Principes, 40(3), 1996, pp. 125–128

Stem Structure of the Cuban Belly Palm (Gastrococos crispa)

JACK B. FISHER,[1] JAMES N. BURCH, AND LARRY R. NOBLICK[2]

[1]*Fairchild Tropical Garden, 11935 Old Cutler Road, Miami, Florida 33156; and Department of Biological Sciences, Florida International University, Miami, Florida 33199*

ABSTRACT

Tissue samples were taken from the periphery and center of a single trunk with a pronounced swelling (three times the basal stem diameter) halfway up the trunk. In the hard peripheral region, fresh density increased and percent water content decreased from the upper to the lower levels of the trunk. In the trunk center, fresh densities of upper and lower levels were similar and twice that of the swollen middle level. The dry density of the trunk center was greatest at the base, which was 10 times that of the swollen middle level. Percent water content of the trunk center at the middle level was about twice that of the lower and one-third more than the upper level. The observations on density and anatomy support the view that the peripheral ring of lignified tissue is the main mechanical tissue in the trunk. The swollen region had little or no starch and is the main water-storing region of the trunk.

The localized trunk swellings in some palms have long attracted the interest of botanists and palm enthusiasts. The Cuban belly palm, *Gastrococos crispa* (Kunth) H. E. Moore (formerly *Acrocomia crispa* (Kunth) Baker ex Becc.) with its pronounced trunk swelling is a fine example. The spongy tissue that makes up the bulk of the swelling is assumed to be an adaptation for water storage in this endemic from seasonally dry areas of Cuba. However, we found no published information on the structure or density of the trunk of this species. There are no documented observations as to how the swelling develops: whether it is a result of primary growth within the leaf crown or whether it develops by later thickening when the region is older and some distance below the leaf crown (Tomlinson 1990: p. 171).

On 24 August 1992 a mature specimen of *Gastrococos* growing on the grounds of The Montgomery Foundation in Miami, Florida was blown down during Hurricane Andrew. This presented a unique research opportunity to collect and examine trunk material of a precious horticultural specimen that would not otherwise be sacrificed for study. The effects of Hurricane Andrew have already been described (Klein 1992) and illustrated on the cover of the October 1992 issue of *Principes*.

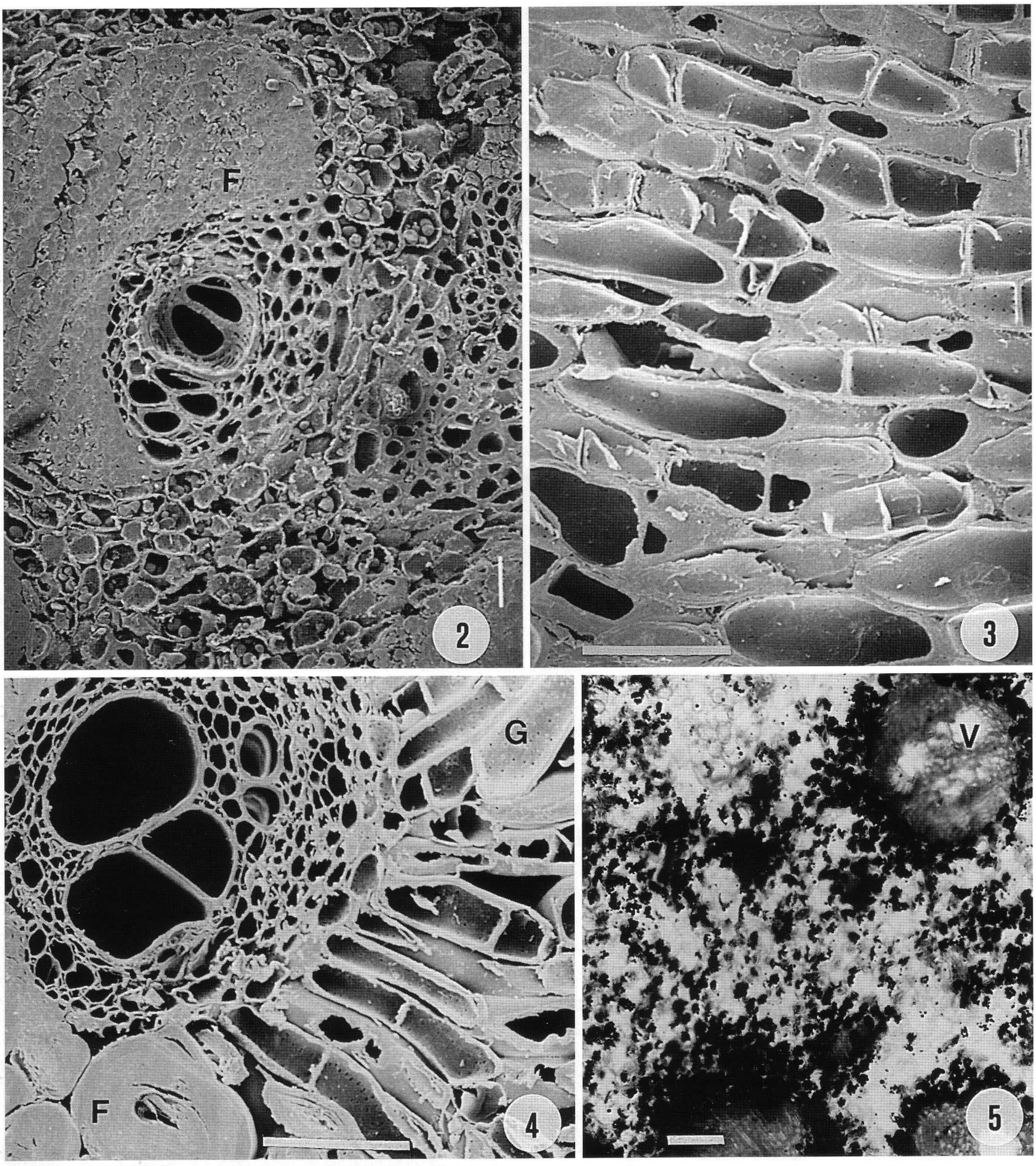
Materials and Methods

A tree of *Gastrococos crispa* (FTG 91-426A) estimated at over 40 years old was collected at The Montgomery Foundation, Miami, Florida on 19 September 1992, more than 3 wk after it was blown down. The leaf crown was still green and had 17 expanded leaves and three spear leaves. The trunk was cut with a chain saw (Fig. 1). Six small samples were collected from the periphery and center of each of three disks cut from lower, middle (swollen), and upper levels of the trunk. The lower level was 180 cm long and cylindrical with a diameter of 25 cm. The middle, swollen level was 460 cm long with a maximum diameter of 70 cm. The upper level was 260 cm (to the

1. Collecting trunk samples of *Gastrococos*. Entire lower region (held by J. Burch on left), half of the swollen middle region (held by L. Noblick on right).

[1] Correspondence to the Fairchild Tropical Garden address.

[2] Present address: Montgomery Foundation, 11901 Old Cutler Road, Miami, Florida 33156.

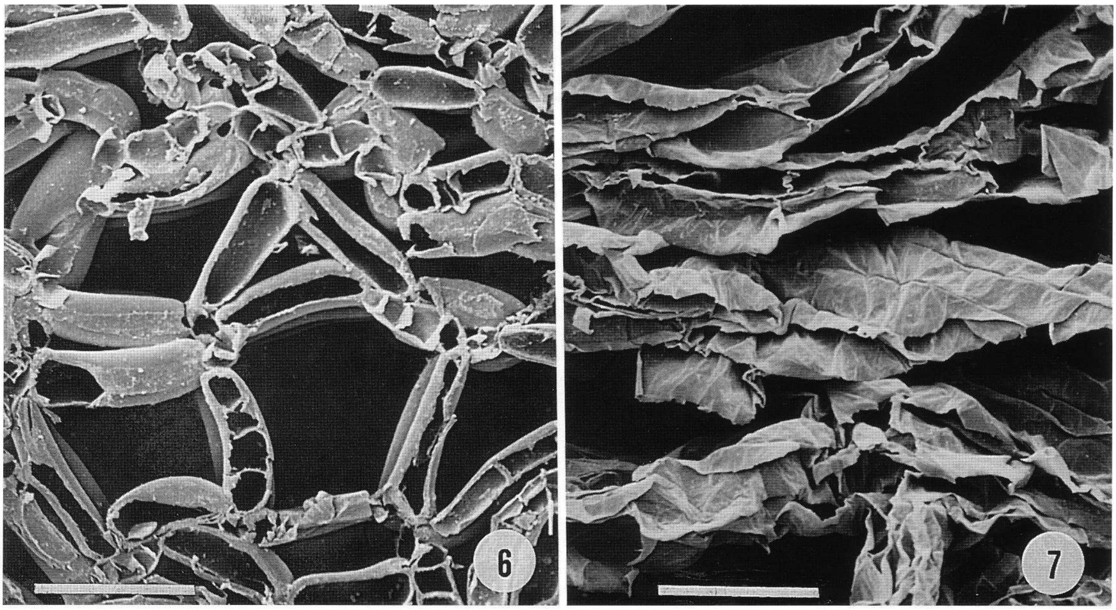


2–5. Cross sections of trunk tissue. 2. Peripheral vascular bundle of upper trunk; note region of very thick-walled fibers and starch grains inside cells of the ground tissue. 3. Peripheral ground tissue of middle trunk; starch grains absent. 4. Central vascular bundle of lower trunk. 5. Central vascular bundles and ground tissue of upper trunk, stained with I_2KI that stains starch grains black. F, fibers; G, ground tissue; V, vascular bundle. Bars: 50 μm (2, 3, 4); 100 μm (5).

base of the leaf crown) and cylindrical with a diameter of 21 cm.

The tissue samples were weighed fresh and their volume calculated by water displacement (adjusted for water absorption into the spongy tissue by reweighing after volume measurements). The samples were dried in a 75°C oven for 4 wk and weighed.

Adjacent tissue samples were preserved in FAA (formalin-alcohol-acetic acid) and stored in 70% ethanol. Sections were later cut with a razor by hand and stained with aqueous toluidine blue for



6, 7. Central ground tissue of trunk in cross section. 6. Lower trunk; note thick cell walls. 7. Swollen, middle trunk; note larger cells with thinner walls that collapsed during preparation. Bar: 50 μm (6, 7).

general anatomy, with I_2KI solution for starch, and with phloroglucinol-HCl for lignin. Some blocks of tissue were air-dried, sputter coated with gold-palladium, and observed with a scanning electron microscope (I.S.I. Model Super IIIA).

Results

Anatomy. The peripheral region of the trunk was dense and extremely hard throughout its length. Vascular bundles were arranged close together, and each had a wide zone of thick-walled fibers (Fig. 2). The cells of the ground tissue between the vascular bundles were thick-walled and lignified (Fig. 3). The hardest tissues with the thickest-walled fibers and ground parenchyma cells were at the lower level of the trunk. The cell lumen was barely visible in each fiber (Fig. 2).

The trunk center had more diffuse vascular bundles, each with a wide fiber zone (Fig. 4). Bundle density was similar in the upper and lower levels and was least in the swollen middle level. The cells of the central ground tissue (Fig. 4) were more radially elongated than in the periphery. The cell walls were thickest and most lignified at the lowest level (Fig. 6). Walls are thinnest and unlignified at the middle level (Fig. 7). Intercellular spaces, which impart the spongy consistency to the tissue, were most numerous at the middle level and related to the elongated shape of these cells. It was difficult to cut the central part of the middle region without crushing because the tough fiber bundles were imbedded within the soft spongy ground tissue.

Chemical tests for starch (I_2KI solution) showed that large amounts of starch occurred in the upper level of the trunk in the ground cells of the peripheral and central regions (Figs. 2,5). No starch was present within the vascular bundles. We found from little to essentially no starch in the lower and middle levels of the trunk (Fig. 3). The spongy central tissue in the swollen middle level lacked starch but had small cytoplasmic structures that were possibly plastids or lipid droplets.

Tissue Density. Fresh and dry tissue densities were directly correlated to the relative wall thickness and lignification in the fibers and ground tissue (Table 1). The most dense tissue was the peripheral region of the lower level. The least dense tissue occurred in the central region of the middle level. The maximum difference in peripheral dry density was 7:10 (middle to lower). The maximum difference in central dry density was approximately 1:10 (middle to lower). Percent water content was greatest in the central middle region, twice that of the central lower and one-third more than that of the central upper region (Table 1).

Table 1. Comparisons of trunk tissues in the trunk of Gastrococus crispa. *Averages of six tissue samples are given for each location.*

Level in Trunk	Fresh Density (g/cm³)	Dry Density[a] (g/cm³)	Water Content (percent)
	Periphery of trunk		
Lower	1.264a	1.011a	20.0a
Middle	1.172b	0.692b	41.1b
Upper	1.144b	0.693b	38.9b
	Center of trunk		
Lower	0.893a	0.483a	46.0a
Middle	0.418b	0.048b	88.5b
Upper	0.807c	0.305c	62.2c

Within each column, values followed by the same letter are not significantly different (using an F test with $P = 0.001$). Periphery and center regions are compared separately.

[a] Presented as dry mass per original fresh mass.

Discussion

The dense, lignified peripheral tissues form a cylinder of supporting tissue in the trunk. The density of older tissues increases at the base of the trunk, as in other palms (Rich 1986, 1987*a*, *b*). The cell walls of fibers and parenchyma cells (ground tissue), which appear to remain alive for the life of the palm, increase in thickness and degree of lignification as they age. Thus, the mechanical strength of the trunk increases at lower levels as the trunk grows taller.

In *Gastrococos*, the swollen middle level is a result of ground tissue cells becoming radially elongated with these thin-walled, unlignified cells radiating around each of the vascular bundles in the central region, similar to other palms with soft, spongy trunk centers, e.g., *Socratea* (Tomlinson 1990) and *Roystonea* (*Oredodoxa*), *Caryota*, and *Ptychosperma* (*Actinophloeus*) (Schoute 1912). Prolonged expansion and cell division within the ground tissue of the central region of the trunk of *Archontophoenix* were demonstrated convincingly by Waterhouse and Quinn (1978). However, the timing of such ground cell expansion, whether within or below the crown, is undocumented for *Gastrococos*.

The suggestion that the swollen region acts as a "bottle" to store water is supported by the high percentage of water contained in the spongy central tissues.

Acknowledgments

This research was supported by grants from the National Science Foundation (grant DEB-9224126) and The John D. and Catherine T. MacArthur Foundation. Larry Noblick was supported by a Montgomery Foundation postdoctoral fellowship. We thank Birgith Phillips for technical assistance and George Taylor for help with the SEM.

LITERATURE CITED

KLEIN, W. M., JR. 1992. Fairchild Tropical Garden hit by Hurricane Andrew. Principes 36: 225–227.

RICH, PAUL M. 1986. Mechanical architecture of arborescent rain forest palms. Principes 30: 117–131.

———. 1987*a*. Developmental anatomy of the stem of *Welfia georgii*, *Iriartea gigantea*, and other arborescent palms: implications for mechanical support. Amer. J. Bot. 74: 792–802.

———. 1987*b*. Mechanical structure of the stem of arborescent palms. Bot. Gaz. 148: 42–50.

SCHOUTE, J. C. 1912. Über das Dickenwachstum der Palmen. Ann. Jard. Bot. Buitenzorg, Sér. 2. 11: 1–209.

TOMLINSON, P. B. 1990. The structural biology of palms. Clarenden Press, Oxford.

WATERHOUSE, J. T., AND C. J. QUINN. 1978. Growth patterns in the stem of the palm *Archontophoenix cunninghamiana*. Bot. J. Linn. Soc. 77: 73–93.