

# Mechanical contribution of secondary phloem to postural control in trees: the bark side of the force

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## Supporting information:

### Notes S1: Interpretation of released strains measured on bark

The strain released on a living tissue reflects its state of mechanical stress, which results from the whole mechanical history of the tissue. This mechanical history includes processes occurring during the formation of the tissue, called maturation stress in the case of wood, and disturbances occurring later, due to the action of external factors (such as gravity), and internal factors (such as the redistribution of stresses occurring because of the growth of other tissues). Released strains are commonly measured on the outer surface of wood in the living trunk. In this case, its interpretation is easy, because wood located at the outer surface has been produced recently, so that its mechanical history is simple. Outer wood is considered in a native state, and disturbances that occurred since are considered negligible, so that the released strain is equal to the maturation strain.

In the case of bark, the released strain is measured on the whole phloem tissue, not just its youngest part. Consequently, its mechanical history includes all the disturbance that occurred in bark throughout the life of the tree. At least three sources of disturbance can be identified (1) passive bending of the stem due to gravity including self-weight and external load (epiphytes, fallen branches from other trees, etc.), (2) active bending of the stem due to wood maturation, (3) axial compression due to wood maturation.

The two first effects are due to bending actions, thus inducing symmetric stress between the upper and the lower sides. Passive bending will induce tensile stress in the bark located on the upper side of the stem, and compression on the lower side. Active up-righting will induce the reverse pattern (compression on the upper side and tension on the lower side). The mean stress (average between upper and lower sides) induced by bending effects is always zero (considering a wood cylinder as a homogeneous material). If both effects occur at the same rate, as is the case for a stem with stationary orientation, these effects offset each other and will cause no disturbance at all.

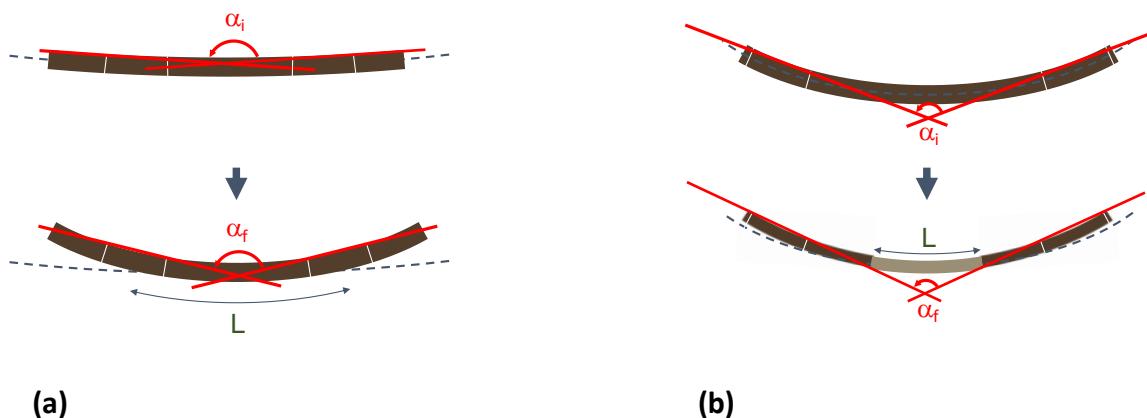
The third effect is due to the redistribution of wood maturation stress in the section, resulting in axial contraction of the whole stem, and hence in compressive stress on all sides. The mean stress resulting from the action of the three effects is always expected to be compressive unless another process contributes to the stress generation.

The figure S3 presents the mean longitudinal released strain ((LRS<sub>US</sub>+LRS<sub>LS</sub>)/2) recorded on adult trees. The mean released strains evidence that *Pachira*, *Tarrietia*, *Virola*, *Simarouba* and *Cecropia* barks can generate tensile stresses in the bark, whereas *Laetia* and *Gouphia* cannot (Extended data figure S3b).



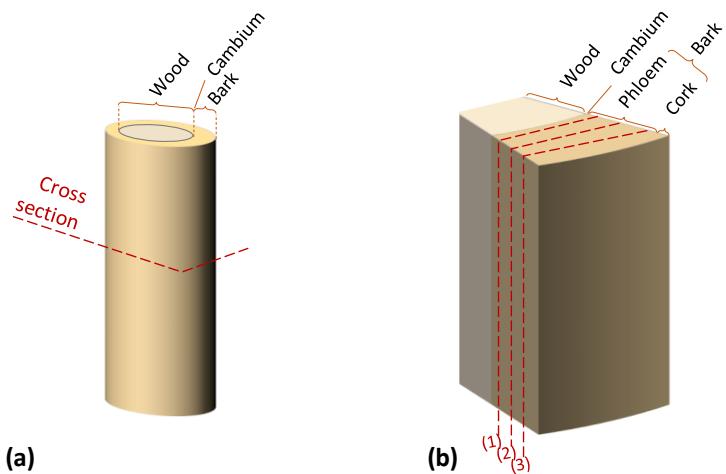
**Fig. S1: Bark of *Gouania glabra* after peeling of the external part (cork).**

(a) Wrinkled surface on the upper side of the naturally tilted stem, evidencing the compression exerted by the wood on the bark. (b) Smooth surface on the lower side, consequence of the pull exerted on the lower side by the curving wood core.



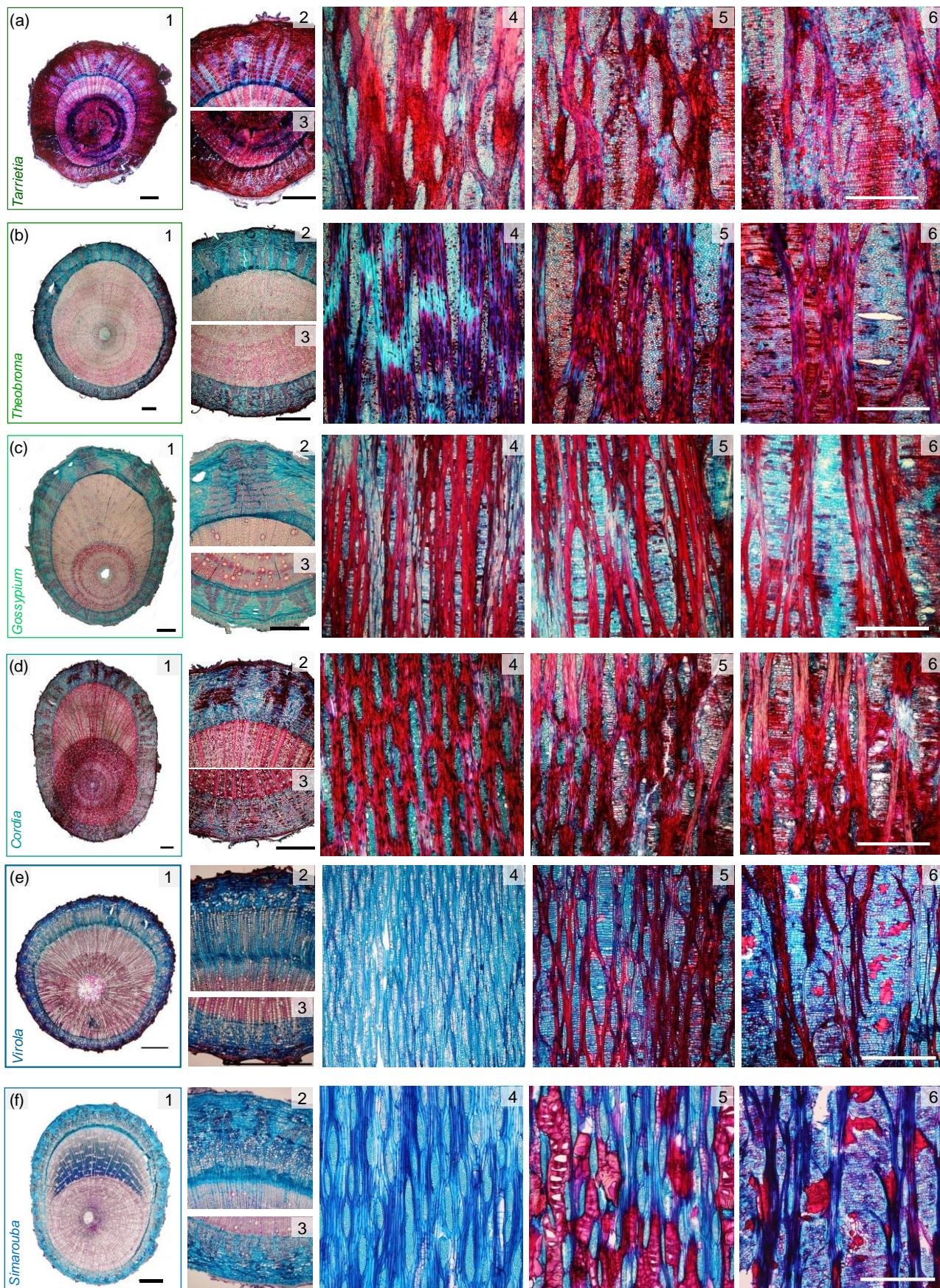
**Fig. S2: schematic representation of measurements of the change in curvature**

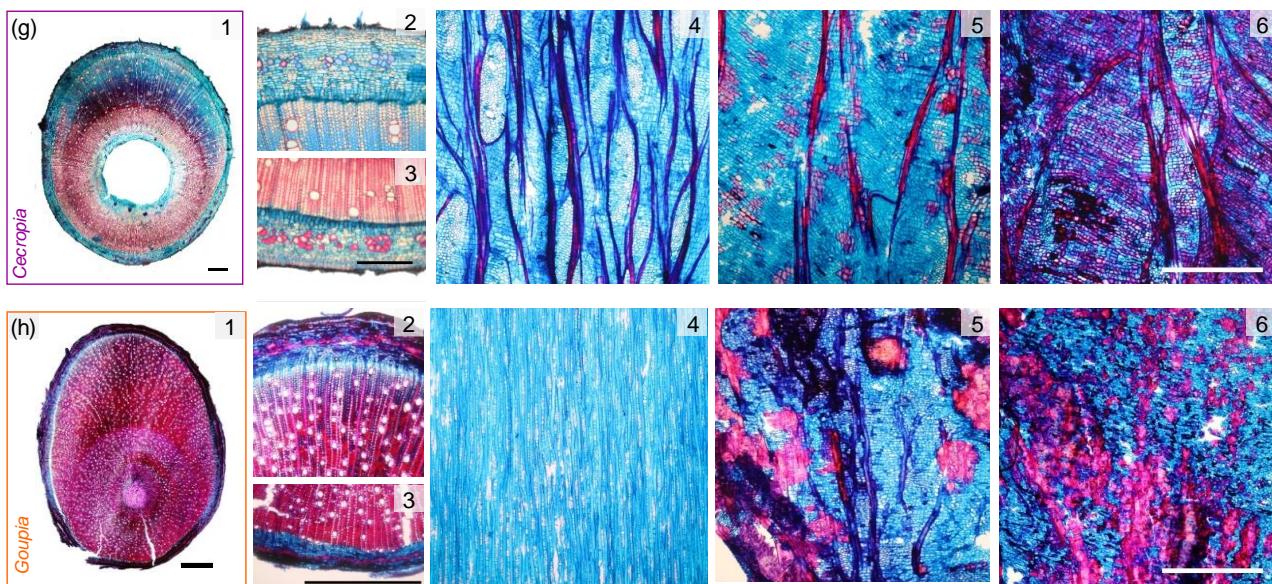
(a) during spring-back; (b) during debarking.  $\alpha$  is the angle between the lines joining two marks, one on the left and one on the right side. The change in  $\alpha$  when the bark was removed from a segment of length  $L$  is related to the change in curvature:  $\Delta C = (\alpha_f - \alpha_i) / L$ .



**Fig. S3: schematic representation of the position of the sections.**

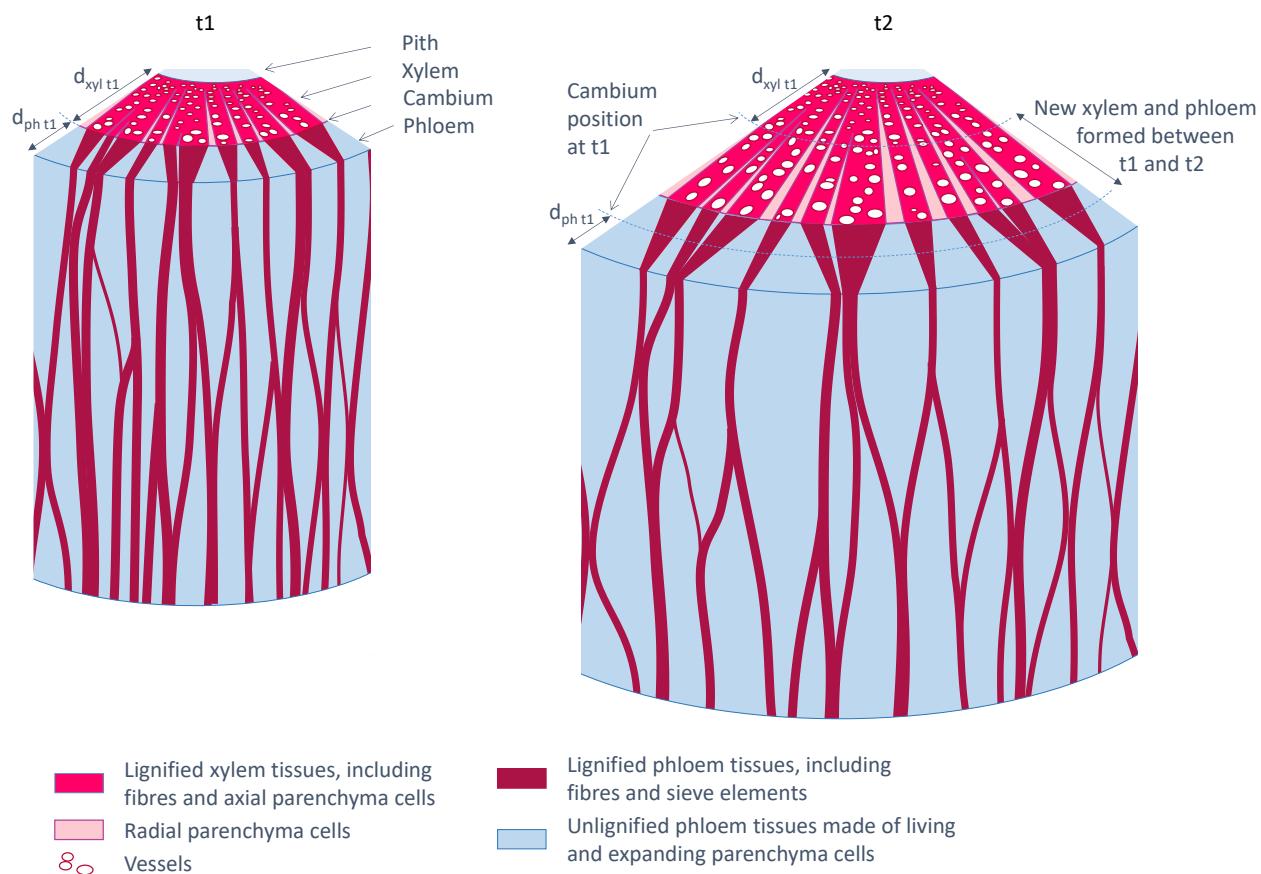
(a) Cross section in seedling stems and (b) Longitudinal-tangential sections in the phloem of adult trees, (1) near the cambium, (2) in the middle of the phloem and (3) near the cork. Longitudinal-tangential sections were made on large diameter trees to minimise the curvature of the tangential plane and to enable access to thick bark, which made it possible to obtain several sections within the thickness of the bark.



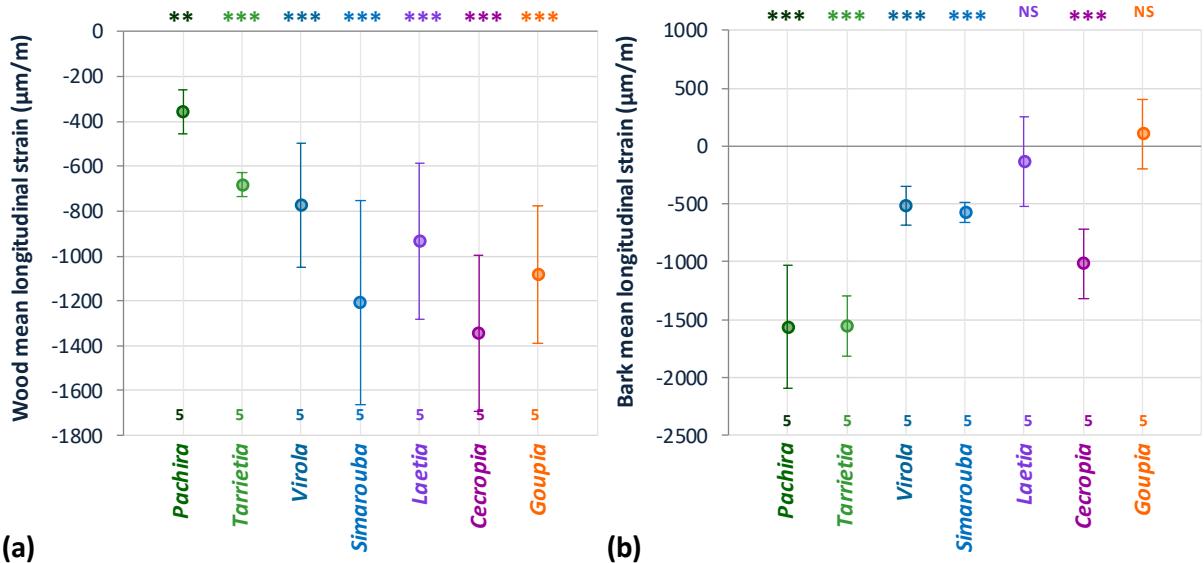


**Fig. S4: Cell organisation in the wood and bark of (a) *Tarrietia utilis*, (b) *Theobroma cacao*, (c) *Gossypium hirsutum*, (d) *Cordia alliodora*, (e) *Virola michelii*, (f) *Simarouba amara*, (g) *Cecropia palmata*, and (h) *Gouphia glabra*.**

(1) Full cross section of a young stem. The top of the section corresponds to the upper side of the tilted stem where tensile stress is generated to bend it upwards. (2) Detail of the upper side of the stem, including wood (bottom) and bark (top), separated by the cambium. (3) Detail of the lower side of the tilted stem including bark (bottom) and wood (top). (4-6). Longitudinal sections of the phloem (inner bark) of a large tree made at increasing distance from the cambium. Bars, 1 mm. The phloem fibre network is well organised in *Gossypium*, *Tarrietia*, *Theobroma* and *Cordia* like in *Pachira*, but nearly absent in *Gouphia* like in *Laetia*. In *Simarouba* and *Cecropia* and *Virola*, an enlarging organised network is visible on longitudinal sections but less clear on transverse sections. A cross section of a *Gouphia* seedling is shown, but bark efficiency indexes were not measured on *Gouphia* seedlings.

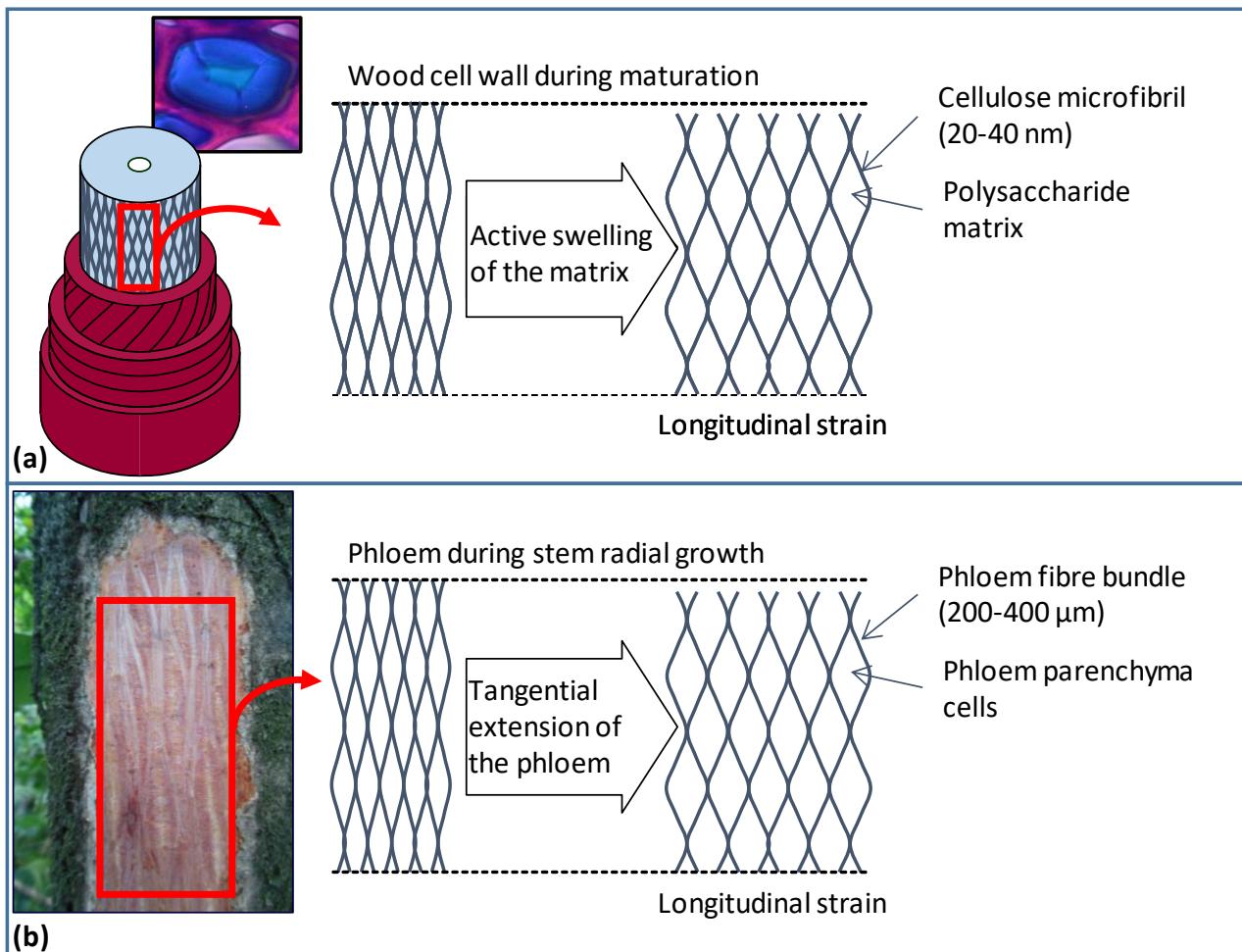


**Fig. S5: Schematics of the 3D organisation of tissues in a growing stem of *Pachira* (and other Malvaceae).** Both xylem and phloem cells are produced by the same mother cells in the cambium, which can divide either on the wood side or on the bark side. Then, during stem growth, the sister cells are separated by the newly produced cells. Tensile stress in phloem is generated by radial growth of the xylem pushing the phloem outwards, thereby inducing tensile tangential stress, which is transmitted in the axial direction by the trellis organisation of the phloem fibres. t<sub>1</sub>: early stage during growth, t<sub>2</sub>: later stage. d<sub>xyl t1</sub>: wood thickness at t<sub>1</sub>, d<sub>ph t1</sub>: bark thickness at t<sub>1</sub>.



**Fig. S6: Mean longitudinal released strains in naturally tilted trees**

(a) Mean and standard deviation of longitudinal released strains in wood. (b) Mean and standard deviation of longitudinal released strains in bark. \*\* and \*\*\* indicate the significance difference from zero (one sample t-test) at  $\alpha = 0.01$  and  $0.001$  respectively. NS: not significant.. Numbers indicate the number of tree per species.



**Fig. S7: Analogy between the mechanisms generating tensile stress in trees at two different scales.** (a) In the gelatinous layer of tension wood (at the nanometric scale) and (b) in the bark of *Pachira aquatica* (at the sub-millimetre scale). Current knowledge of the mechanism enabling the gelatinous layer to generate tensile stress (Almérás & Clair, 2016) supports the hypothesis of a mechanism by which the swelling of the gelatinous matrix (Chang *et al.*, 2015) puts the rigid cellulosic network under tensile stress (Clair *et al.*, 2011) (cellulose microfibril aggregates are 20 to 40 nm thick). In the bark, the matrix is made of phloem parenchyma cells and the network is made of phloem fibre bundles (200–400 µm). However, the analogy is limited to the trellis organisation of the fibre network, which efficiently redirects transverse extension into longitudinal tension, but the driving force is different.

**Table S1: Data relative to measurements made on saplings.** Diam: Stem diameter at the measurement position (mm) in the direction of bending,  $\Delta C$ : change in curvature during Spring-back or debarking ( $^{\circ} \cdot \text{dm}^{-1}$ ), stand: standardized value accounting for the stem diameter.

Species	Family	#	Diam (mm)	$\Delta C$ spring-back ( $^{\circ} \cdot \text{dm}^{-1}$ )	$\Delta C$ spring-back stand ( $^{\circ} \cdot \text{dm}^{-1}$ )	$\Delta C$ debarking ( $^{\circ} \cdot \text{dm}^{-1}$ )	$\Delta C$ debarking stand ( $^{\circ} \cdot \text{dm}^{-1}$ )
<i>Pachira aquatica</i>	Malvaceae	Pa1	11.8	8.2	9.7	-4.9	-5.8
<i>Pachira aquatica</i>	Malvaceae	Pa2	11.2	2.8	3.1	-7.5	-8.5
<i>Pachira aquatica</i>	Malvaceae	Pa3	5.2	21.3	11.1	-11.2	-5.8
<i>Pachira aquatica</i>	Malvaceae	Pa4	7.9	17.6	14.0	-9.1	-7.2
<i>Pachira aquatica</i>	Malvaceae	Pa5	10.2	4.1	4.2	-4.8	-4.9
<i>Pachira aquatica</i>	Malvaceae	Pa6	9.7	8.7	8.4	-9.9	-9.7
<i>Pachira aquatica</i>	Malvaceae	Pa7	10.4	7.9	8.3	-10.7	-11.1
<i>Pachira aquatica</i>	Malvaceae	Pa8	16.0	3.8	6.1	-2.5	-4.0
<i>Pachira aquatica</i>	Malvaceae	Pa9	9.1	8.1	7.4	-6.1	-5.5
<i>Pachira aquatica</i>	Malvaceae	Pa10	8.7	8.2	7.1	-9.7	-8.4
<i>Pachira aquatica</i>	Malvaceae	Pa11	6.5	20.3	13.3	-12.7	-8.3
<i>Pachira aquatica</i>	Malvaceae	Pa12	9.6	6.7	6.4	-6.5	-6.2
<i>Tarrietia utilis</i>	Malvaceae	Tu1	9.7	13.5	13.2	-8.6	-8.4
<i>Tarrietia utilis</i>	Malvaceae	Tu2	8.2	9.8	8.0	-5.2	-4.2
<i>Tarrietia utilis</i>	Malvaceae	Tu3	8.0	6.7	5.3	-6.7	-5.3
<i>Tarrietia utilis</i>	Malvaceae	Tu4	10.4	7.2	7.5	-4.9	-5.1
<i>Tarrietia utilis</i>	Malvaceae	Tu5	6.3	13.3	8.4	-7.8	-4.9
<i>Tarrietia utilis</i>	Malvaceae	Tu6	7.4	10.3	7.6	-7.6	-5.6
<i>Tarrietia utilis</i>	Malvaceae	Tu7	6.6	20.5	13.4	-11.6	-7.6
<i>Tarrietia utilis</i>	Malvaceae	Tu8	8.8	9.9	8.7	-6.6	-5.8
<i>Tarrietia utilis</i>	Malvaceae	Tu9	8.6	1.6	1.3	-2.0	-1.7
<i>Tarrietia utilis</i>	Malvaceae	Tu10	7.1	5.4	3.8	-5.6	-4.0
<i>Theobroma cacao</i>	Malvaceae	Tc1	9.0	4.7	4.2	-3.2	-2.9
<i>Theobroma cacao</i>	Malvaceae	Tc2	8.7	9.5	8.3	-2.9	-2.5
<i>Theobroma cacao</i>	Malvaceae	Tc3	14.5	2.5	3.6	-2.0	-2.9
<i>Theobroma cacao</i>	Malvaceae	Tc4	13.1	2.6	3.5	-3.9	-5.0
<i>Theobroma cacao</i>	Malvaceae	Tc5	13.7	3.0	4.1	-1.4	-2.0
<i>Theobroma cacao</i>	Malvaceae	Tc6	10.2	7.6	7.7	-2.5	-2.5
<i>Theobroma cacao</i>	Malvaceae	Tc7	13.7	2.6	3.5	-0.6	-0.8
<i>Theobroma cacao</i>	Malvaceae	Tc8	10.2	7.2	7.3	-6.9	-7.0
<i>Theobroma cacao</i>	Malvaceae	Tc9	11.9	8.2	9.8	-5.2	-6.2
<i>Theobroma cacao</i>	Malvaceae	Tc10	10.7	8.2	8.8	-5.2	-5.5
<i>Theobroma cacao</i>	Malvaceae	Tc11	11.8	2.7	3.2	-1.9	-2.3
<i>Theobroma cacao</i>	Malvaceae	Tc12	12.3	3.1	3.9	-3.3	-4.1
<i>Gossypium hirsutum</i>	Malvaceae	Gh1	6.8	6.1	4.2	-8.8	-6.0
<i>Gossypium hirsutum</i>	Malvaceae	Gh2	5.7	11.3	6.4	-2.3	-1.3
<i>Gossypium hirsutum</i>	Malvaceae	Gh3	6.8	17.7	12.0	-8.4	-5.7
<i>Gossypium hirsutum</i>	Malvaceae	Gh4	7.9	2.8	2.2	-1.5	-1.2
<i>Gossypium hirsutum</i>	Malvaceae	Gh5	7.5	7.8	5.8	-1.2	-0.9
<i>Gossypium hirsutum</i>	Malvaceae	Gh6	6.3	12.2	7.6	-8.7	-5.5
<i>Gossypium hirsutum</i>	Malvaceae	Gh7	5.5	12.1	6.7	-5.2	-2.9
<i>Gossypium hirsutum</i>	Malvaceae	Gh8	6.2	10.0	6.2	-4.3	-2.7
<i>Gossypium hirsutum</i>	Malvaceae	Gh9	6.9	9.3	6.4	-4.6	-3.1
<i>Gossypium hirsutum</i>	Malvaceae	Gh10	7.3	10.7	7.8	-4.9	-3.6

<i>Gossypium hirsutum</i>	Malvaceae	Gh11	6.2	5.7	3.5	-4.7	-2.9
<i>Virola michelii</i>	Myristicacea	Vm1	5.0	2.1	1.0	-0.8	-0.4
<i>Virola michelii</i>	Myristicacea	Vm2	9.4	10.1	9.5	-1.8	-1.6
<i>Virola michelii</i>	Myristicacea	Vm3	6.2	3.4	2.1	-0.1	-0.1
<i>Virola michelii</i>	Myristicacea	Vm4	3.8	1.6	0.6	-0.3	-0.1
<i>Virola michelii</i>	Myristicacea	Vm5	5.3	20.0	10.5	-0.8	-0.4
<i>Virola michelii</i>	Myristicacea	Vm6	8.8	6.6	5.8	-0.1	-0.1
<i>Virola michelii</i>	Myristicacea	Vm7	4.9	13.9	6.9	0.0	0.0
<i>Virola michelii</i>	Myristicacea	Vm8	3.9	8.5	3.3	-1.5	-0.6
<i>Cordia alliodora</i>	Boraginaceae	Ca1	13.2	2.4	3.2	-0.7	-0.9
<i>Cordia alliodora</i>	Boraginaceae	Ca2	11.3	4.2	4.7	-1.1	-1.2
<i>Cordia alliodora</i>	Boraginaceae	Ca3	11.0	0.2	0.2	-0.5	-0.5
<i>Cordia alliodora</i>	Boraginaceae	Ca4	10.1	3.2	3.3	-0.5	-0.5
<i>Cordia alliodora</i>	Boraginaceae	Ca5	9.4	3.9	3.6	-0.1	-0.1
<i>Cordia alliodora</i>	Boraginaceae	Ca6	9.7	1.8	1.8	-0.8	-0.8
<i>Cordia alliodora</i>	Boraginaceae	Ca7	11.4	0.5	0.6	-0.1	-0.1
<i>Cordia alliodora</i>	Boraginaceae	Ca8	14.6	5.4	7.9	-1.5	-2.1
<i>Cordia alliodora</i>	Boraginaceae	Ca9	9.4	2.9	2.7	-1.0	-0.9
<i>Simarouba amara</i>	Simaroubaceae	Sa1	6.8	13.5	9.1	-0.7	-0.5
<i>Simarouba amara</i>	Simaroubaceae	Sa2	7.0	9.4	6.6	-0.2	-0.2
<i>Simarouba amara</i>	Simaroubaceae	Sa3	6.1	12.7	7.7	-0.5	-0.3
<i>Simarouba amara</i>	Simaroubaceae	Sa4	7.5	9.0	6.7	0.4	0.3
<i>Simarouba amara</i>	Simaroubaceae	Sa5	6.0	7.9	4.7	-0.4	-0.2
<i>Simarouba amara</i>	Simaroubaceae	Sa6	11.8	4.8	5.7	0.5	0.6
<i>Simarouba amara</i>	Simaroubaceae	Sa7	6.6	7.5	4.9	2.3	1.5
<i>Simarouba amara</i>	Simaroubaceae	Sa8	5.9	9.6	5.7	-0.3	-0.2
<i>Simarouba amara</i>	Simaroubaceae	Sa9	8.6	6.9	6.0	0.4	0.3
<i>Simarouba amara</i>	Simaroubaceae	Sa10	9.8	11.2	11.0	0.6	0.6
<i>Laetia procera</i>	Salicaceae	Lp1	7.4	18.0	13.3	1.2	0.9
<i>Laetia procera</i>	Salicaceae	Lp2	6.9	12.5	8.6	1.0	0.7
<i>Laetia procera</i>	Salicaceae	Lp3	7.3	8.6	6.3	0.0	0.0
<i>Laetia procera</i>	Salicaceae	Lp4	8.2	8.6	7.1	0.7	0.6
<i>Laetia procera</i>	Salicaceae	Lp5	7.4	18.3	13.6	1.9	1.4
<i>Laetia procera</i>	Salicaceae	Lp6	8.7	25.5	22.1	1.5	1.3
<i>Laetia procera</i>	Salicaceae	Lp7	7.9	21.4	16.9	1.5	1.2
<i>Laetia procera</i>	Salicaceae	Lp8	7.1	20.8	14.7	1.0	0.7
<i>Laetia procera</i>	Salicaceae	Lp9	7.5	10.3	7.8	2.0	1.5
<i>Laetia procera</i>	Salicaceae	Lp10	7.4	13.6	10.1	2.1	1.5
<i>Cecropia palmata</i>	Urticaceae	Cp1	12.1	11.6	14.0	0.5	0.5
<i>Cecropia palmata</i>	Urticaceae	Cp2	11.5	7.9	9.1	3.6	4.1
<i>Cecropia palmata</i>	Urticaceae	Cp3	18.0	14.4	26.0	2.1	3.8
<i>Cecropia palmata</i>	Urticaceae	Cp4	12.6	8.5	10.7	0.4	0.5
<i>Cecropia palmata</i>	Urticaceae	Cp5	9.3	7.8	7.3	1.1	1.1
<i>Cecropia palmata</i>	Urticaceae	Cp6	9.3	11.7	10.8	2.3	2.1
<i>Cecropia palmata</i>	Urticaceae	Cp7	10.0	19.1	19.1	0.9	0.9
<i>Cecropia palmata</i>	Urticaceae	Cp8	12.7	12.9	16.4	2.6	3.3
<i>Cecropia palmata</i>	Urticaceae	Cp9	13.1	17.7	23.2	0.6	0.8

**Table S2: Measurements on the adult trees.** Tree diameter (cm), release strain in the longitudinal (LRS) and tangential (TRS) direction measured in both bark and wood on both the upper side (US) and lower side (LS) of the tilted stems. LRS and TRS are in  $\mu\text{m.m}^{-1}$ .

Species	Family	Tree #	Tree diam. (cm)	Bark LRS US	Bark LRS LS	Bark TRS US	Bark TRS LS	Wood LRS US	Wood LRS LS	Bark diff LRS	Wood diff LRS	Bark mean LRS	Bark mean TRS	Wood mean LRS
<i>Pachira aquatica</i>	Malvaceae	Pa1	9.5	-3745	-85			-698	-239	-3660	-459	-1915	-469	
<i>Pachira aquatica</i>	Malvaceae	Pa2	13	-1900	-135			-741	90	-1765	-831	-1018	-326	
<i>Pachira aquatica</i>	Malvaceae	Pa3	20.4	-2080	80			-327	-198	-2160	-129	-1000	-263	
<i>Pachira aquatica</i>	Malvaceae	Pa4	8	-3700	-454	-1800	-2590			-3246		-2077	-2195	
<i>Pachira aquatica</i>	Malvaceae	Pa5	9.5	-1890	-40	-2975	-2410			-1850		-965	-2693	
<i>Pachira aquatica</i>	Malvaceae	Pa6	10.5	-2340	-1895	-2460	-2080			-445		-2118	-2270	
<i>Pachira aquatica</i>	Malvaceae	Pa7	31	-3015	-1155	-850	-1770	-620	-295	-1860	-325	-2085	-1310	-458
<i>Pachira aquatica</i>	Malvaceae	Pa8	7	-1562	-1150	-2193	-1667	-375	-191	-412	-184	-1356	-1930	-283
<i>Tarrietia utilis</i>	Malvaceae	Tu1	36	-2141	-467	-3605	-1695	-1160	-320	-1674	-840	-1304	-2650	-740
<i>Tarrietia utilis</i>	Malvaceae	Tu2	47	-1793	-1295	-4669	-2377	-1002	-177	-498	-825	-1544	-3523	-590
<i>Tarrietia utilis</i>	Malvaceae	Tu3	33	-2199	-588	-1652	-2220	-1458	83	-1611	-1541	-1394	-1936	-688
<i>Tarrietia utilis</i>	Malvaceae	Tu4	31	-2124	-997	-2090	-3229	-1307	-67	-1127	-1240	-1561	-2660	-687
<i>Tarrietia utilis</i>	Malvaceae	Tu5	34	-2130	-1814	-3273	-3408	-1240	-172	-316	-1068	-1972	-3341	-706
<i>Virola sp</i>	Myristicaceae	Vsp1	11.5	-990	-186	-654	-433	-785	-69	-804	-716	-588	-544	-427
<i>Virola sp</i>	Myristicaceae	Vsp2	23	-345	-446	-1399	-804	-1605	-14	101	-1591	-396	-1102	-810
<i>Virola sp</i>	Myristicaceae	Vsp3	11.7	-810	-674	-2300	-625	-1815	-579	-136	-1236	-742	-1463	-1197
<i>Virola sp</i>	Myristicaceae	Vsp4	15	-495	-582	-626	-477	-1103	-272	87	-831	-539	-552	-688
<i>Virola sp</i>	Myristicaceae	Vsp5	13.8	241	-887	-1710	-2491	-1187	-316	1128	-871	-323	-2101	-752
<i>Simarouba amara</i>	Simaroubaceae	Sa1	26	-655	-494	-2085	-1344	-2178	-151	-161	-2027	-575	-1715	-1165
<i>Simarouba amara</i>	Simaroubaceae	Sa2	6	-806	-472	-802	-20	-2076	-1635	-334	-441	-639	-411	-1856
<i>Simarouba amara</i>	Simaroubaceae	Sa3	20	-498	-658	-1311	-2100	-1318	129	160	-1447	-578	-1706	-595
<i>Simarouba amara</i>	Simaroubaceae	Sa4	16	-1030	-270	-1760	-2607	-2590	-110	-760	-2480	-650	-2184	-1350
<i>Simarouba amara</i>	Simaroubaceae	Sa5	23.2	-232	-619	-1950	3319	-1903	-246	387	-1657	-426	685	-1075
<i>Laetia procera</i>	Salicaceae	Lp1	20.3	350	119	-265	1080	-642	-225	231	-417	235	408	-434
<i>Laetia procera</i>	Salicaceae	Lp2	28.9	395	-346	-1450	-580	-2508	-226	741	-2282	24.5	-1015	-1367
<i>Laetia procera</i>	Salicaceae	Lp3	7	70	47	-1025	-1137	-1380	-219	23	-1161	58.5	-1081	-800
<i>Laetia procera</i>	Salicaceae	Lp4	15	-220	-1303	-900	-3070	-2145	197	1083	-2342	-762	-1985	-974
<i>Laetia procera</i>	Salicaceae	Lp5	10.2	-68	-424	1192	-1073	-2025	-174	356	-1851	-246	59.5	-1100
<i>Cecropia palmata</i>	Urticaceae	Cp1	19.8	-1179	-1698	-2065	-2039	-1703	-190	519	-1513	-1439	-2052	-947
<i>Cecropia palmata</i>	Urticaceae	Cp2	21.1	-277	-1784	-1364	-4120	-1949	-484	1507	-1465	-1031	-2742	-1217
<i>Cecropia palmata</i>	Urticaceae	Cp3	16.5	245	-1930	-759	-1540	-2325	-1388	2175	-937	-843	-1150	-1857
<i>Cecropia palmata</i>	Urticaceae	Cp4	19	-652	-1621	-1875	-461	-1967	-417	969	-1550	-1137	-1168	-1192
<i>Cecropia palmata</i>	Urticaceae	Cp5	13.5	-776	-495	-3623	-2440	-3030	14	-281	-3044	-636	-3032	-1508
<i>Gouphia glabra</i>	Goupiaceae	Gg1	16	129	-568	-935	-1420	-2531	-264	697	-2267	-220	-1178	-1398
<i>Gouphia glabra</i>	Goupiaceae	Gg2	14.5	236	-325	-1296	-826	-2405	-205	561	-2200	-44.5	-1061	-1305
<i>Gouphia glabra</i>	Goupiaceae	Gg3	20	86	-195	-1436	-1381	-1971	-234	281	-1737	-54.5	-1409	-1103
<i>Gouphia glabra</i>	Goupiaceae	Gg4	13	1041	-368	-1009	-1160	-2010	50	1409	-2060	337	-1085	-980
<i>Gouphia glabra</i>	Goupiaceae	Gg5	12.6	808	193	-1680	-2068	-901	-340	615	-561	501	-1874	-621

**Table S3: Statistical analysis of the change in curvature of saplings during spring back and during debarking measured on the nine species.** t: student t; std: standard deviation df: degree of freedom; p.v: p-value; Sig.: significance. \*\* and \*\*\* indicates the significance difference from zero (one sample t-test) at  $\alpha = 0.01$  and  $0.001$  respectively. NS: not significant.

T-test  $\Delta C$  Spring-back standardized VS 0 (species level).

	mean	std	t	df	p.v	Sig
<i>Pachira</i>	8.3	3.3	8.60	11	3.28E-06	***
<i>Tarrietia</i>	7.7	3.7	6.52	9	1.09E-04	***
<i>Theobroma</i>	5.7	2.5	7.88	11	7.56E-06	***
<i>Gossypium</i>	6.3	2.6	8.08	10	1.08E-05	***
<i>Cordia</i>	3.1	2.3	4.05	8	3.67E-03	**
<i>Virola</i>	5.0	3.8	3.69	7	7.78E-03	**
<i>Simarouba</i>	6.8	2.0	10.94	9	1.68E-06	***
<i>Laetia</i>	12.1	5.0	7.59	9	3.36E-05	***
<i>Cecropia</i>	15.2	6.5	7.00	8	1.12E-04	***

T-test  $\Delta C$  debarking standardized VS 0 (species level).

	mean	std	t	df	p.v	Sig
<i>Pachira</i>	-7.1	2.1	-11.67	11	1.54E-07	***
<i>Tarrietia</i>	-5.3	1.9	-8.92	9	9.17E-06	***
<i>Theobroma</i>	-3.6	1.9	-6.65	11	3.62E-05	***
<i>Gossypium</i>	-3.3	1.8	-5.96	10	1.40E-04	***
<i>Cordia</i>	-0.8	0.6	-3.85	8	4.90E-03	**
<i>Virola</i>	-0.4	0.5	-2.23	7	6.06E-02	NS
<i>Simarouba</i>	0.2	0.6	1.00	9	3.43E-01	NS
<i>Laetia</i>	1.0	0.5	6.36	9	1.31E-04	***
<i>Cecropia</i>	1.9	1.5	3.89	8	4.64E-03	**

## References

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