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Property characterization of plantation-grown palasan rattan (*Calamus merrillii* Becc.)

W. P. Abasolo[*]
Forest Products and Paper Science Department, College of Forestry and Natural Resources, University of the Philippines, Los Baños, Laguna, Philippines 4031

Abstract: The mechanical properties of plantation-grown palasan rattan (*Calamus merrillii* Becc.) were compared with those of wild rattan. The effect of specific gravity and fibre percentage on strength variability within a particular position was evaluated. The influence of rattan age on strength properties was also assessed. In terms of MOR and MOE, both plantation-grown and wild rattan were more or less similar proving that the former is not inferior to the latter in strength properties. This would imply that plantation-grown rattan could also be used in the industry without negatively affecting the mechanical properties of the finished products. Ovendry specific gravity and fibre percentage did not influence the variation in strength properties within a particular position. Similarly, rattan age did not influence the strength properties. Apparently, a young rattan would also possess the same strength values as that of a mature stem.

Key words: Calamus merrillii, plantation-grown rattan, wild rattan, MOR, MOE, ovendry specific gravity, fibre percentage.

INTRODUCTION

The rattan furniture business is a resource-base industry that relies heavily on the constant supply of raw materials (Mohd. Ali and Barizan, 2002). Due to the unhampered destruction of forest habitat, the supply of rattans has declined tremendously through the years. The only way for the industry to survive is through the establishment of rattan plantations.

In response to the looming problem of diminishing stock of raw materials from the natural forest, the Philippine Government has established approximately 12,000 ha of rattan plantations through loans and grants in 1988 (DENR, 1988). Assuming that the plantations have been well managed, it would imply that they are now ready for harvest. Although these plantations could really solve the raw material crisis, the

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[*]E-mail: willieabasolo@yahoo.com

main drawback is that the mechanical and physical properties of this plantation material are not fully known.

For trees, plantations connote accelerated growth, leading to the production of more juvenile wood that has inferior wood quality (Koubaa *et al.*, 2005) as compared to mature wood. This is brought about by shorter, thinner-walled tracheids, larger microfibril angle, lower holocellulose with high lignin content (Zobel and Sprague, 1998), ultimately leading to lower modulus of elasticity (Kretschmann and Bendtsen, 1992). For rattans, there is either very little information or none at all that deals with the properties when grown in plantations.

The present study was conducted in order to compare the mechanical, physical and anatomical characteristics of plantation-grown rattan and wild rattan to see whether the plantation-grown rattan is inferior in quality to wild rattan.

MATERIALS AND METHODS

Uneven-aged palasan rattan (*Calamus merrillii* Becc.) grown in plantations including those from the natural stand were utilized in this study (Table 1). After determining the total stem length, 2 m long samples were obtained from the basal (5 cm from the ground) and top portions (10 cm from the immature shoot) for evaluation of mechanical, physical and anatomical characteristics evaluation. Thus, both mature and juvenile parts of the stem were considered in the evaluation.

Mechanical testing

Using a Shimadzu Universal Testing Machine (UTM), static bending test was

Table 1. Sample characteristics and locations of collection

Sample	Age (yrs)	Total length (m)	Diameter (cm)		Location of plantation
			Average	Std. dev.	
NAT	Unknown	22	2.95	0.60	Los Baños, Laguna*
QP2-84	20	16	2.95	0.60	Pagbilao, Quezon
LP2-86	18	41	3.73	0.30	Daraga, Legaspi
TP-89	15	33	4.86	0.55	Ormoc, Leyte
LP1-90	14	53	3.92	0.59	Daraga, Legaspi
NP-93	11	3	4.56	0.38	Southern Negros
MLP-93	11	11	3.66	0.36	Ormoc, Leyte
QP1-94	10	6	3.15	0.83	Pagbilao, Quezon
AKP-94	10	10	3.71	0.30	Ormoc, Leyte
MP-94	10	8	3.57	0.29	Southern Negros
MP-96	8	17	4.41	0.44	Southern Negros
PNOC-97	7	5	3.41	0.52	Sorsogon
NP-97	7	11	3.48	0.42	Southern Negros

* Makiling Forest Reserve

performed on the samples following the ASTM (1975) methodology. To prevent the possible effect of varying moisture content on bending strength, the samples were completely submerged in water prior to testing.

Specific gravity

After the static bending test, the samples were cut in half adjacent to the point of breakage. Thus, four consecutive 1 cm thick disks were prepared. Along the cross section of these disks, the peripheral and core regions were delineated from which 0.5 cm x 0.5 cm x 1 cm sample blocks were prepared. A total of ten blocks per region were made. Following the gravimetric method, ovendry specific gravity was derived. The data obtained from the peripheral and core regions were averaged.

Anatomical analysis

From the disks prepared in the previous experiment, 1 cm^3 cubes were prepared from the peripheral and inner regions. Cross sections of 35-45 μm were then sliced off using a sliding microtome. The sections were stained with safranin and fast green and mounted. Photographs were obtained from a compound microscope equipped with a Nikon Cool Pix digital camera. A total of five pictures per region were taken. With the aid of the Scion Image Analysis Software fibre percentage was determined (Abasolo *et al.*, 2005). Data from the two regions were again consolidated after which average values were used in the analysis.

RESULTS AND DISCUSSION

From the survey of 12 palasan plantations situated all over the Philippines it was found that the length of rattan ranged from 3 m to 53 m and average diameter, from 2.95 cm to 4.86 cm. The morphological characteristics of the samples from rattan obtained from plantations and the natural stand (NAT) were similar.

Mechanical properties

The modulus of rupture (MOR) and the modulus of elasticity (MOE) are depicted in Figure 1. MOR of the basal region of the natural stand (NAT) was about 45 MPa while the plantation samples gave values ranging from 15 to 50 MPa. As for the top portion, NAT was 23 MPa while the plantation samples were from 8 to 24 MPa. Modulus of elasticity (MOE) for NAT was approximately 8 GPa and 5.2 GPa while the plantation samples gave a range of 5.12-9.75 GPa and 1.66-5.35 GPa for the basal and top region, respectively. This showed that the mechanical properties of rattan from NAT fall within the range of the properties of the plantation-grown rattan.

The basal region was obviously several times stronger than the top region. This is consistent with earlier investigations (Rich, 1987; Bhat *et al.*, 1996) where rattan flexibility tends to increase with height. Nevertheless, what was striking was the fact

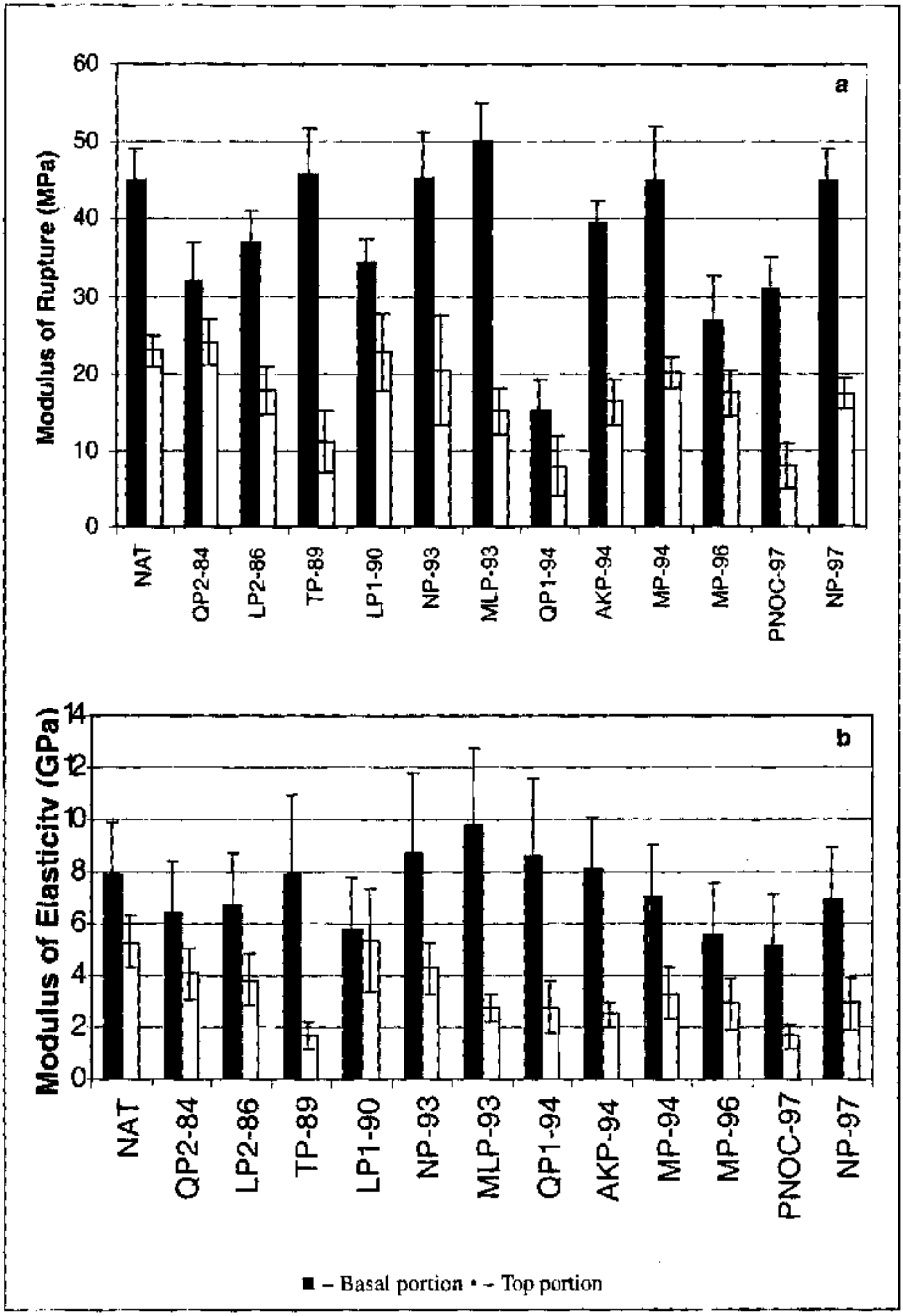

Figure 1. Mechanical properties of basal and top portions of *C. merrillii*

that in MLP-93, basal strength was more than 100 times higher than that of the top portion. Besides between-position differences (base and top), within-position variation was also noticed. Nevertheless, this was comparatively smaller in contrast with the former (Table 2).

There are several factors that can influence strength properties: species, stem position, fibre proportion, specific gravity, age and moisture content (Bhat and Thulasidas, 1992). Differences between base and top were simply due to differences in stem maturation. The base being the first part to be produced by the plant, was obviously more mature than the top; hence, logically it is stronger than the top portion. However, for within-position differences, only the influence of specific gravity, fibre proportion and age were considered because moisture content and species were the same for all the samples.

Specific gravity and fibre percentage

Figure 2 represents the ovendry specific gravity and fibre percentage values of the individual samples. The specific gravity of plantation samples gave a range of 0.47 -0.62 and 0.26-0.48 for the basal and top portions respectively. The NAT samples fell within this range with about 0.57 and 0.45 for the two respective portions. Fibre percentage, on the other hand, was about 40 and 27 for the NAT whereas the plantation samples ranged from 22-48 and 21-33 for the basal and top portions respectively. Similar to specific gravity, the NAT was again within the range of the fibre percentage of plantation-grown rattan. Between and within-position variations were again noticed and this follows the trend of the mechanical properties (Table 2). Whether these variations affected the differences in rattan strength was then verified.

Relationship between specific gravity and fibre percentage

Correlation of the specific gravity values with the mechanical properties of rattans showed that the strength values (both MOR and MOE) for basal portion, were unaffected by the specific gravity of the stem (Fig. 3). Although there was a weak

Table 2. Comparison of the properties of the basal and top portions of *C. merrillii*

	Base and top comparison					
Properties	Position	Mean	SD	F-computed	F-tabulated	Remarks
MOR (MPa)	Base	37.87	9.81			
	Top	17.03	5.34	64.48	4.75	***
MOE (GPa)	Base	7.28	1.37			
	Top	3.32	1.19	59.42	4.75	***
Specific gravity	Base	0.55	0.05			
	Top	0.36	0.07	100.11	4.75	***
Fibre percentage	Base	35.27	6.39			
	Top	26.12	3.20	44.23	4.75	***

*** Values significantly different from each other

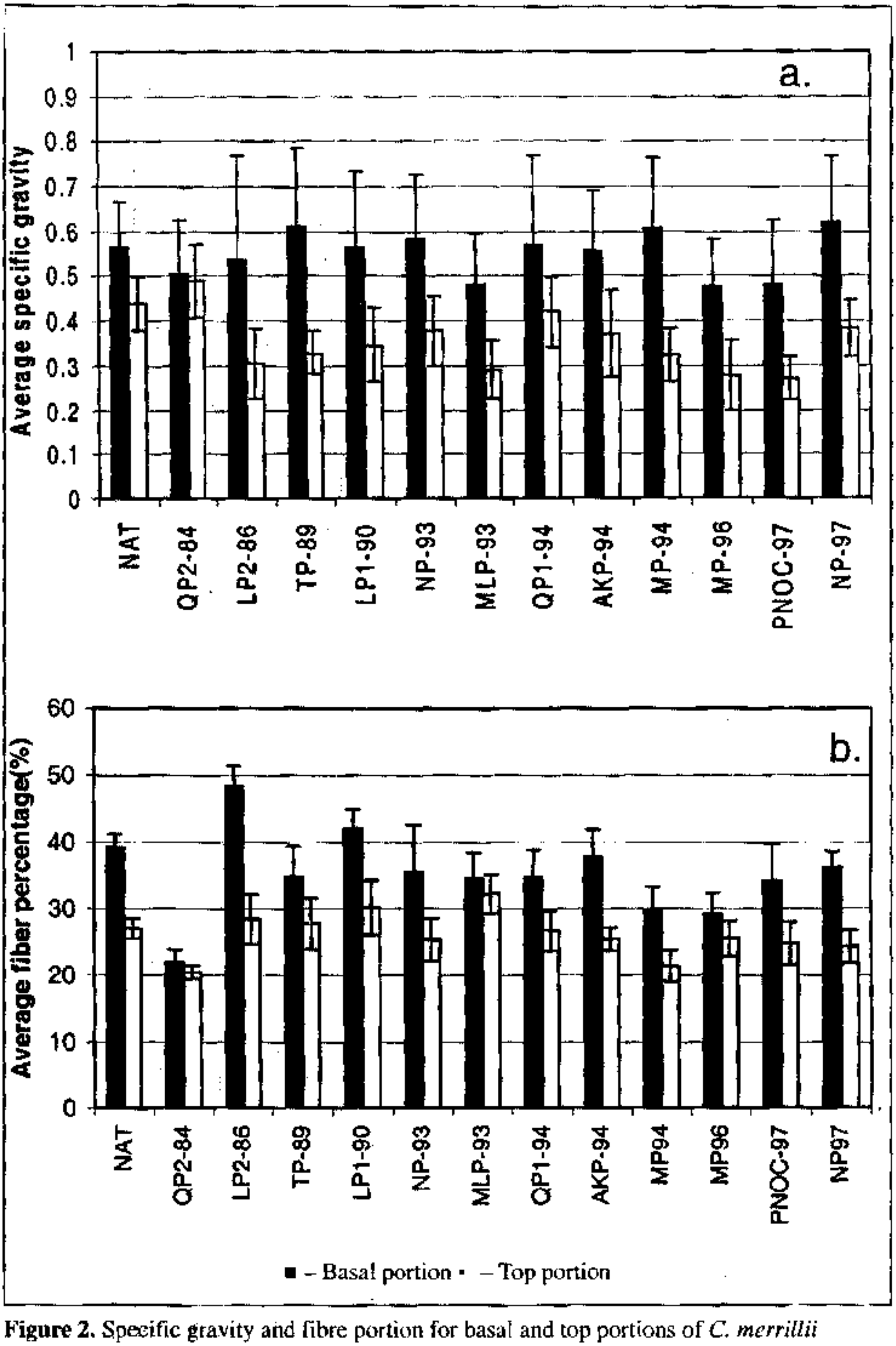

Figure 2. Specific gravity and fibre portion for basal and top portions of *C. merrillii*

positive trend in the graph, the relationships between these two parameters was not significant. For the top portion, strength was moderately influenced by the specific gravity.

Fibres with their thick cell wall provide mechanical strength to the structure. To highlight the influence of microfibril angle on the stiffness of the rattan, Abasolo *et al.* (2005) first standardized Young's modulus (MOE) with respect to fibre percentage.

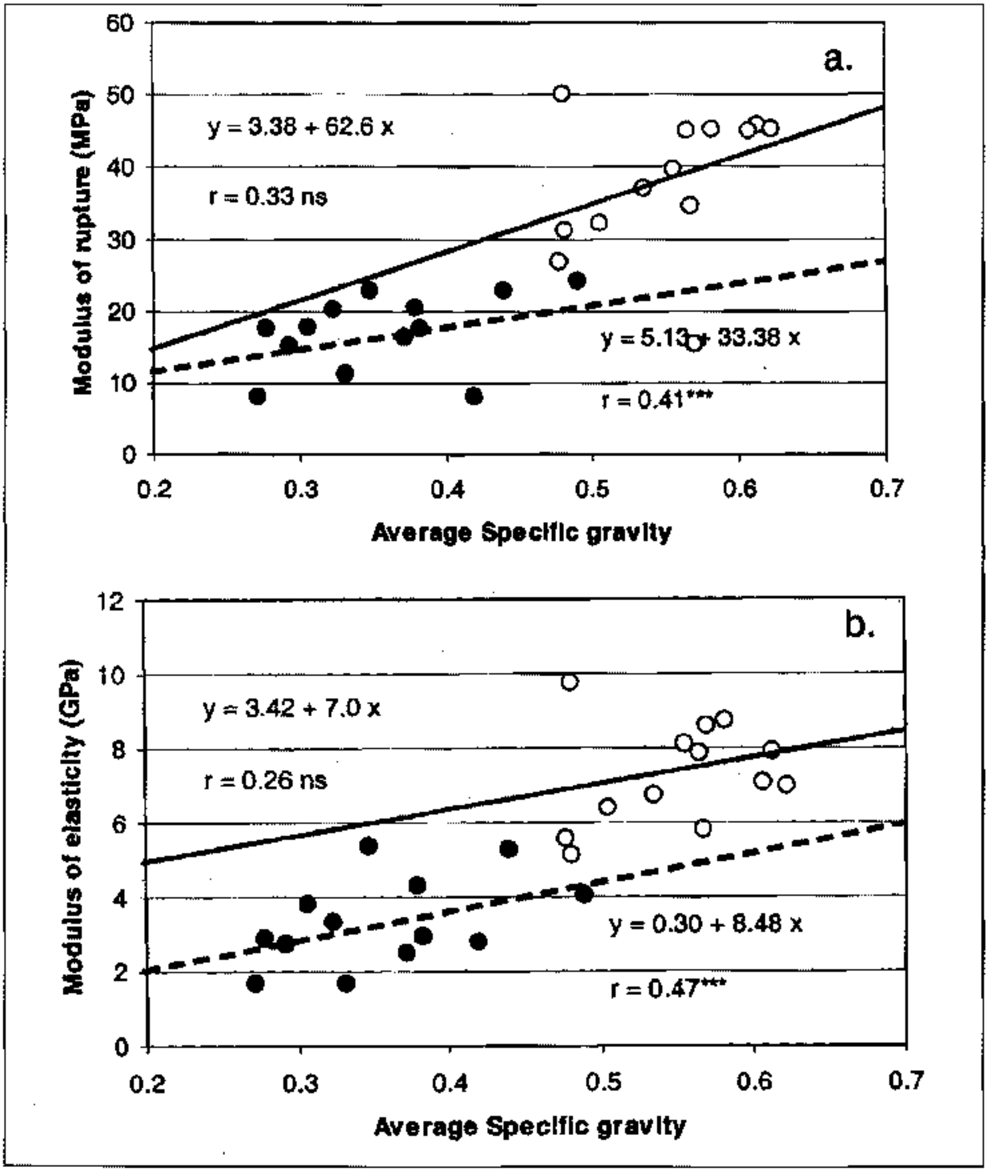

Figure 3. Relationship between mechanical properties and specific gravity in *C. merrillii*

When MOR and MOE of the samples were correlated to fibre percentage (Fig. 4), strength was found to be unaffected by fibre percentage. Probably the proportion of fibres present in the individual samples was more or less the same as evident from the very small standard deviation in fibre percentage for the two positions. This was irrespective of whether the rattan was grown in the natural forest or in plantations as long as they were taken from the same position within the stem. Thus, fibre proportion did not contribute to the variation in mechanical properties between the samples.

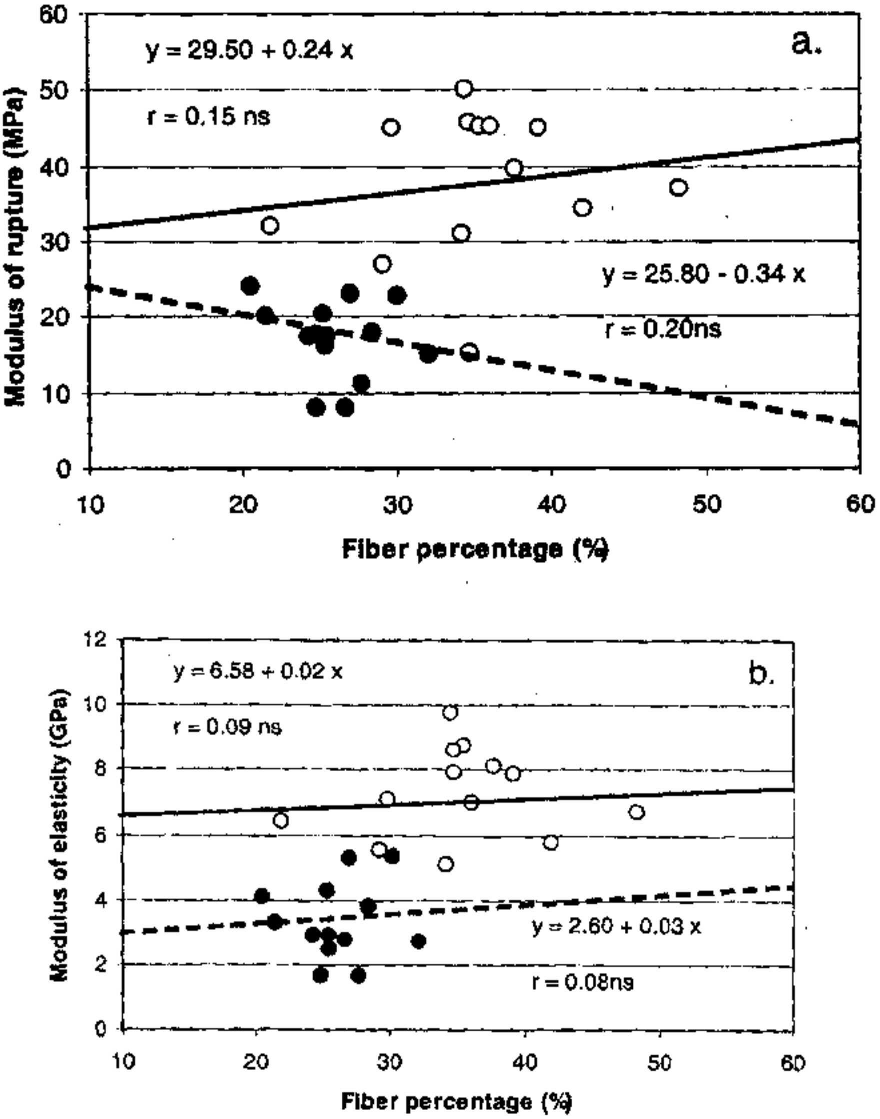

Figure 4. Relationship between mechanical properties and fibre proportion in *C. merrillii*

Influence of age

One unique characteristic of rattan plant is its ability to retain living protoplasts all through its life cycle (Tomlinson, 1990). This would imply that it has the capacity to continuously deposit lignin and cellulose to its cell wall as the stem matures. For this reason, rattan fibres possess not only two cell wall layers (primary and secondary wall) as in wood, but several layers of alternating broad and narrow lamellae (Parameswaran and Liese, 1985). Therefore, there is a possibility that although the specific gravity and fibre percentage of all the samples remain approximately the same, the older stem would have stronger fibres compared to the younger ones. To verify this, MOR and MOE were correlated to the age of the rattan (Fig. 5). Because the age of NAT was unknown, only the plantation samples were used in this analysis.

Surprisingly, the strength of the basal portion was unaffected by age. In fact, the graph showed that strength was constant along the different ages. Apparently, this showed that the basal portion of a 5-year-old rattan has the same strength properties as that of a 20-year-old. The top portion, on the other hand, was moderately affected by age. Being closest to the apical meristem (shoot), it was more likely that these tissues were not fully mature. Because of that, stability in properties had not yet been achieved by the plant at this portion.

This means that although additional strengthening materials could be deposited by the cells as they mature, such addition would only be secondary in importance to the initial strength properties of the structure manufactured by the plant right after its stem emergence. Monocot stems like rattan do not significantly modify their properties because they do not undergo secondary growth unlike trees (Haygreen and Bowyer, 1996). Thus, it has no other way but to produce a stem that can withstand any load requirement. As Tomlinson (1990) pointed out, rattan plants produce an over-built stem that could withstand future load requirements. Therefore, a 5-year-old stem could already carry the load requirements of a 20-year-old rattan and thus the two age groups have the same strength properties.

Potential of plantation grown rattan

To show the potential of plantation-grown rattan, the data of NAT are projected for comparison with values of the plantation-grown rattan (Fig. 1). The basal MOR of NAT was lower compared to samples TP-89, NP-93, MLP-93, MP-94, and NP-97. The remaining plantation samples were weaker as compared to NAT; nevertheless, when their values were averaged and the percentage difference between them and NAT was evaluated, their MOR was lower only by about 23 per cent. Similarly if basal MOE was compared, samples TP-89, NP-93, MLP-93, QP1-94, AKP-94 were again higher than NAT while the rest differed only to the extent of about 21 per cent. This would imply that the ultimate strength and flexibility of plantation-grown rattan are more or less similar to rattan taken from the wild. Therefore it is highly probable that items made from these rattans would not be inferior in strength to those made from wild rattan.

The study further proves that plantation age is immaterial. If the main considerations in deciding the proper cutting cycle for rattan plantations are flexibility and strength, harvesting can be done at anytime. The only concern now for rattan growers should

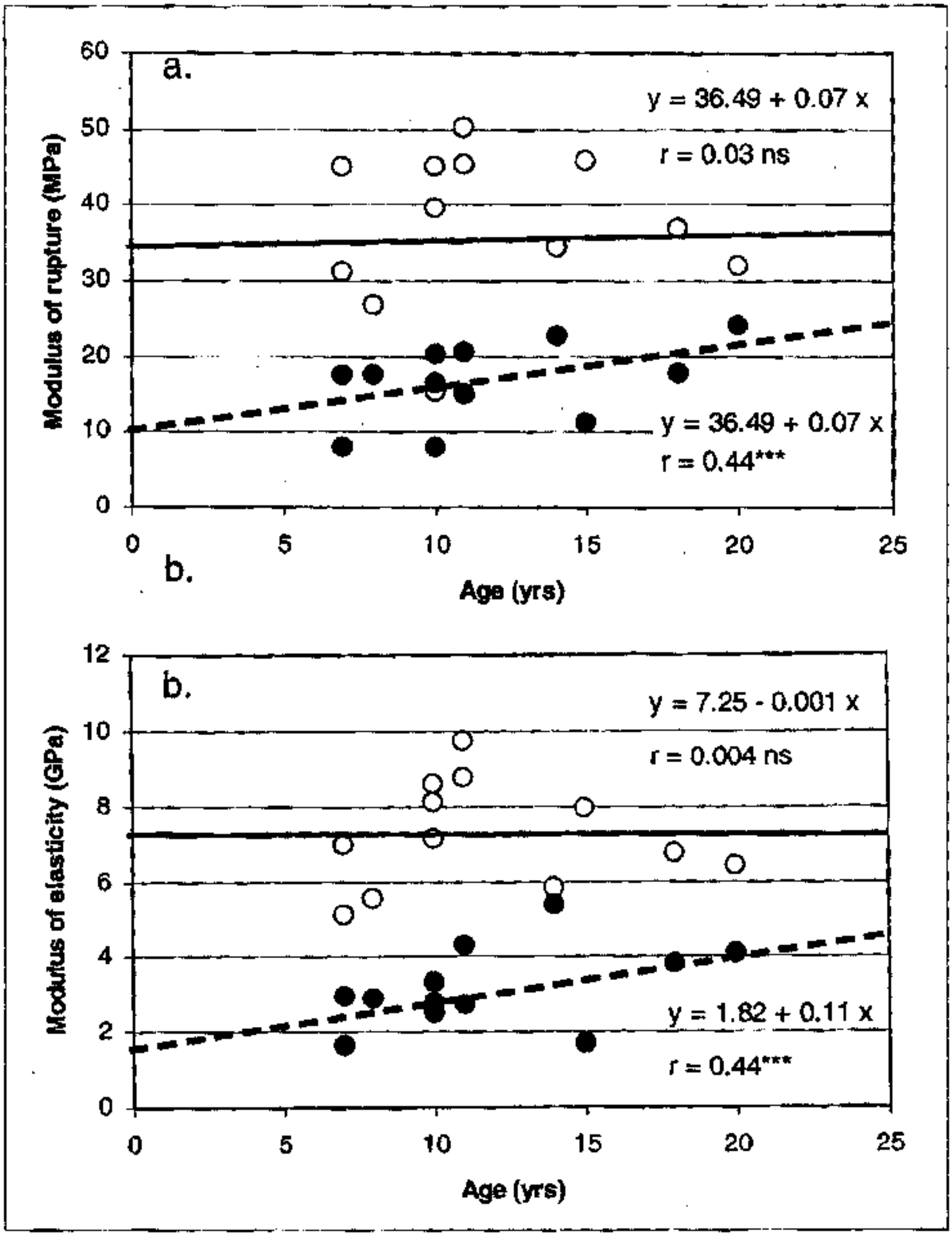

Figure 5. Relationship between mechanical properties and age in *C. merrillii*

be to provide the optimum conditions for promoting growth in order to produce longer stems, hence more harvestable volume at the shortest time possible.

CONCLUSION

Plantation-grown rattan was more or less similar in strength properties to wild rattan. Thus, it can also be utilized in the same way as the wild rattan. Specific gravity and fibre percentage did not affect the variation in strength properties within a particular position. Strength was also not influenced by age. Thus, if rattan strength is the main consideration in deciding the cutting cycle of the plantation, there is no need to wait for 10-15 years before harvesting the plantation because a young rattan would also possess the same strength properties as that of a mature stem.

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