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Influence of Basic Density in Determining the Maturity of Forest Planted Calamus Manan.

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ABSTRACT

The study focus on the maturity attributes of forest planted *Calamus manan* by determine the influences of basic density. Twenty *C. manan* culms were selected and harvesting from forest reserve area in Lipis District, Pahang. Segregation of the culms were done according to age-group of 6, 12, 18 and 24-year-old. Harvested culms were cut a few cm above the ground level and continued to 24 m long along the length of the stem. Then each culm was further cut into 3 m length and make a total of 8 pieces from each culms. Thee prepared samples transferred to rattan primary processing center in Temerloh and underwent hot oil treatment process in diesel. After undergoing an air-dried process for two weeks, these samples were subsequently tested to determine basic density and strength. The results indicate that the lower part of the rattan shows to have higher basic density compare to the upper part of the rattan. The older rattan (18 and 24-year-old) shows to have higher basic density compare to young rattan (6 and 12-year-old). Rattan with higher basic density shown to have higher strength compared to those with lower basic density. Older rattan possessed higher strength of 7 to 8 times greater than the *C. manan* aged of 6 and 12-year-old.

Keywords: Planted *Calamus manan*, age-group, basic density, strength.

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INTRODUCTION

The *Calamus manan* is one of the main species of rattan used to produce furniture and wickers in Malaysia [1], [2]. It is durable, very flexible, and versatile over the other rattans species. By virtue of its higher commercial value, this species is commonly overexploited.

This led to resource exhaustion, and the species become scarce and expensive [1]. Malaysia government in its natural resources sustainable program had initiated rattan plantation in the forest areas and intercropping between rubber trees. The Forestry Departments in Peninsular Malaysia, Sarawak and Sabah initiated the establishment of rattan plantation in forest reserve areas [3], [4]. Several private companies and government agencies have joined in concerted effort to support the latter. However, the program of intercropping rattan species between rubber trees and plantation species was ceased due to the poor quality of rattan production.

Studies on wild and planted *C. manan* of the same age-group has produced different quality material between the two groups. Differences exist in the fiber wall thickness between the wild and the planted rattan [1], [2]. However, the fibre length was almost similar [5], [6], [7]. No study has been carried to determine the quality of rattan planted in the forest reserve areas especially in their strength of cultivated rattan. The current study aimed at determining the maturity of the forest planted *C. manan* using the basic density as an indicator.

MATERIALS AND METHODS

Twenty individual culms of planted *C. manan* consisting of five from each age group of 6, 12, 18 and 24 years were used in the study. Rattan stems of age-group 6, 12, 18 and 24 years were harvested from a forest reserve area in Lipis District, Pahang. The age of the rattan determined based on the date of planting as provided by the Forestry Department Pahang.

Each rattan stem sampled and labeled at eight level of portions height. Each portion height level consisted of a length of three (3) meters. Therefore, portion height 1 represent culm height from 0 to 3 m, portion height 2 represent culm height 3 to 6 m, portion height 3 represent culm height 6 to 9 m, portion height 4 represent culm height 9 to 12 meters, portion height 5 represent culm height 12 to 15 m, portion height 6 represent culm height 15 to 18 meters, portion height 7 represent culm height 18 to 21 meters and portion height 8 represent culm height 21 to 24 m. This length was considered as standard length commonly practiced by the rattan industry in the country for processing and utilization purposes [1].

Within a week after harvesting, these rattans underwent oil heat treatment process in diesel oil as standard practice by rattan industry in Malaysia [1], [2]. This is also being outlined by Razak *et_al*. (2001a) [8] and Izyan *et al*. (2010) [9]. The duration of the process takes about 20 minutes. All processed rattan were air-dried for about 14 days. This rattan was cut into smaller sizes according to the size required for physical and mechanical studies. These samples were kept in a conditioning chamber set at 20°C and 65% RH to produce an equilibrium moisture content of about 12±1%. The mechanical tests were conducted using Shimadzu Universal Testing Machine in accordance to British Standard BS EN 310 (1993) [10] and ASTM standard: D 143-14 (1974) [11].

RESULTS AND DISCUSSION

The cross section between 24-year-old and 12-year-old rattan at part one from the same height shown in Figure 1. Variation in the culm density between the outer and inner part of the culm. The outer part of older rattan (24-year-old) shows to have a much higher density compared to younger one (12-year-old). Portion height 1 that is near the base show to be smaller in diameter compared to the other pertions height 2 to 8. The diameter of the rattan increases from the bottom to the top.

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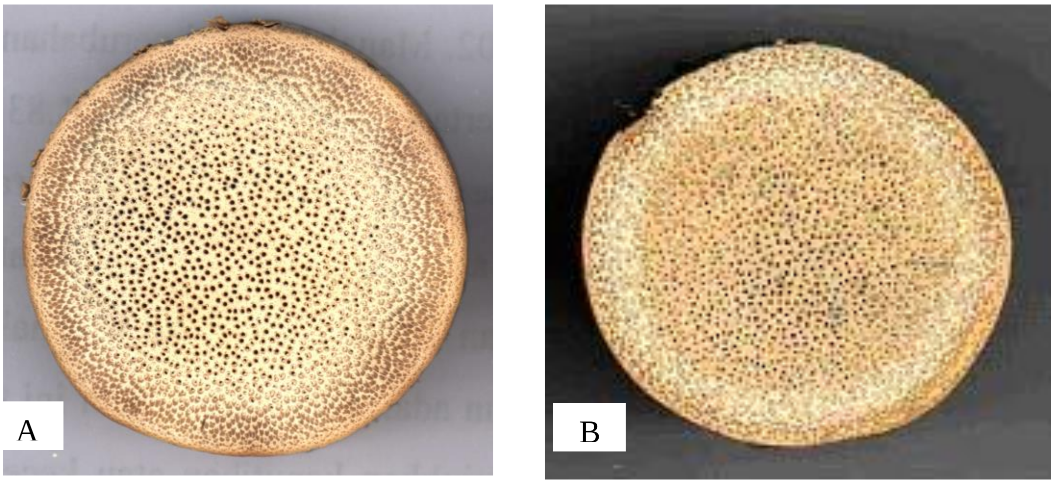

Figure 1: The cross-section is showing a distinct variation in density between an outer and inner part of cultivated 24 years-old (picture A) and a 12 year-old *C. manan.*

The basic density is a unit which measures the relative amount of solid cell wall material in the *C. maman*. The trend relation of basic density with part shown in Figure 2. This result indicates that the basic density increases as the *C. manan* get older [1], [2], [12], [13]. The analysis of variance (ANOVA) of the basic density are summarized in Table 1. The multiple range tests (MRT) of the basic density on effects of age, number of tree, and culm height of the plante *C. manan* tabulated in Table 2. The basic densities decrease significant from the basal to the upper parts. The findings were in agreement with the previous study [8], [12], [14], [15]. This relationship is related to the amount of matured fibre present in the *C. manan* at a perticular culm height. The lower part contains a high amount of fibres compared to the top part of the rattan [16].

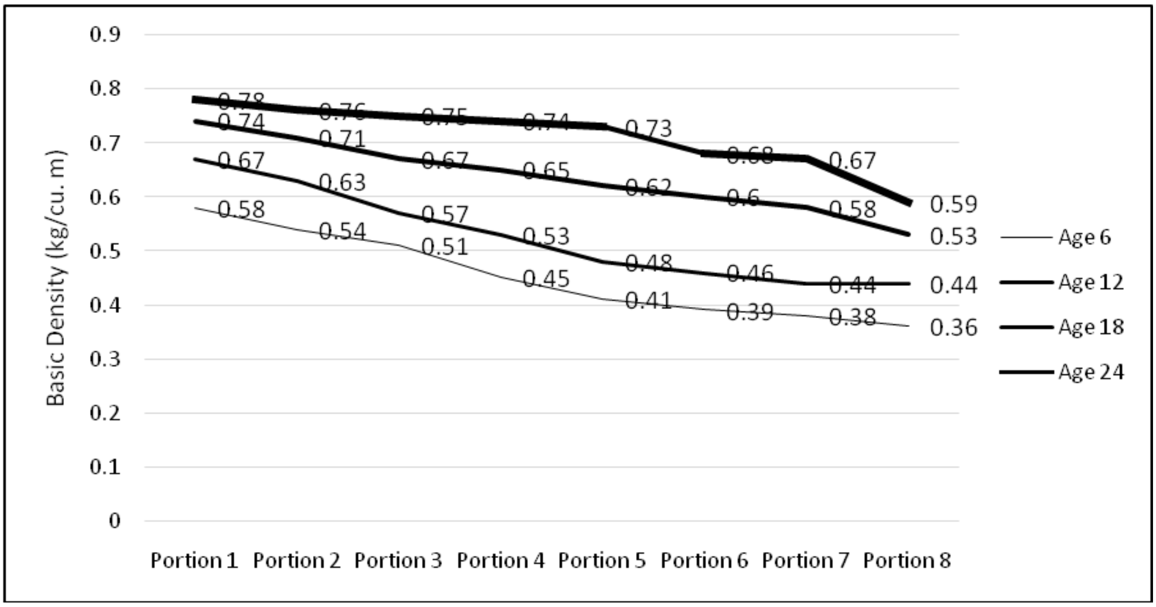

Figure 2: The basic densities (kg/m³) of *C. manan* according to age-group and portions height.

Table 1: The analysis of variance on basic density of planted *C. manan*

Source of variation	df	F-Value and statistical significance for basic density (kg/m³)
Age-group	3	2775.055 **
No. of culm	4	1.94 ns
Portion height	7	1313.801 **

Table 2: Multiple range tests of the basic density of cultivated *C. manan*.

	Basic Density (kg/m³)					
Age-group	6	12	18	24		
	0.43 a	0.47 b	0.61 c	0.70 d		
No. of culm	1	2	3	4	5	
	0.55 b	0.55 b	0.54 a	0.54 a	0.56 b	
Portion height	1	2	3	4	5	6
	0.62 f	0.58 e	0.56 d	0.54 c	0.51 b	0.47 a

ns: not significant at P<0.05, **: highly significant at P<0.01.
Values in the same rows followed by the same letter are not significantly different at the 0.05 probability level.

Table 3: The relationship between basic density and age-groups.

Equation	Intercept, a	Slope, b	R^2	Standard error	P-value
Basic density = a + b*Age	0.302	0.0164	0.81	0.0121	<0.0000

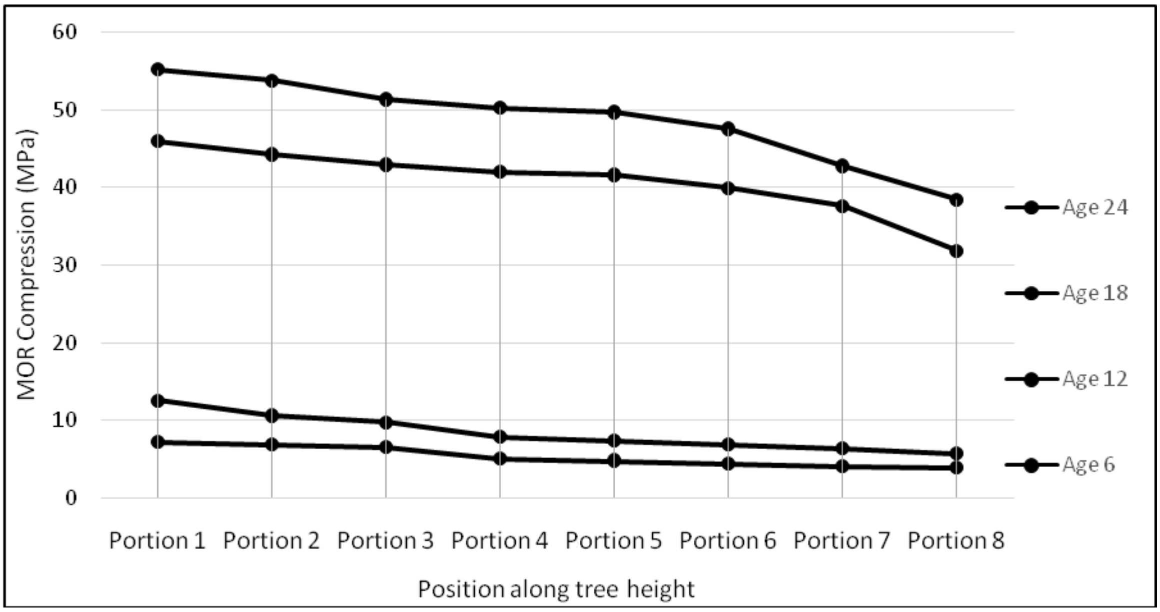

Figure 3: The modulus of rupture on compression tests at various age-group of cultivated *C. manan* at portions height 1 to 8

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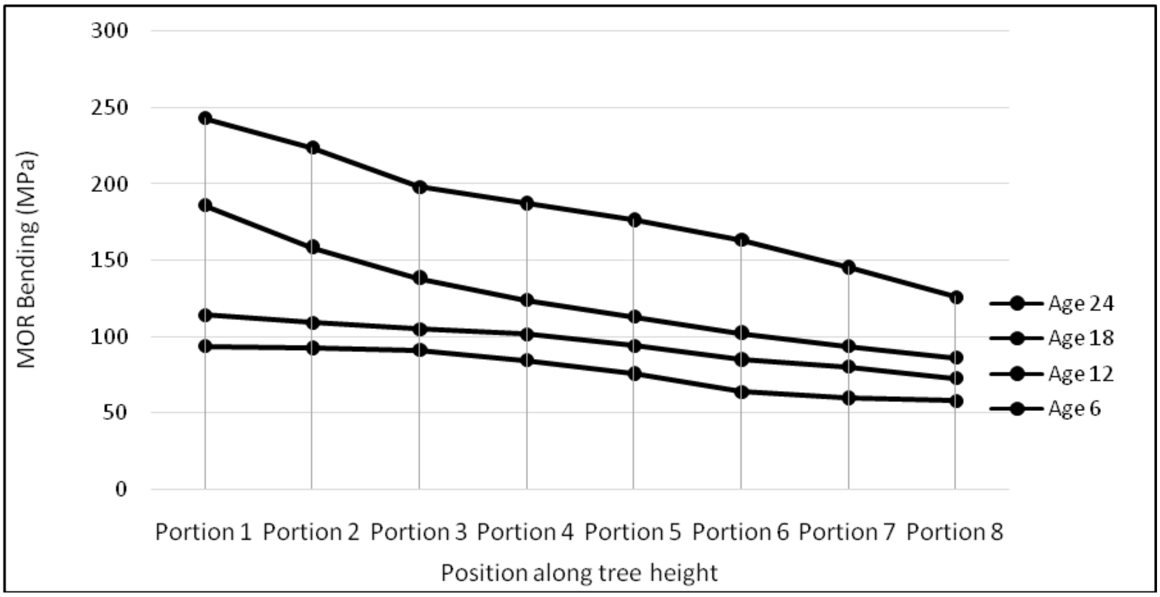

Figure 4: The modulus of rupture on bending tests at different age-group of cultivated *C. manan* at portions height 1 to 8.

The relationship between basic density and age factor analyzed using regression as shown in Table 3. The correlation coefficient indicated a moderately strong relationship between both variables. This value can be used to construct prediction limits for new observation in age and, even the strength properties.

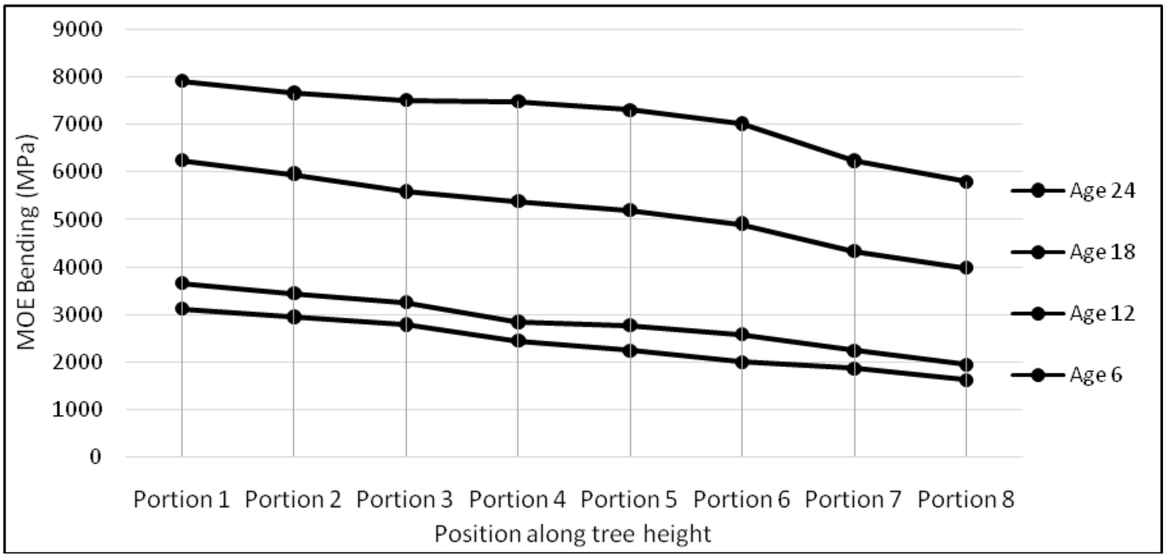

Figure 5: MOE on static bending tests at different age-group of cultivated *C. manan* of portions height 1 to 8.

Table 4: The ANOVA on mechanical properties of the planted *C. manan*.

Source of variation	DF	F-Value and statistical significance		
		MOR for Compression (MPa)	MOR for Bending (MPa)	MOE for Bending (MPa)
Age-group	3	3333.08 **	586.27 **	3245.00 **
No. of culm	4	0.50 ns	1.56 ns	0.99 ns
Portion height	5	35.61 **	50.51 **	109.18 **

ns: not significant at P<0.05, **: highly significant at P<0.01

Table 5: Duncan multiple range test on MOR bending, MOE bending and MOR compression.

Age-group	Compression strength	Bending strength MOR (MPa)	Bending strength MOE (MPa)
6	6.5 a	93.1 a	2860 a
12	7.3 b	93.2 a	2890 a
18	39.8 c	104.3 a	4120 b
24	43.7 d	134.9 b	5830 c

Values in the same rows followed by the same letter are not significantly different at 0.05 probability level.

The values of the modulus of rupture (MOR), modulus of elasticity (MOE) for static bending tests and modulus of rupture (MOR) for compression tested tabulated in Figure 3. The strength values of rattan decreased based on the position of rattan heights [1]. Portion height 1 shows the highest strength value, while portion height 8 has the lowest strength. Rattan from 24-year-old exhibited the highest strength value as compared to other age-groups. The MOR from static bending ranged from 168.3 MPa to 167.8 MPa. These results are expected possess the highest basic density [17], [18], [19]. This is followed by 18-year-old age-groups having the MOR from static bending range from 30.5 MPa to 42.9 MPa. There was a sudden decreased in strength for the 12-year-old and 6-year-old age-groups rattan. The strength ranged from 4.7 MPa to 7.7 MPa and 3.9 MPa to 6.6 MPa respectively. These strength for both age-groups are considered as too low and might not be suitable for utilization for the industry. The strength properties relate very well with the density as being discussed earlier.

The ANOVA on strenght properties of planted *C. amanan* at different ages, culms, and portion height are shown in Table 6. Table 7 shows the Duncan multiple range tests (MRT) on MOR bending, MOE bending and MOR compression. Significat differences exists in the MOR for compression, and MOR and MOE for bending between the various age-group and portion height of the *C. manan* [1], [12], [20].

CONCLUSION

The lower part of the culms possesses higher basic density compare to upper part of the rattan. The older rattan (18 and 24-year-old) shows to have higher basic density compare to young rattan (6 and 12-year-old). Samples with higher density show to have higher strength compare to lower density. Older rattan indicates to have greater strength compares to younger rattan. It can be concluded that the planted *Calamus manan* of age 18 and above possessed the mechanical characteristics that make them suitable for utilization.

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