechanical land clearing which is carried out only if the first burning is insufficient, bulldozers are used to stack the unburnt material into windrows before second burning is carried out. This concentrates the nutrients left after burning only on the windrows and the areas in between are deprived of additional nutrients. The soils between windrows are further compacted by moving machinery, creating recognizable differences in quality and site properties within the plantation area.

A cursory examination of *A. mangium* plantations in Ulu Sedili in 1985 showed distinct differences in heights of the trees growing on and between windrows. Observations on this matter were started in 1985 in a one- year- old plantation of *A. mangium* in Ulu Sedili Forest Reserve, and a study was conducted under the Malaysian - German Forestry Research Projects (MGFRP). The preliminary results

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were compiled by von Hahn (unpublished report 1986). The statistical evaluation as well as the evaluation of remeasured data of 1989 is reported here.

Materials and methods

Study site

Ulu Sedili Forest Reserve is located in southeast of Peninsular Malaysia between Kota Tinggi and Mersing in the state of Johor.

The experimental site is underlain by deeply weathered acid igneous rocks, probably granitic, and derived colluvium. These igneous rocks were intruded into Permian Sediments (Chong 1980) which were originally mainly calcareous but have also been deeply weathered and intensively leached. The soils are brownish yellow coarse sandy clay to coarse sandy clay loam of the Tai Tak series (Lim 1984, Paramananthan 1987). It is deep, well drained and resembles the Rengam series more commonly developed on granitic rocks in Peninsular Malaysia; in terms of the soil taxonomy (USDA 1975) it is Typic Paleudult.

The mean annual rainfall is 2820 *mm*. February to April, sometimes until May, are dry months with an average monthly precipitation of 150 to 200 *mm*. Heavy rainfalls occur during November to December with 350 to 500 *mm* per month. The monthly average temperature remains nearly constant around 26°*C* (Nieuwolt 1982).

The topography of the area can be described as gently sloping to undulating or rolling with inclination varying from 5 to 12 %. The research plots had three to five-month- old nursery raised seedlings planted in a spacing of 3.0 x 3.0 *m*. Into each planting hole 120 *g* of Christmas Island Rock Phosphate was added (Ibu Pejabat Perhutanan 1984).

Experimental Layout

The trial field was situated on a gently inclining slope in the northeast aspect. The plots stretch from the upper slope near the broad ridge down to the lower slope. As the length of each plot did not exceed 40 *m* , significant difference in site conditions caused by the sloping terrain is not expected.

The research plot was split into two different treatments, *i.e.* the windrow strips (rich) and the denuded strips (poor). Four replications for each treatment, with a total of eight plots were set up. The plot size varied from 288 to 441 m^2 with 32 to 49 trees in each plot with a total of 284 trees.

Tree measurements

For growth estimation of the trees, diameter at breast height (DBH) and total tree height of all observed trees were measured. The first measurement was in August 1985 and the second in August 1989. The diameter was measured using the diameter tape. Height sticks of 1.5 *m* length were used for height measurement in 1985, and in 1989 the heights were measured using the Suunto clinometer.

Soil and leaf samples

Soil samples were taken with an auger from 0 to 10 *cm* and 10 to 30 *cm* depths. For each plot a composite sample consisting of at least three single samples from the lower, middle and upper third of the slope was taken.

Leaf sampling was done analogous to soil sampling in both years. From each plot a composite sample was collected consisting of five following leaves 10 *cm* below the terminal bud of five sun-exposed branches of a dominant tree.

Soil and leaf analyses were carried out in the soil laboratory at FRIM. Soils were analyzed for texture, pH (wet), cation exchange capacity (CEC determined only in 1989), N, P, K, Ca, Mg, and organic matter content. For leaves the elements analyzed were N, P, K and Mg. In addition, ash content, organic carbon content and C/N ratio were determined.

Results

Tree height and diameter

The height and diameter of trees on the rich site were always better in 1985 and in 1989 compared to the poor site (Table 1 and 2).

To compare increment between poor and rich sites (1985 to 1989), the data were of trees still existing until 1989.

Analysis of variance (ANOVA) was used to analyse the data. A significant difference (1% level) was observed between the treatments both for height and diameter.

Table 1. Tree dimensions on poor site (means of each plot and total mean)

	1985				1989			
Plot No.	No.of trees	Height (*m*)	DBH (*cm*)	BA (cm^2)	No.of trees	Height (*m*)	DBH (*cm*)	BA (cm^2)
1	36	4.55	5.0	21.4	27	16.8	15.8	204.3
3	40	4.55	5.1	21.3	26	18.4	16.8	226.2
5	36	4.77	5.1	21.8	29	16.7	16.2	211.9
7	35	4.98	5.4	23.7	30	19.5	16.5	217.3
Total mean		4.71	5.1	22.1		17.9	16.3	215.0

Tree heights on both sites showed similar development in the observed period. The difference in mean annual height increment was 0.1 *m* only. For diameter, too, the same development was found on poor and rich sites. The annual increment was

Table 2. Tree dimensions on the rich site (means of each plot and total mean)

	1985				1989			
Plot No.	No.of Trees	Height (*m*)	DBH (*cm*)	BA (cm^2)	No.of Trees	Height (*m*)	DBH (*cm*)	BA (cm^2)
2	30	5.33	7.0	40.9	21	19.8	20.1	325.0
4	40	5.16	6.6	32.3	27	17.6	17.5	244.7
6	31	5.76	7.4	43.4	23	18.8	18.8	281.8
8	36	6.48	9.2	67.2	25	21.0	20.2	323.8
Total mean		5.68	7.6	46.0		19.3	19.1	293.8

3.3 *cm* and 3.4 *cm*, respectively, which is a difference of 0.1 *cm* only. Both the poor and the rich sites have similar diameter and height development (Figures 1a and 1b).

On the other hand, the basal area increment was not equal on both sites (Tables 1 and 2, Figure 1c). It was higher on the rich site as basal area development depends very much on the initial basal area (Assmann 1961). Since timber volume increment depends on basal area development, the annual timber production on rich sites is higher as well. Stand volume in 1989 was calculated according to the volume equation given by Watts (1989). Using mean square diameter, the total volume for one *ha* (300 stems) is 47.9 m^3 on poor sites, and 68.2 m^3 on rich sites. There is a difference of about 20.3 m^3. Thus the timber production within five years was 4 m^3 y^{-1} ha^{-1} higher on rich sites.

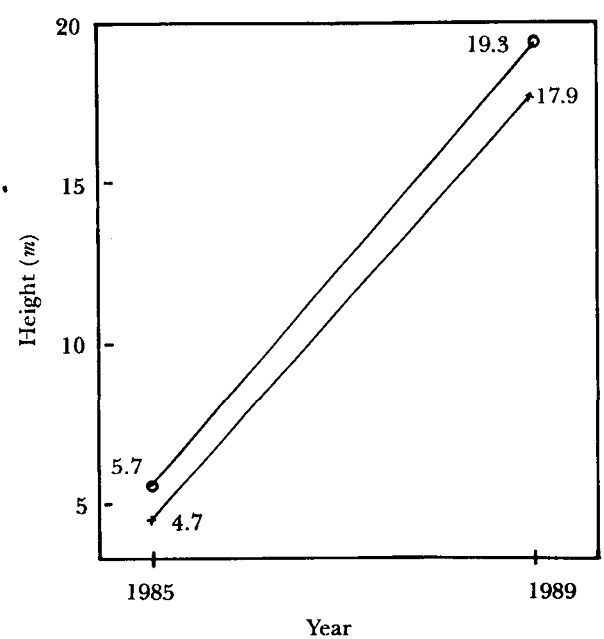

Figure 1a. Height development

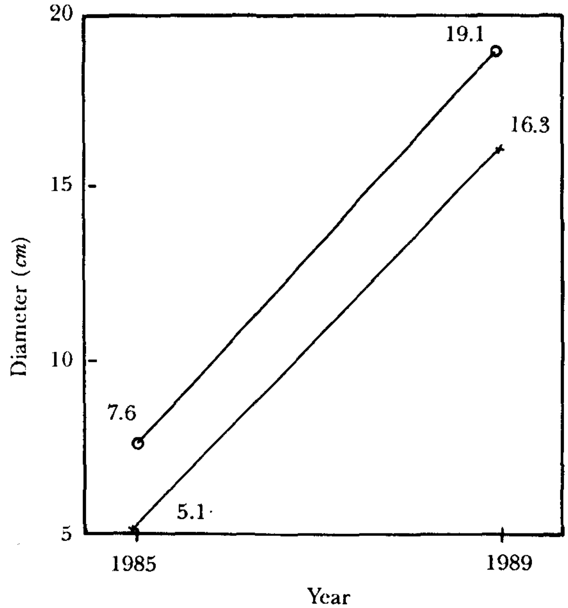

Figure 1b. Diameter development

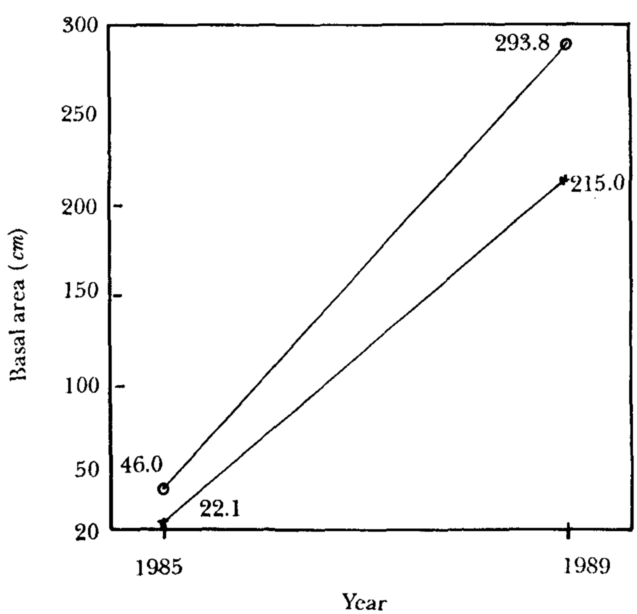

Figure 1c. Basal area development

Soil analysis

The results of soil analysis are given in Table 3. The cation exchange capacity (*meq* $100g^{-1}$ soil) determined in 1989 was 4.5 on rich and 4.2 on poor sites.

Table 3. Results of soil analysis and analysis of variance (mean values)

Poor site							
Elements	N %	organic C%	P ppm	K *meq*	Ca *meq*	Mg *meq*	pH wet
1985							
0 - 10 *cm*	0.07	1.42	2.3	0.06	0.32	0.15	4.6
10 - 30 *cm*	0.06	0.99	1.6	0.04	0.16	0.10	4.7
1989							
0 - 10 *cm*	0.11	1.00	1.8	0.07	0.28	0.19	3.8
10 - 30 *cm*	0.08	0.56	0.8	0.03	0.24	0.11	3.8

Rich site							
Elements	N %	organic C%	P ppm	K *meq*	Ca *meq*	Mg *meq*	pH wet
1985							
0 - 10 *cm*	0.07	1.64	5.5 **	0.19 **	2.31 **	0.65**	5.8 **
10 - 30 *cm*	0.07	1.15	2.6	0.13 *	0.80	0.33 *	5.1
1989							
0 - 10 *cm*	0.14**	1.33	3.2 *	0.13 *	1.33 **	0.52 **	4.2 *
10 - 30 *cm*	0.08	0.72	1.7 *	0.04	0.40	0.28 *	4.0 **

Analysis of variance: rich / poor ; ** significant at 1 % ; * significant at 5 %

In 1985 the nitrogen content in both sites was very low as nitrogen was lost to the atmosphere during initial burning. The N-content increased after four years obviously due to decomposition of fallen litter as well as nitrogen fixation by root nodules of the leguminous tree *A. mangium.* Between sites there was a significant difference in nitrogen content in 1989 in top soil only.

There is a significant difference in P, K, Ca and Mg in the top soil between the two sites in 1985. This was expected with the concentration of organic matter from the burnt residue which accumulates on windrows, thus creating poor and rich sites.

In 1989 there was still a higher amount of P, K, Ca and Mg in the soil of the windrow site. Interesting is the trend of nutrient status development when the amount of some nutrients on the poor site (K, Mg in top soil and Ca in sub soil) was slightly increasing whereas on the rich site it was decreasing. Phosphorus suffered the heaviest loss in all sample positions (top and sub soils in both sites).

The pH values follow the nutrient status. The rich soil was less acid than the poor soil. After four years the soil acidity increased by 0.8 to 0.9 on the poor site, but much more on the rich site (1.1 - 1.6).

Leaf analysis

The results of the leaf analysis show similar differences as observed in the soils (Table 4). The higher amount of elements in leaves of trees in enriched sites in 1985 is significant in nitrogen, phosphorus and in the C/N ratio only. Additionally, there was an increased potassium content in the rich site's leaves in 1989. Although there were slightly higher amounts of nutrients in the leaves in 1989 compared with 1985 (except for magnesium which remained equal), an increase was only significant on the rich site in potassium and phosphorus content. Reduction of P uptake followed the heavy loss in P content in the soil. The C/N ratio was much smaller in 1989 on both sites due to much lower organic C content.

Table 4. Results of leaf analysis and analysis of variance (mean values)

Elements	N %	P %	K %	Mg %	Ash %	C %	C/N
Poor sites							
1985	2.29	0.085	1.49	0.12	4.40	50.6	22.2
1989	2.47	0.084	1.51	0.14	4.74	33.3	13.5
Rich sites							
1985	2.50 *	0.110 **	1.55	0.12	4.64	50.5	20.4 *
1989	2.63 *	0.094 *	2.11 **	0.14	5.01	32.1	12.3 *

Analysis of variance: Rich /Poor ; ** significant at 1% ; * significant at 5%

Discussion

Soil and leaf data

It was confirmed by soil analysis that site preparation by clearfelling and windrowing applied in Ulu Sedili plantation had a distinct impact on soil nutrient status. Compaction by using heavy machinery might have had an additional influence, but this was not investigated. Tan (1986) also found distinct impacts of soil disturbance by tractor activities on growth of plantation trees.

After a four-year period, especially in the rich site, there was a loss of nutrients which have been its advantage up to then. The strong increase of acidity is another indicator of the decline in quality both on poor and rich sites, due to land clearing. Only nitrogen content improved in both sites indicating a recovery from site preparation. The decomposition of the newly produced litter as well as nitrogen fixation had contributed to this as reflected also in the foliar analysis.

In tropical forest ecosystems, most of the nutrients are stored in the vegetation above ground (Whitmore 1986). Site preparation methods that burn this nutrient pool and expose the ash to leaching waste a lot of the ecological potential of the site. Additionally, sites of low trophic level, like the soil of this research plot, have difficulties in replenishment of nutrient deficits by fertilization (Fölster 1986). Due to the rather low cation exchange capacity, storage of nutrients in the soil is very limited. Therefore, the release of nutrients from decomposing organic matter is the most important source for crops, especially those with long rotations like forest trees. Thus it is important to keep as much nutrients as possible on the site, to care for soil organic matter content and to maintain a continuous vegetation decomposition. The waste of nutrients through land clearing was investigated by Ruhiyat (1989) who found 30 to 45% loss of nutrients in *A. mangium* plantations compared to natural forests.

Tree growth and development

The results of this investigation showed that in 1985, trees on the rich site enjoyed better site conditions in the beginning. At the time of the first measurement (one year after planting), the trees were 20 % taller, 50 % bigger in diameter, and the basal area was double (108 %). By 1989 the growth rates of diameter and height on the rich site slowed down and were nearly equal to those on the poor sites (Figures 1a and 1b). In conclusion, volume increment on the rich site was higher (Figure 1c). With continuation of this growth performance, the rotation period to reach desired dimensions would be delayed on poor sites.

A. mangium responded better to good site conditions in the early stage. As soon as the nutrient content of the soil was reduced, the rich site was no more an advantage. Only the lead in dimension which was gained in the early years created the prerequisite for higher volume production later. In Ulu Sedili it was 20 m^3 ha^{-1} in five years. Within a rotation period of 20 years this will be a loss of 80 m^3 ha^{-1} on half of the plantation area. This is true if the difference in volume growth rates remains constant.

It seems to be better if nutrients derived from decomposition of organic matter could be spread over the whole plantation area. All trees then can gain from the release of nutrients from the former vegetation cover equally. In this way the whole plantation may show consistent growth.

Recommendations

Plots in this experiment were measured in 1985 and 1989 only. For investigation of the annual development a yearly measurement is necessary. This will demonstrate the development trends much better from which more precise predictions of further growth performance can be made. In order to gain better information about growth performance of *A. mangium* on the two contrasting sites, measurements should be continued.

Since only one site preparation was examined, it is necessary to investigate other methods too. It is important to optimize the use of the available nutrients and to prevent them from loss. Therefore, equal distribution of ash (no windrowing) and possibilities of nutrient retention by using cover crops or other methods should be tested. Additional to the ecological and growth assessment, comparative economic studies should be included.

If large scale plantations are sought, it is necessary to study different management practices that are both ecologically and economically feasible. This has to be done for site preparation methods too. If no techniques for plantation establishment can be found which can do without burning, plantation of light demanding species should be shifted to already opened land (reforestation of tin mining areas, *etc*.). Secondary forest should be enriched with species able to grow under shelter trees. Clearfelling and burning of the slash then can be abandoned.

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