EFFECTS OF FERTILISER ON WOOD PROPERTIES OF PLANTATION GROWN *ACACIA MANGIUM*

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ANI SULAIMAN, WAN RASIDAH ABDUL KADIR & MOHD. SHUKARI MIDON. 1991. Effects of fertiliser on wood properties of plantation grown *Acacia mangium*. The wood properties of 6 - *y* - old *Acacia mangium* applied with different combinations of N and P fertilisers during its early growth were studied. Differences in height and diameter growth increment and basic density were found to be insignificant at all levels of treatment. Nitrogen application appeared to have some effects in improving the heartwood to sapwood ratio. An interaction was also observed between portions of disc and fertiliser treatment. Combination of P and N improved the mechanical strength of timber while with N alone, the strength appeared to decrease.

Key words: *Acacia mangium* - fertiliser - wood properties - tree growth

Introduction

Tropical soils, as in Malaysia, are well known for their low organic and available nutrient content. Many attempts have been made to establish forest plantations in Malaysia. However, these efforts were substantially reduced when growth performance was far below expectation. This problem has caused the forest management authorities to give serious consideration to developing appropriate silvicultural techniques before establishing such plantations. Under the Compensatory Forest Plantation Programme, some allocations have been reserved for fertiliser trials (Anonymous 1985). Thus, preliminary studies have been conducted in Kemasul Forest Reserve to find out the effects of fertiliser application on the growth of *Acacia mangium* and its wood properties. Data collected during three years of growth revealed that this species responded to phosphorus fertilisation on Durian series (Typic Plinthudult) soil (Wan Rasidah *et al.* 1988).

This study examines the effects of earlier fertiliser application on the growth and wood properties of 6 - *y* - old *A. mangium* trees with respect to its basic density, strength, growth rate and proportion of heartwood to sapwood present. Even though many wood characteristics are under genetic control, silvicultural practices and environmental conditions will also influence wood properties such as density, fibre characteristics and juvenile corewood (Bevege 1984).

Materials and methods

The trial was established in Kemasul Forest Reserve in 1983 with newly planted *A. mangium* seedlings. It comprised five replications with six fertiliser treatments.

Each treatment consisted of 36 trees planted at 3.0 × 3.7 *m* distance with the central 25 as recording trees. Two nutrient elements were tested: nitrogen in the form of ammonium sulphate (AS) and phosphorus in the form of triple superphosphate (TSP) and Christmas Island Rock Phosphate (CIRP). The first fertiliser application was done three months after transplanting with three levels of N (0, 25 and 50 *g*) and two levels of P (0 and 60 *g*), broadcasted around the tree base. The application was repeated at six monthly intervals until the trees were 21-*mth*-old, and followed by one more application at twice the initial amount of N. The design was a completely randomised block with factorial application of fertiliser. Early enumerations were based on height and diameter increment.

The diameter growth increment of 6-*y*-old *A. mangium* was assessed from all the trees in the 30 plots comprising the six treatments and five replicates. For tree total height, measurements were taken from 90 felled trees used in the study. Each felled tree was cut into 2.5 *cm* discs for basic density determination from the lower (A) portion at 0.15 *m* height, middle (B) portion at 3.5 *m* height and upper (C) portion at 6 *m* height of the clear bole. The remaining portions were used for mechanical strength tests in accordance with standard method (Anonymous 1957).

The discs were brought back to the sawmill for sampling into smaller pieces. From each disc, two strips of about 50 *mm* wide were cut across the diameter and arbitrarily marked as N, S, E and W to indicate the four different radii of each disc. From each radius, three samples of 50 × 50 × 25 *mm* were taken radially from the pith outwards for determination of basic density based on green volume of timber and its oven dry weight.

Results and discussion

In comparing the control with each of the five fertiliser combinations, Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT) techniques were employed and the data set was analysed using the Statistical Analysis System (SAS) package. In general, application of fertiliser after transplanting has no significant effect on tree growth measured after six years, but differences were observed on certain wood properties.

Tree growth

For height increment, all the five fertiliser treatments performed better than the control. However, they are not significantly different from the control or each other (Table 1). During the early tree growth, P fertiliser showed significant increase in height (Wan Rasidah *et al*. 1988) but after 36 months, growth was maintained though not significantly. This was observed even when the trees had reached six years of age (Table 1). The reason could be that in the initial stages, all the P fertiliser was used up so that later the trees had to rely on their natural recycle to replace the deficiency in P. Therefore applied P fertiliser is required for the tree to improve its growth.

Table 1. Mean height and diameter increment of *A. mangium* at 3 and 6 *y* old

Treatment	Height (*m*)		Diameter (*cm*)	
	3 *y*	6 *y*	3 *y*	6 *y*
N0P0	14.0 ns	21.6 ns	8.09 ns	17.26 ns
N0P1	14.2 ns	22.7 ns	7.59 ns	17.12 ns
N1P0	14.2 ns	22.6 ns	8.39 ns	18.67 ns
N1P1	14.3 ns	22.1 ns	7.47 ns	18.32 ns
N2P0	14.0 ns	22.6 ns	8.67 ns	16.81 ns
N2P1	14.3 ns	22.5 ns	8.32 ns	19.03 ns

Diameter growth in *A. mangium* for all treatments did not show any significant increase even from its early age (Table 1). At 6 *y* old, control trees showed better performance than two of the treatments (N0P1 and N2P0). This result is expected for N2P0 because lack of P fertiliser led to poor girthing in rubber trees (Tajuddin 1981). Nitrogen is responsible for the increase in rate of diameter growth (Shepard 1982). Probably, absence of P in N2P0 is insufficient to support the diameter growth. The lower value in diameter increment could not be explained as the nitrogen-fixing potential of the tree was not established. However, the differences observed in all the treatments are insignificant. In rubber trees, deficiency in nitrogen resulted in small crown and reduced girthing (Tajuddin 1981). From recent findings by Chamshama and Hall (1978) on *Eucalyptus tereticornis,* P fertiliser appeared to have no direct effect on height and diameter increment. The effect on the height increment was only evident when it was applied with nitrogen fertiliser. However, in *A. mangium* its application is not significant even from its early growth.

Wood properties

Basic density had no interaction effect between different fertiliser treatments and position of discs (Table 2). It is also observed that, there was no significant difference between the control and each of the five fertiliser combinations used (Table 3). The highest basic density was obtained with treatments N0P1 and N1P1. The basic density was found to be highest at the lower bole (A) than at the middle (B) or top (C) part of the bole (Table 4). However, the values are not significantly different.

Table 2. ANOVA results for basic density and heartwood to sapwood (HS) ratio

Source	Pr > F	
	Basic density	HS Ratio
Fertiliser	0.3696 ns	0.0048 **
Disc position	0.3114 ns	0.2330 ns
Fertiliser * Disc	0.4481 ns	0.0002 **

** = highly significant at 1% level; ns = not significant

As in the case of basic density, the highest strength values were obtained in timbers from trees treated with N1P1 followed by N0P1. These are true for all mechanical strength values tested, that is, modulus of rupture, modulus of elasticity, compression parallel to grain, hardness and shear parallel to grain (Figure 1), both in green and air dry conditions. The lowest strength values were observed in timbers treated with N2P0 with the highest nitrogen. It was noticed that the hardness value for green timber was higher than air dried. This occurence was not uncommon in some species of Malaysian timbers. Example can be seen in bintangor (*Callophylum restusum*) where its green value is 2670 *N* and its air dried value 2580 *N*. Other species are keruing (*Dipterocarpus grandiflorus*), teak (*Tectona grandis*), yemane (*Gmelina arborea*) and a few others (Lee *et al.* 1979). The strength properties of *A. mangium* under control (N0P0) and different fertiliser treatment (N1P0, N1P1, N2P1, N2P0 and N0P1) were compared and analysed using Scheffe' method for both green and air dried conditions (Tables 5a & 5b).

Table 3. Results based on different discs for heartwood to sapwood ratio and basic density for each treatment

Parameter	Disc	Treatment					
		N0P0	N0P1	N1P0	N1P1	N2P0	N2P1
HSRATIO	A	3.19 c	9.38 a	9.11 a	9.05 a	10.87 a	6.48 b
	B	8.05 a	7.31 a	7.65 a	7.74 a	8.68 a	7.93 a
	C	7.39 a	6.61 a	6.61 a	7.99 a	7.35 a	7.35 a
BD	-	0.61 a	0.67 a	0.54 a	0.67 a	0.58 a	0.53 a

Means in rows having the same letter are not significantly different at 5% level; HSRatio = heartwood to sapwood ratio; BD= Basic Density; abbreviations similar for Tables 4, 5a and 5b

Table 4. Results based on different treatments for heartwood to sapwood ratio and basic density for each disc

Parameter	Treatment	Disc A	Disc B	Disc C
HSRATIO	N0P0	3.19 b	8.05 a	7.39 a
	N0P1	9.38 a	7.31 b	6.61 b
	N1P0	9.11 a	7.65 ab	6.61 b
	N1P1	9.05 a	7.74 a	7.99 a
	N2P0	10.87 a	8.68 ab	7.35 b
	N2P1	6.48 a	7.93 a	7.35 a
BD	-	0.64 a	0.59 a	0.56 a

The green strength results indicate that there is no significant difference at 5% levels by Scheffe' method for modulus of rupture, modulus of elasticity and compression parallel to the grain. However, there was a significant difference at 5% level for hardness properties between N0P0 and N1P1 treatments. Similarly for shear strength there was a significant difference between treatments N0P0 and N1P1 as well as between N2P0 and N1P1, but there is no significant difference between N0P0 and N2P0.

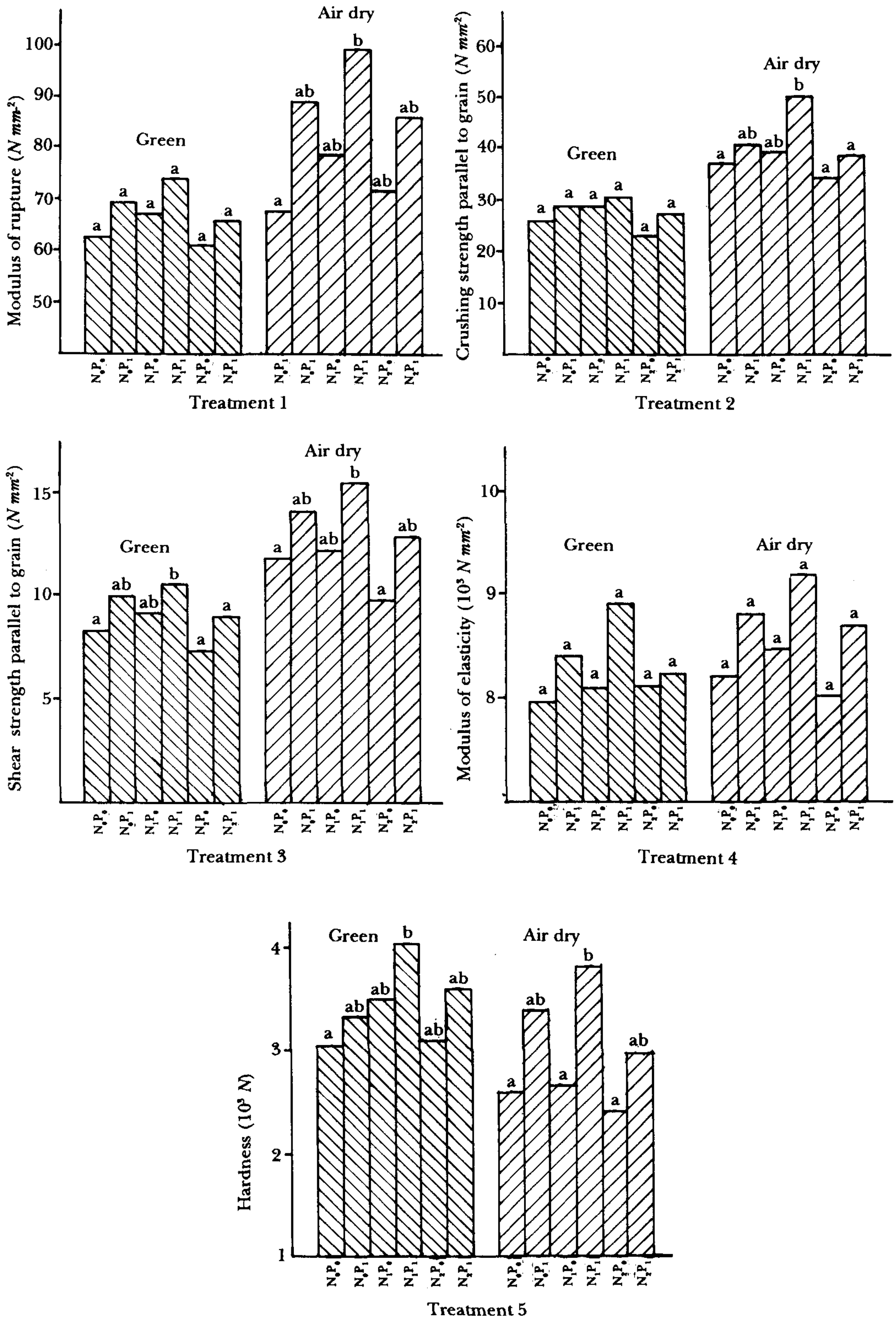

Figure 1. Comparative strength value of 6-y-old *A. mangium* with different fertiliser application

In the case of air dry conditions, the only property which has no significant difference between different fertiliser treatments is modulus of elasticity. For modulus of rupture, there was a significant difference between N0P0 and N1P1. The compression parallel to grain and shear parallel to grain values show significant difference for N0P0 and N1P1 as well as between N2P0 and N1P1, but no

Table 5a. Comparative strength properties of 6-y-old *A. mangium* under different soil treatment (green condition)

Treatment	Modulus of Rupture ($N\ mm^{-2}$)	Modulus of Elasticity ($N\ mm^{-2}$)	Compression parallel to grain ($N\ mm^{-2}$)	Hardness (N)	Shear parallel to grain ($N\ mm^{-2}$)
N0P0	62.23 a	7899 a	25.98 a	3047 a	8.24 a
	(12.48)	(1728)	(6.18)	(1045)	(1.89)
N1P0	67.14 a	8136 a	29.33 a	3510 ab	9.26 ab
	(12.17)	(1639)	(5.50)	(1004)	(1.87)
N1P1	73.10 a	8909 a	30.67 a	4044 a	10.41a
	(14.62)	(1734)	(6.84)	(994)	(1.76)
N2P1	66.16 a	8219 a	28.08 a	3607 ab	7.58 a
	(8.15)	(1562)	(4.83)	(509)	(0.99)
N2P0	60.77 a	7903 a	24.85 a	3060 ab	7.58 a
	(7.52)	(1402)	(4.48)	(627)	(1.07)
N0P1	70.21 a	8410 a	28.86 a	4288 ab	10.04 ab
	(8.52)	(1396)	(6.44)	(653)	(1.86)

The values within brackets are the corresponding standard deviations

Table 5b. Comparative strength properties of 6 -y -old *A. mangium* under different soil treatment (air dry conditions)

Treatment	Modulus of Rupture ($N\ mm^{-2}$)	Modulus of Elasticity ($N\ mm^{-2}$)	Compression parallel to grain ($N\ mm^{-2}$)	Hardness (N)	Shear parallel to grain ($N\ mm^{-2}$)
N0P0	76.56 a	8198 a	36.93 a	2559 a	11.74 a
	(16.98)	(1716)	(7.49)	(1019)	(2.70)
N1P0	78.87 a	8448 a	39.22 ab	2640 a	12.15 ab
	(15.89)	(1352)	(4.40)	(746)	(1.83)
N1P1	98.89 b	9218 a	46.88 b	3804 b	14.87 b
	(14.56)	(1786)	(11.93)	(1174)	(2.74)
N2P1	85.72 ab	8954 a	39.17 a	2947 ab	12.67 ab
	(8.47)	(1137)	(4.79)	(542)	(1.78)
N2P0	78.00 ab	8045 a	35.45 a	2387 a	10.63 a
	(11.34)	(1039)	(3.41)	(499)	(1.45)
N0P1	88.83 ab	8814 a	40.56 ab	3360 ab	14.15 ab
	(12.29)	(953)	(4.10)	(651)	(1.78)

The values within brackets are the corresponding standard deviations

significant difference between N0P0 and N2P0. As for hardness property, significant difference existed between N0P0 and N1P1, N1P0 and N1P1 as well as between

N2P0 and N1P1. There was no significant difference between N0P0 with N1P0 or N2P0.

A highly significant interaction was observed between fertiliser treatment and position of discs for heartwood to sapwood ratio at 1 % level (Table 2). The results indicate that the effects of fertilizer treatments varied among position of discs tested. Therefore it is necessary to fix the level of disc (A, B, C) and vary the fertiliser levels to test the differences among the treatment depending on the disc being used and *vice versa*. The results are shown in Tables 3 and 4.

For disc A, there was a highly significant difference between fertiliser treatments. Therefore, with Duncan's Multiple Range Test, the average heartwood to sapwood ratios of N0P1, N1P0, N1P1 and N2P0 were significantly better than the control. N2P1 was also significantly better than the control but significantly different from the rest. Thus, all the five fertiliser treatments performed better than the control with respect to their heartwood to sapwood ratio.

Application of nitrogen alone for both levels (N1P0 and N2P0) yielded higher heartwood to sapwood ratios compared to those combined with phosphorus. The difference between N1P0/N2P0 and N2P1 was significant at 5% level.

For disc B, no significant differences were observed between fertiliser treatments. It is obvious that the control performed better than N0P1, N1P0, N1P1 and N2P1. At disc C, there was also no significant differences between fertiliser treatments (Table 4).

When the discs were compared within fertiliser treatments for heartwood to sapwood ratio, the N0P0 and N0P1 combinations showed a significant difference for disc A from discs B and C. The value for disc A was found to be the lowest for N0P0 which is rather unexpected, but highest for N0P1. The lower value for disc A was probably due to the presence of a heartrot which was rather indistinct from the heartwood. Fertiliser treatments for N1P0 and N2P0 were observed to be not significantly different for disc B from discs A and C. However, discs A and C were significantly different from one another. No significant difference was found for N1P1 and N2P1 among the three discs. Disc A had the highest value when treated with N1P1 while it was highest in disc B for N2P1.

Conclusion

Fertiliser treatment that is used in silvicultural practice may result in an increase in growth rate of the tree and affect its wood quality such as basic density and in turn its strength. However, management of forest plantation is always financially restricted, so that objectives such as fast growth, maximum total yield per area and high quality timber need to be considered to obtain the highest return. As fertiliser application is important in bringing about changes in wood properties its effects should be understood before embarking on a large scale management programme.

In this particular study, fertiliser application does not affect the basic density of *A. mangium* wood statistically. The value obtained for all treatments including the control suggest that the wood may be classed under light density wood (530 to 670 $kg\,m^{-3}$). However, further test on its durability is necessary before placing it into any durability classification. Nitrogen application is recommended for improving the heartwood to sapwood ratio in the tree for the Durian type of soil under study.

The strength properties of N1P1 trees seem to have significantly higher values compared to those of N0P0 (controlled) trees in green and air dry conditions. Trees with other fertiliser treatments (N1P0, N2P0 and N0P1) have values that fall between those of N0P0 and N1P1, and N2P0 trees have values below those of N0P0 (Figure 1).

Application of P is neccessary for strength but combination with N improves the strength even further. High nitrogen application on its own appeared to produce lower mechanical strength values for both green and air dried specimen.

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