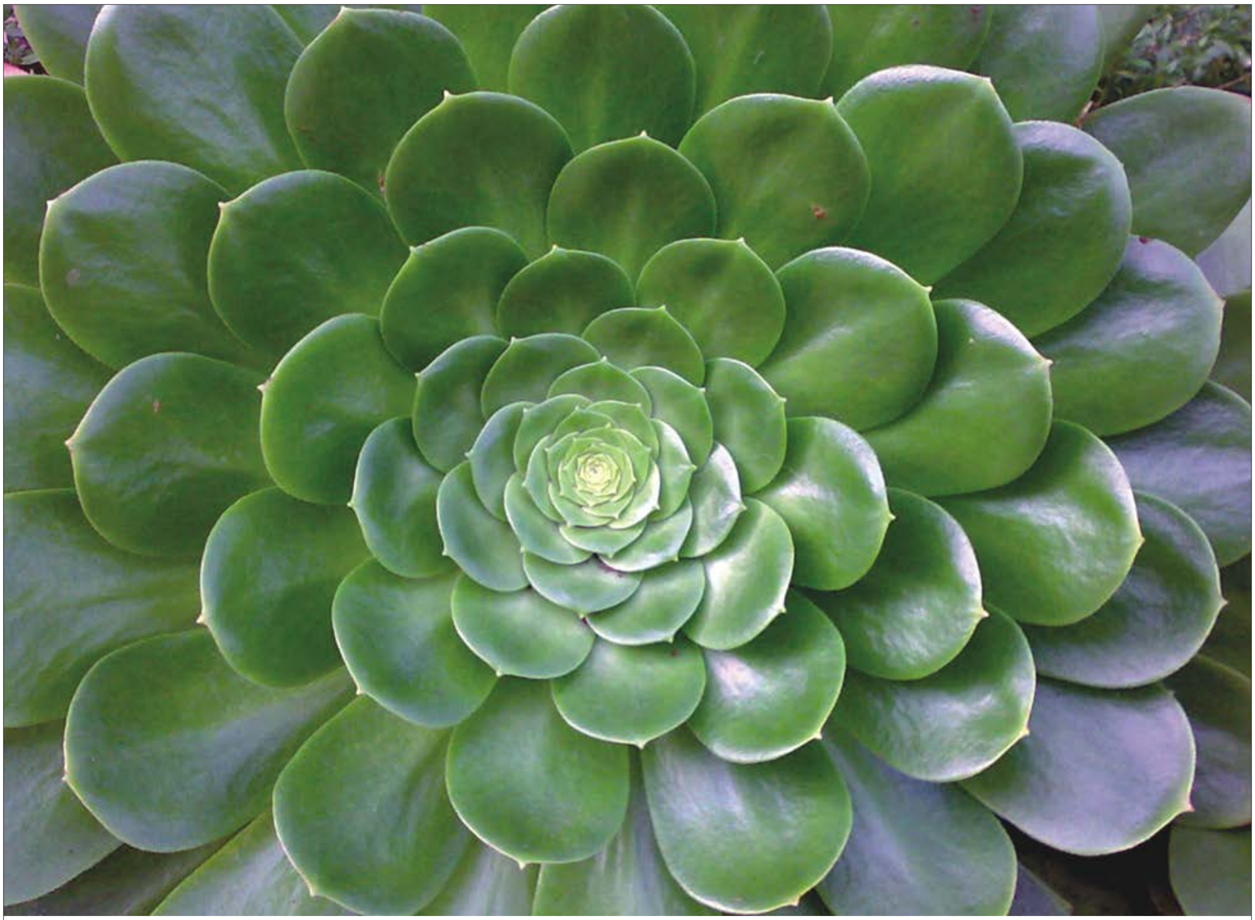

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Relationship Between Basic Density, Compression and Bending Strength of 8, 12, 18 and 24 Year-old *Calamus manan* Cultivated Intercropping Between Rubbertrees

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Abstract: Four age-groups of rattans comprising 8, 12, 18 and 24 year-old culms at portions 1, 2, 3, 4, 5 and 6 from the base were used in this study. The rattans were harvested from two rubber plantation estates in Terengganu and Pahang that possess similar soil characteristics and properties. Generally, the results of the study indicate that rattans with higher basic density possess higher compression and bending strength compares to those with lower values. The lower part of the rattans shows to have higher basic density compare to higher part. The 18 and 24 year old rattans shows to have higher basic density compare to the 8 and 12 year-old. The 18 and 24 year old rattans indicate to have 7 to 8 times higher strength compares to younger rattans. It can be concluded that the cultivated rattans of age 18 and above possessed the mechanical characteristics that makes them suitable for utilization.

Key words: Cultivated *Calamus manan*, different age-group culms, basic density, MOR compression, MOE and MOR bending

Introduction

Rattans considered to be one of the most important non-wood forest products and become the main source of raw materials for furniture and handicraft industry. They are normally used for making furniture, baskets, mats, hunting and fishing utensil, items for adornment, etc. *Calamus manan* locally known as rotan manau is the most popular of all the rattans found in Malaysia. This rattan is very flexible, versatile, strong and possess higher quality appearance with almost uniform diameters between the nodes and internodes over the other rattans species.

Due to over-exploitation and the high demands by the furniture and handicraft industry, the supply of naturally growth *C. manan* has becomes scarce and expensive. In order to ensure availability and consistency supply of the rattans to the local industry the Malaysia government started the rattans cultivation programme. The programme was started in mid 1980's where the rattans species especially the *C. manan* were cultivated in the natural forest and intercropping between rubbertrees on large scale plantation. Aminuddin and Supardi (1991) reported that under this programmed more than 13,000 ha of land was cultivated with rattans.

After more than over a decade, this cultivated rattans had reached the recommended harvesting age (Aminuddin and Supardi, 1991; Salleh and Aminuddin, 1986). Early observations based on the growth performance of the rattans showed promising returns. As a result, some of these rattans were harvested.

Studies on wild and cultivated *C. manan* have been investigated by several researchers (Razak *et al*., 2000; Ani and Lim, 1991; Weiner and Liese, 1987, 1988). Ani and Lim (1991) studied on 11 year-old cultivated *C. manan* found out that there were differences in the fibre wall thickness

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between the forest and the cultivated one. However, the fibre length was almost similar. These studies however were limited on the rattans of 16 year old and below. No study has been carried out on the strength of cultivated rattans of age older than this. Studies on other rattans species were mostly focused on the physical and mechanical properties of matured with unknown aged (Latif *et al*., 1996; Bhat *et al*., 1992, 1996).

Materials and Methods

Twenty culms of cultivated *Calamus manan* consisting of five from each age group of 8, 12, 18 and 24 were used in the study. Culms of age-groups 8 and 12 were taken from the rubber wood plantation in Paka, Terengganu, while those from age-groups 18 and 24 were taken from rubber wood plantation in Temerloh, Pahang. The sites where these rattans were cultivated were noted to have the similar soil characteristics and properties. The determination of age is based on date of planting as provided by the planters.

Each culm was sampled and labelled at six level of height. A height level or namely a portion consists of a length of 3 m. Portion 1 represent culm height from 0 to 3 m, portion 2 represent culm height 3 to 6 m, portion 3 represent culm height 6 to 9 m, portion 4 represent culm height 9 to 12 m, portion 5 represent culm height 12 to 15 m and portion 6 represent culm height 15 to 18 m. These lengths are considered to be standard lengths that are commonly practiced by the rattans industry in the country for processing and utilization purposes. Only portions 1, 2, 3, 4, 5 and 6 are taken and used in the studies. These are due to the difficulties in extracting the rest of culm portion and to get uniform characteristics.

Within a week after harvesting, these rattans were treated in hot diesel oil as normally practiced by the local rattans industry. This is also being outlines by Razak *et al*. (2000). The duration of the process take about 20 minutes. All processed rattans were air-dried for about 14 days. These rattans were cut into smaller sizes according to size required for physical and mechanical studies. These samples were kept in a conditioning chamber of about 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 Anonymous (1957, 1974). The study and testing were carried out both in UMS and FRIM.

Results and Discussion

The cross section of 12 year old and 24 year old rattans at portion one from the same height are shown in Fig. 1. It shows variation in culm density between the outer and inner part of the culm. The outer part of older rattans (24 year old) show to have a much higher density compare to younger one (12 year old). The diameter of the rattans increases from the bottom portion to the top.

The basic density is a measure of the relative amount of solid cell wall material. The results of basic density studies are tabulated in Table 1. The trend of the relation of basic density with portion is shown in Fig. 2. This result indicates that the basic density is significantly higher as the age of the rattans mature. The analysis of variance (ANOVA) of the results is shown in Table 2. The multiple range tests (MRT) on effects of age, portion and culm on basic density of cultivated *C. manan* is shown in Table 3. The basic densities significant decreases from the basal to the upper portions. These findings were in agreement with previous study (Razak *et al*., 2000; 2004; Roszaini, 1998). This relationship is probably related to the percentage amount of fibre base on height of the rattans. The lower portion contain higher amount of fibres as compared to the upper part of the rattans.

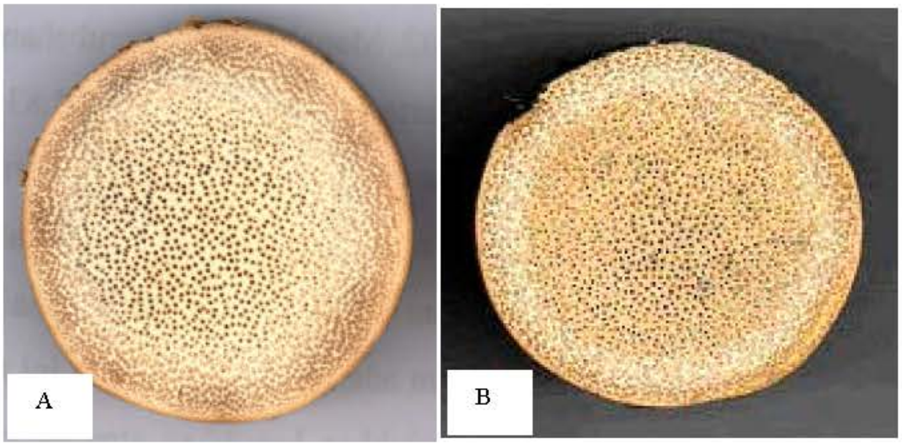

Fig. 1: Cross-section between matured 24 year-old group *C. manau* (A) and 12 year-old *C. manan* (B)

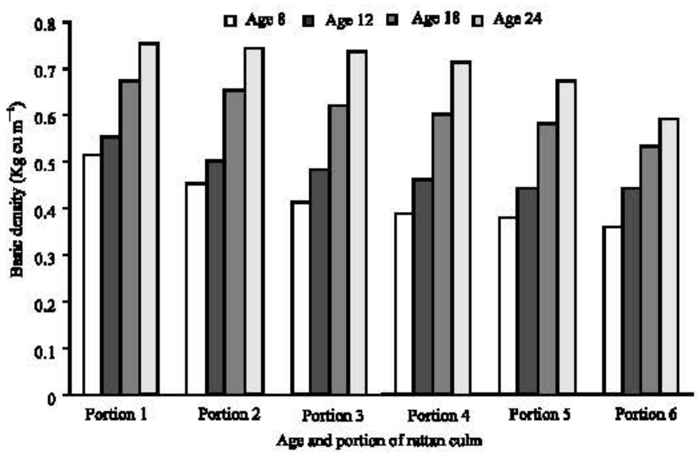

Fig. 2: Trend on basic densities by portions of *C. manan* from different age-groups

Table 1: Means value for basic density of age-group 8, 12, 18 and 24 year-old culm

	Basic density (kg m^{-3}) of portions					
Age	1	2	3	4	5	6
8	0.51	0.45	0.41	0.39	0.38	0.36
12	0.55	0.50	0.48	0.46	0.44	0.44
18	0.67	0.65	0.62	0.60	0.58	0.53
24	0.75	0.74	0.73	0.71	0.67	0.59

Table 2: Summary of analysis of variance on basic density of cultivated *C. manan* at different ages, culms and portions

Source of variation	df	F-value and statistical significance basic density (kg m^{-3})
Age	3	801.55**
Culms per age	4	1.94ns
Portion	5	87.45**

The relationship of basic density and age factor was analyzed using regression as shown in Table 4. 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.

Table 3: Multiple Range Tests (MRT) on effects of age, portion and culm on basic density of palnted *C. manan*

Basic density						
Age	8	12	18	24		
	0.43a	0.47b	0.61c	0.70d		
Culm per age	1	2	3	4	5	
	0.55b	0.55b	0.54a	0.54a	0.56b	
Portion	1	2	3	4	5	6
	0.62f	0.58e	0.56d	0.54c	0.51b	0.47a

ns: Not significant at $p<0.05$, **: Highly significant at $p<0.01$, Means in the same rows followed by the same letter(s) are not significantly different at the 0.05 probability level

Table 4: Relationship between basic density and rattans at different 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	*

* Significant at the 0.05 probablity level the 0.05 probablity level

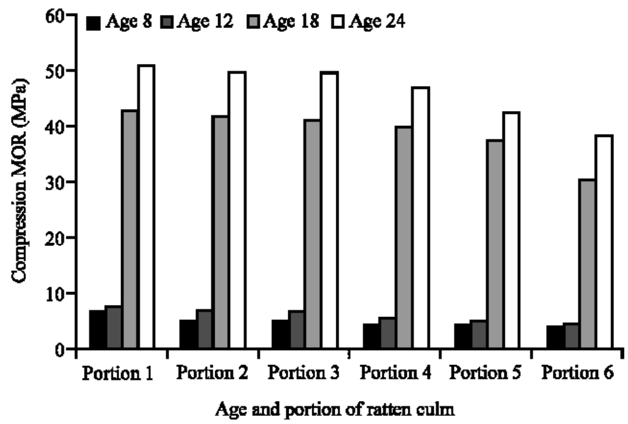

Fig. 3: Modulus of rupture on compression tests at different age-groups of cultivated *C. manan* at portions 1, 2, 3, 4, 5 and 6

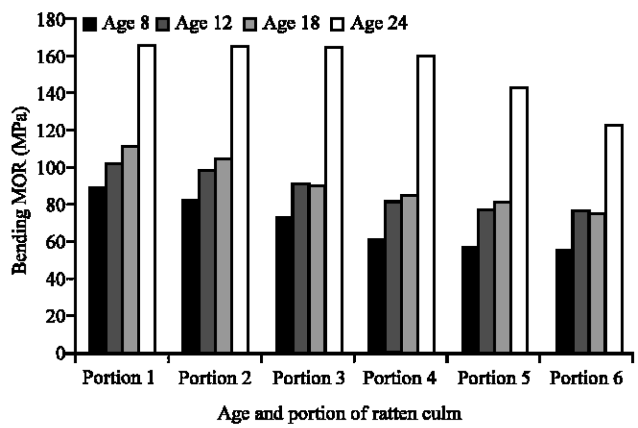

Fig. 4: Modulus of rupture (MOR) on bending tests at different age-group of cultivated *C. manan* at portions 1, 2, 3, 4, 5 and 6

The results of mean values of Modulus Of Rupture (MOR), Modulus Of Elasticity (MOE) for static bending tests and Modulus Of Rupture (MOR) for compression tests are shown in Fig. (3-5) and Table 5. Generally, the mean strength values of rattans decrease with the portion. Portion 1 shows

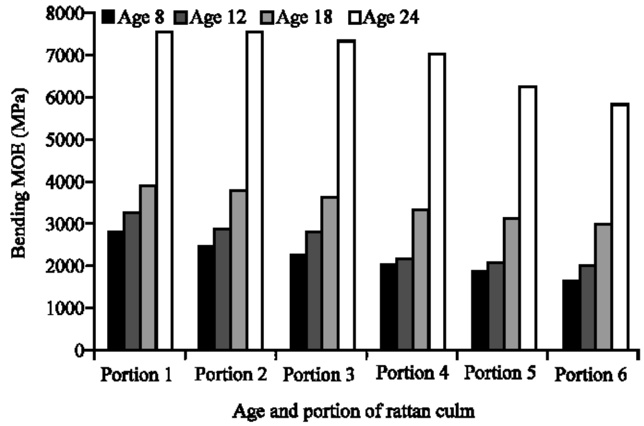

Fig. 5: Modulus of elasticity on static bending tests at different age-group of cultivated *C. manan* at portions 1, 2, 3, 4, 5 and 6

Table 5: Means value for modulus of rupture for compression, modulus of rupture and modulus of elasticity for static bending tests at 12% moisture content for *C. manan* of age-groups 8, 12, 18 and 24 year-old

		Compression	Static bending	
Age	Portions	MOR (MPa)	MOR (MPa)	MOE (MPa)
8				
	1	6.6	91.5	2790
	2	5.0	84.6	2460
	3	4.8	75.7	2250
	4	4.4	63.8	2020
	5	4.1	60.0	1870
	6	3.9	57.9	1640
12				
	1	7.7	105.1	3260
	2	6.9	101.4	2850
	3	6.4	94.0	2780
	4	5.5	85.1	2190
	5	5.0	80.5	2050
	6	4.7	79.8	1960
18				
	1	42.9	114.3	3890
	2	42.0	107.5	3780
	3	41.6	92.6	3600
	4	39.9	88.3	3310
	5	37.6	83.4	3130
	6	30.5	78.1	2990
24				
	1	51.3	168.3	7520
	2	50.2	167.8	7490
	3	49.6	166.9	7310
	4	47.5	163.6	7020
	5	42.7	145.6	6250
	6	38.4	126.2	5810

* Values are means of four replicates

the highest strength value, while portion 6 have the lowest strength. Rattans from 24 year old exhibited the highest strength value as compared to other age-groups. The MOR from static bending ranged from 168.3 to 167.8 MPa. These are expected, as they possess the highest basic density. This is followed by 18 year old age-group having the MOR from static bending range from 30.5 to 42.9 MPa. However, there was a sudden decrease in strength values for the 12 year-old and 8 year-old age

Table 6: Summary of analysis of variance on mechanical properties of cultivated *C. manan* at different ages, culms and portions

		F-value and statistical significance		
Source of variation	df	Compression MOR (MPa)	MorB (MPa)	MoeB (MPa)
Age	3	3333.08**	586.27**	3245.00**
Culms	4	0.50ns	1.56ns	0.99ns
Portion	5	35.61**	50.51**	109.18**

ns: Not significant at p<0.05, **: Highly significant at p<0.01

Table 7: Duncan Multiple Range Test (DMRT) of MOR bending, MOE bending and MOR compression tests on cultivated *C. manan*

		Bending strength	
Age	Compression strength	MOR (MPa)	MOE (MPa)
8	6.5a	93.1a	2860a
12	7.3b	93.2a	2890a
18	39.8c	104.3a	4120b
24	43.7d	134.9b	5830c

Means in the same rows followed by the same letter(s) are not significantly different at the 0.05 probablity level

rattans. The strength values ranged from 4.7 MPa to 7.7 MPa and 3.9 MPa to 6.6 MPa, respectively. These strength values for both age-groups are considered as too low and might not be suitable for utilization for the industry. Table 6 and 7 shows the ANOVA on mechanical properties and DMRT of MOR bending, MOE bending and MOR compression, test on cultivated *C. manan*.

The contrast in strength between different age-group of the rattan are seen in Table 5 and Fig. 4 which showed clearly the MOR on compression tests at portions 1, 2, 3, 4, 5 and 6. The strength properties relate very well with the density as being discussed earlier.

Conclusions

The lower part shows to have higher basic density compare to higher part of the rattans. The older rattans (18 and 24 year-old) shows to have higher basic density compare to the young rattans (8 and 12 year-old). Samples with higher densities shows to have higher strength compares to lower densities in term of MOR in compression, MOR and MOE in bending. Older rattans indicate to have higher strength compares to younger rattans. It can be generally concluded that the cultivated *Calamus manan* of age 18 and above possessed the mechanical characteristics that makes them suitable for utilization.

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