ANATOMICAL AND PHYSICAL FEATURES OF 11-Y-OLD CULTIVATED *CALAMUS MANAN* IN PENINSULAR MALAYSIA

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ANI SULAIMAN & LIM S. C. 1991. Anatomical and physical features of *ll-y*-old cultivated *Calamus manan* in Peninsular Malaysia. Nine stems of 1 l-y-old *Calamus manan* grown in FRIM premises were examined for their physical and anatomical features. The stem diameter varied from 2.2 to 3.7 *cm,* internode length from 2.3 to 38.8 *cm* and specific gravity based on green volume and oven dry weight from 0.22 to 0.54. Anatomical features examined were the structure of the epidermis, periphery of the central cylinder, vascular bundles, the parenchyma ground tissues, and the fibres. There were some appreciable differences in. the anatomical features among the bottom, middle and top portions of the nine canes studied.

Key words: *Calamus manan* - anatomy - internodal length - diameter - specific gravity

Introduction

Calamus manan (rotan manau) is a solitary stemmed, large diameter rattan. The stem grows to a length of 100 *m* or more with a diameter of up to 8 *cm.* However, the stem base is often as slender as 2.5 *cm* in diameter and with internode to 40 *cm* long. *C. manan* is spread widely, but is usually confined to steep slopes in hill dipterocarp forest and rarely found in lowland Dipterocarp forest (Dransfield 1979). It is the most important rattan in furniture trade and found in abundance only in the Malay Peninsula and Sumatra and rarely in Borneo (Dransfield 1977).

With fast depleting resources of rotan manau and its increasing economic importance, trial planting of rotan manau has been carried out. Since 1977, about 45 *ha* have been established in the Forest Research Institute Malaysia (FRIM) and the Sungai Buloh Forest Reserve in Selangor (Aminuddin 1985). The rate of growth of individuals is likely to vary immensely. The planted *C. manan* in Sungai Buloh Forest Reserve has been estimated to grow at a maximum rate of about 3 my^{1} (Dransfield 1979) while the same species growing in Ulu Langat, Selangor, Peninsular Malaysia showed a maximum growth rate of only 1.2 *m* y^{1} (Manokaran 1977).

The quality, flexibility in usage and properties of rotan manau are well known. The physical and anatomical features of mature rotan manau in the natural forest have been investigated by several researchers (Teoh 1978, Liese & Weiner 1987, Weiner & Liese 1987, 1988). However, little work has been done on the cultivated rotan manau.

The objective of the present study is to evaluate the physical and anatomical features of the cultivated rotan manau.

Materials and methods

Nine rattan stems of about 11 years old were collected from FRIM premises for the present study. The stem length ranged from 9.5 to 18.2 *m* and the diameter from 2.2 (base of the stem) to 3.7 *cm* (Table 1). Each stem was divided equally into bottom (B), middle (M) and top portions (T).

Table 1. Length and diameter of nine stems examined

Stem	Length *(m)*	Diameter *(cm)*		
		B	M	T
1	9.5	2.2	2.5	2.9
2	9.8	2.7	3.2	3.2
3	12.5	2.9	3.1	3.4
4	10.0	2.4	2.4	2.9
5	18.2	2.8	3.3	3.7
6	12.1	2.5	2.8	3.4
7	12.5	2.3	2.9	3.2
8	13.0	2.8	3.0	3.3
9	11.7	2.3	3.3	3.3

B = bottom portion; M = middle portion; T = top portion

Samples of about 5 *cm* length were taken from the internode of each of the three portions of the stem to determine the specific gravity based on oven dry weight and green volume. The green volume of the sample was determined by water displacement. The diameter was measured by using a veneer caliper. The length of each internode from the bottom to the top of the stem was also measured.

For anatomical studies, samples were obtained from the B, M and T portions of the internode and treated according to the method described by Liese and Weiner (1987). The samples were pretreated with boiling water for about 10 *min* before embedding in 20% polyethylene glycol (MW2000). The embedded specimens were then sectioned to about 20 *Im* thickness and stained for microscopic studies. Measurements of the fibre dimensions were made on macerated fibres obtained after treating with a mixture of 50% hydrogen peroxide and 50% glacial acetic acid based on a standard method.

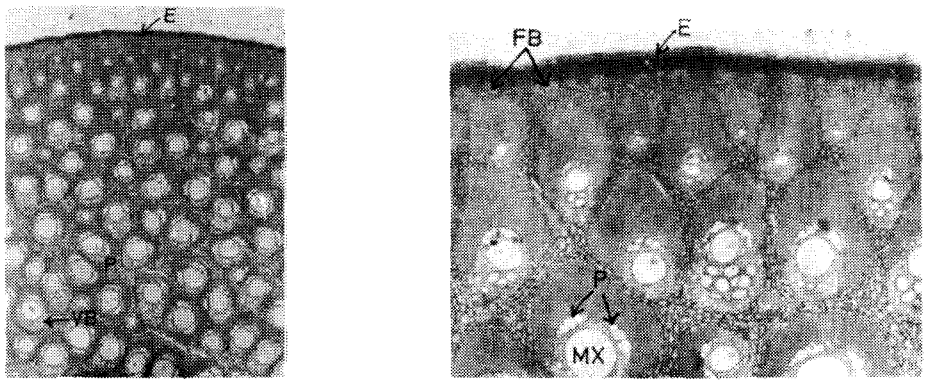
Results and discussion

Anatomical features

The cross section of the rattan stem is typical of any monocotyledon, which consists primarily of vascular bundles embedded in parenchymatous tissue

(Parthasarathy & Klotz 1976) (Figure la). It has no growth rings (Mosteiro 1980). The most remarkable feature of woody monocotyledons is that most of them achieve their stature without secondary thickening. Generally, the cross section of a rattan stem can be divided into peripheral, cortex and inner central cylinder (Tomlinson 1961, Teoh 1978).

The outermost layer of the stem is the epidermis, which is made up of uniseriate, unlignified rectangular cells. In between the epidermis and the first row of fully developed vascular bundles are layers of parenchyma cells in which a row of small fibre bundles are embedded evenly along the circumference of the stem (Figure 1b). These minute fibre bundles are about one quarter and one tenth the size of the vascular bundles near the epidermis and the central portion of the stem respectively. Fibre bundles are completely devoid of vascular tissues (Liese & Weiner 1987).



(a) (b)

Figure 1. Cross section of *C. manan.* a. Showing vascular bundle (VB), parenchyma ground tissue (G),and epidermis (E) (xlO). b. Showing epidermis (E), fibre bundles (FB), metaxylem (MX) **and phloem strands** (P) (x32)

The vascular bundles found in the peripheral part of the central cylinder are more crowded. It is interesting to note that the smaller vascular bundles intermingle with the larger vascular bundles. Generally, a typical vascular bundle consists of xylem and phloem, surrounded by a fibre mass and parenchyma cells. The xylem is mainly made up of a single metaxylem vessel with diameter ranging from 130 to 220 um. On an average, the diameters of metaxylem in the middle and the bottom portions appear to be of equal size, that is, 179 um. Those of the top portion show a much smaller diameter, that is around 128 u*m*. In some vascular bundles, two or more protoxylems in addition to the metaxylem can be found. The phloem can be in a rounded or crescent-shaped mass or a single strand making up of five or more cells. The fibre mass consists of lignified fibres and contributes to the strength of the rattan cane.

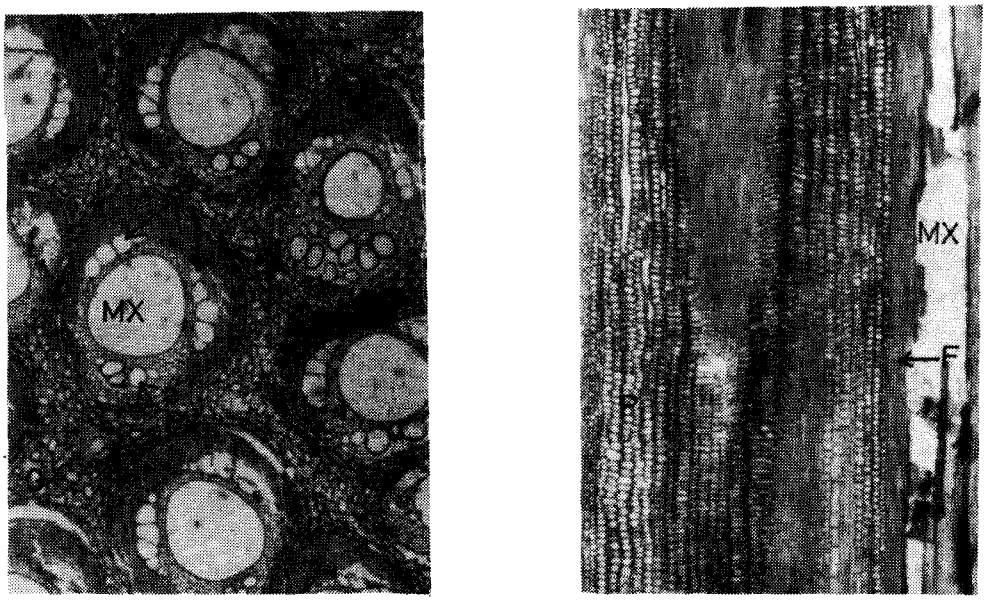
The central portion of the stem contains numerous vascular bundles which are much bigger than those found in the periphery (Figure 2a and Table 2). The vascular bundles, with diameter ranging from 0.60 to 0.76 *mm,* are

embedded in the parenchyma without any fixed orientation; the shape and size also vary from one another. The diameter of the vascular bundles for all the three portions of the nine canes is almost similar, that is 0.69 *mm* in the bottom portion and 0.71 *mm* in both the top and middle portions.

The metaxylem vessel, which occupies the central portion of vascular bundle, is normally fairly wide with a diameter of 340 to 450 U*m* and fairly visible to the naked eye. Larger xylem diameter (412 *Im)* is observed in the top portion than in the middle (397 U*m)* or bottom (373 U*m)* portions of the stems. The metaxylem is initially encircled by a few cells thick of parenchyma followed by a crescent-shaped fibre sheath on one end. Protoxylem is frequently found in the vascular bundles on the open-end of the fibre sheath.

The phloem strands are normally made up of four to eight cells per strand. There appears to be a similar number of phloem strands per vascular bundle in all the three portions of the stems. The mean number of phloem cells per strand is also similar, that is between five to seven.

The fibres, which are heavily lignified, are generally in the shape of a crescent on the cross section. However, the shape of the fibre sheath becomes more oblong with the middle portion protruding out when the fibres are situated near the periphery. Generally, the fibre bundles situated near the peripheral zone consist of thicker-walled cells and are greater in area than those found scattered in the central portion of the stem.



(a) (b)

Figure 2. Anatomical features of *Calamus manan.* a. Showing the transverse section of the central portion of the stem and. b. The longitudinal section, metaxylem (MX), phloem strands (P), fibre sheath (F), protoxylem (PX) and parenchyma ground tissue (G) (x32)

Table 2. Anatomy of ll-y-old rotan manau (C. *manan)* in Peninsular Malaysia

Stem		Vascular bundle			Diameter of metaxylem		Fibre				Phloem	
		No. per mm^2	Diameter (mm) P	C	(Um) P	C	Length (mm)	Width (Um)	Lumen (Um)	Wall thickness (total in a single fibre) (lm)	No. of strand per VB	No. of cell per strand
1	T	3	0.33	0.73	170	410	1.43	15.0	7.0	8.0	2	4 - 6
	M	4	0.35	0.69	170	390	1.41	19.0	7.0	12.0	2	5 - 7
	B	4	0.21	0.63	180	360	2.12	21.0	8.0	13.0	2	5 - 6
2	T	3	0.35	0.69	160	420	1.40	20.0	13.0	7.0	2	5 - 7
	M	3	0.40	0.64	170	390	1.42	17.0	6.0	11.0	2	4 - 7
	B	3	0.41	0.60	200	370	1.67	21.0	10.0	11.0	2	5 - 7
3	T	4	0.35	0.70	150	390	1.36	17.0	7.0	10.0	2	5 - 7
	M	3	0.36	0.73	180	370	1.66	25.0	17.0	8.0	2	5 - 7
	B	3	0.32	0.71	140	350	1.48	20.0	8.0	12.0	2	5 - 7
4	T	3	0.38	0.65	150	420	1.43	17.0	7.0	10.0	2	4 - 7
	M	3	0.50	0.65	160	380	1.40	18.0	7.0	11.0	2	5 - 7
	B	2	0.46	0.69	200	400	1.40	19.0	8.0	11.0	2	4 - 6
5	T	2	0.37	0.69	160	400	1.48	18.0	7.0	11.0	2	4 - 5
	M	2	0.43	0.76	190	410	1.55	20.0	9.0	11.0	2	4 - 6
	B	2	0.41	0.71	220	400	1.34	19.0	6.0	13.0	2	5 - 6
6	T	3	0.42	0.72	200	450	1.30	15.0	7.0	8.0	2	4 - 7
	M	2	0.35	0.76	190	440	1.25	17.0	7.0	10.0	2	5 - 7
	B	2	0.35	0.72	210	430	1.75	20.0	7.0	13.0	2	4 - 7
7	T	3	0.40	0.70	200	400	1.32	15.0	5.0	10.0	2	5 - 7
	M	3	0.42	0.67	200	380	1.86	22.0	14.0	8.0	2	5 - 6
	B	3	0.43	0.67	180	340	1.47	19.0	6.0	13.0	2	5 - 6
8	T	3	0.33	0.76	130	410	1.43	20.0	12.0	8.0	2	5 - 7
	M	2	0.45	0.75	200	420	1.55	21.0	11.0	10.0	2	5 - 8
	B	3	0.38	0.71	150	350	1.48	20.0	8.0	12.0	2	5 - 7
9	T	2	0.43	0.75	160	410	1.27	14.0	8.0	6.0	2	5 - 7
	M	2	0.41	0.73	150	390	1.40	18.0	10.0	8.0	2	5 - 7
	B	3	0.34	0.73	130	360	1.43	23.0	10.0	13.0	2	5 - 7

T = top portion; M = middle portion; B = bottom portion; P = periphery; C = central portion; VB = vascular bundle

The fibre length varies from 1.25 to 2.12 *mm in* the nine stems investigated. The length is comparable to that of the wild *C. manan* with the range of 1.22 to 2.05 *mm* (Abd. Latiff *et al.* 1987). The fibre wall thickness examined has the range of 6 to 13 Um whereas Abd. Latif *et al.* (1987) reported the range from 6.87 to7.72Um in the wild matured cane. Except for the fibre lumen there appears to be a decreasing trend in the dimensions of the fibre, particularly the length, width and wall thickness from the bottom towards the top portion of the stems. The reason for the thicker fibre wall at the bottom portion of the stem is perhaps due to the nature of growth where fibre wall thickness increases with age almost throughout the life time of the palm (Parathasarathy & Klotz 1976). A high

percentage of the fibres have thick secondary walls showing multilayered structure which improves the elasto-mechanical properties of the stem of rotan manau (Parameswaran & Liese 1985).

The ground tissue is made up of thin-walled parenchyma cells. Weiner and Liese (1988) described the cells as having an irregular outline forming an interwoven network which resembles a 'jigsaw puzzle'. The vertical arrangement resembles a 'pile of coins' (Figure 2b).

The anatomy of the nine stems of 11-y-old *C. manan* is given in Table 2.

Table 3. Mean values of the anatomical properties of nine 11-y-old C. *manan* canes

Stem	Vascular bundle			Diameter of metaxylem		Fibre				Phloem	
	No. per mm^2	diameter (mm)		(Um)		Length (mm)	Width (Um)	Lumen (Um)	Wall thickness (total in a single fibre) (Um)	No. of strands per VB	No. of cells per strand
		P	C	P	C						
T	3	0.37	0.71	128	412	1.38	16.78	8.11	8.67	2	5 - 7
M	3	0.41	0.71	179	397	1.50	19.67	9.78	9.89	2	5 - 7
B	3	0.37	0.69	179	373	1.57	20.22	7.89	12.33	2	5 - 7

Physical properties

The physical features of the rattan are important as they greatly influence the prospects of usage and marketability of the rattan. Renuka *et al.* (1987) noted that there are three important physical characteristics used in grading and assessing the usage potential of rattan, that is (i) stem diameter (ii) internode length and (iii) specific gravity.

Stem diameter

The diameter at the bottom, middle and top portions of the stem was measured on each cane (Table 4). The diameter of the bottom portion of the cane ranges from 2.2 *cm* in cane 1 to 2.9 *cm,* in cane 3. At the middle portion it ranges from 2.4 *cm,* in cane 4, to 3.5 *cm,* in cane 5. The larger diameter was observed at the top portion of the cane where the diameter ranges from 2.9 *cm,* in cane 1 and 4, to 3.7 *cm,* in cane 5. The mean value of the diameter at the bottom, the middle and the top portions of the cane stems is 2.54, 2.97 and 3.26 *cm* respectively. This indicates a general increasing trend of stem diameter from the bottom towards the top portions.

Rotan manau can be classified as large if the criterion proposed by Renuka *et al.* (1987) is adopted. Fully matured C. *manan* may measure 8 cm in diameter and be quite slender at the very base with diameter of 2.5 *cm* (Dransfield 1979). Generally, cane with diameter of 3 *cm* and above can be easily accepted by the local cane furniture manufacturers.

Table 4. Mean values of internode length, diameter and specific gravity of 11-y-old C. *manan*

Cane	Internode length			Diameter *(an)*			Specific gravity		
	Mean *(cm)*	Range *(cm)*	C.V. (%)	Bottom	Middle	Top	Bottom	Middle	Top
1	21.2	2.5 -28.5	36.3	2.2	2.5	2.9	0.43	0.37	0.31
2	21.2	2.3 -29.5	35.8	2.7	3.2	3.2	0.49	0.36	0.30
3	21.0	4.3 -29.2	31.4	2.9	3.1	3.4	0.46	0.37	0.30
4	18.6	2.3 -28.0	38.7	2.4	2.4	2.9	0.48	0.41	0.35
5	24.7	2.5 - 38.8	31.1	2.8	3.5	3.7	0.54	0.41	0.34
6	19.9	2.5 -28.0	32.7	2.5	2.8	3.4	0.49	0.34	0.25
7	23.8	6.4 -30.5	15.9	2.3	2.9	3.2	0.53	0.40	0.31
8	20.7	4.4 - 32.0	32.9	2.8	3.0	3.3	0.42	0.32	0.28
9	22.8	4.0 -34.5	30.3	2.3	3.3	3.3	0.50	0.34	0.22
Mean	21.5	-	-	2.54	2.97	3.26	0.48	0.32	0.30

Internode length

The internode length varies very much even within the same stem (Table 4). Among the nine canes studied, the internode length varies from 2.3 *cm,* in cane 2, to 38.8 *cm,* in cane 5, with a mean of 21.5 *cm.* Normally the shorter internodes are found in the lower part of the stem and stay fairly constant from 20% height towards the top.

Specific gravity

The mean specific gravity of the nine stems ranges from 0.22 in cane 9, to 0.54 in cane 5. Generally, the mean specific gravity is higher at the bottom portion of the stem (0.48) and decreases slowly towards the middle (0.32) and then the top (0.30). Renuka *et al.* (1987) also recorded a similar trend of specific gravity in their study of *Calamus* species of Kerala forests in India. Oil palm *(Elaeis guineensis),* which belongs to the family Palmae, also shows a decline in density with an increase in height level (Lim & Khoo 1986). A similar pattern of density variation is also recorded in coconut palm (*Cocos nucifera)* by many researchers (Richolson & Swarup 1977, Sudo 1980).

Conclusion

The physical and anatomical features of nine 11-*y-old* rotan manau canes grown in a plantation were observed. Physical features, stem diameter, internode length and specific gravity were considered because of their importance as indicators of the suitability of the cane for various end uses. The mean diameter of the stems ranged from 2.54 (bottom) to 3.26 *cm* (top) and consequently, they may be only suitable for the production of furniture components which do not require large diameter. The mean internode length was 21.5 *cm* and the specific gravity decreased from the bottom (0.48) to the middle (0.32) and the top (0.30) portions of the cane stem. These values may be taken

into consideration for the production of rattan furniture. Anatomically, there are some appreciable differences between the features observed at the bottom, middle and top portions of the stem. The fibre length of the cultivated cane was similar to that of wild ones. Some differences were, however, also observed in the fibre wall thickness between cultivated and wild canes.

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