High Root-Pressures in Palms

DESPITE some impressive demonstrations of root-pressure[1-3], 'pumping' or positive pressure is generally thought to be of little importance for the ascent of sap in trees. This is probably true for dicotyledons, but in ten species of palms at Calcutta I was able to detect and measure positive root-pressures throughout the year, sometimes enough to lift sap to heights exceeding those of the trees.

A palm has rather uniform adventitious roots growing from the bole, or stem base. The number at bearing stage varies from a few hundred to more than 13,000 as in *Cocos nucifera*. Such a root, generally about 0·7 cm. in diameter, is cut about a metre from the bole. The proximal end, attached to the tree, is connected by a long rubber tube to a glass tube of 3 mm. bore dipped in water, and connexions sealed with paraffin. The distal end, severed from the tree, is connected by a short rubber tube either to a vertical glass capillary tube or a mercury manometer.

The maximum suction, or negative pressure, is usually reached within 10 hr., and may persist for as long as four months. Its value fluctuates rapidly with atmospheric changes, as would be expected if transpiration were an important cause of it. The positive pressure usually starts developing after about 24 hr.. and reaches a maximum after 10–20 days, the time varying between species and between roots of the same tree. After a day or two it begins to decline, and disappears after about two months. There are slight diurnal fluctuations, the pressure being higher by day. Table 1 gives data on 51 palm and 2 banana (*Musa sapientum*) trees. The roots of *Phoenix sylvestris* are not suitable for the operation described, and the low values obtained are probably due to leakage. In seven of the eleven species, the positive pressure exceeds the negative pressure considerably. It often exceeds the plant's needs. Thus a seedling of *Borassus flabellifer*, a little under a metre high, had a root which developed a pressure of 5·24 m. of sap. Again, in *Musa sapientum*, the only monocotyledon other than a palm which I studied, and which behaves just like the palms, the suckers die before reaching a height of 4 m.

In order to demonstrate that my results are due to a physiological property of palms, and not to differences of method, I used just the same methods on

Table 1

Species of trees studied	Number	No. of roots connected for		No. of roots showing		Maximum height (cm.) of water column	
		Suction pressure	Pumping pressure	Suction	Pumping	Sucked	Pumped
Cocos nucifera	11*	20	39	20	34	20·1	1,250
Borassus flabellifer	10	29	36	27	24	51·0	524
Areca catechu	6	25	26	23	19	27·5	550
Livistonia chinensis	6	16	24	16	15	42·0	100
Phoenix sylvestris	5	18	20	12	1	18·2	34
Ptychosperma macarthuri	4	19	19	17	18	34·3	650
Oreodoxa regia	3	5	12	4	6	25·9	650
Chrysalidocarpus lutescens	3	9	15	8	7	39·9	310
Livistonia rotundifolia	2†	5	5	4	4	24·0	40
Caryota urens	1‡	8	8	3	1	62·0	70
Total for the 10 species	51	144	198	134	124	62·0§	1,250§
Musa sapientum	2	11	11	10	9	25·1	670

* Two of these palms were studied at Kayangulam, Kerala State.
† Connexions damaged due to heavy rains at an early stage.
‡ The palm was at its last stage of flowering.
§ Denotes the maximum for all the palms studied.

Table 2

Species of trees studied	Number	No. of roots connected for		No. of roots showing		Maximum height (cm.) of water column	
		Suction pressure	Pumping pressure	Suction	Pumping	Sucked	Pumped
Dalbergia sissoo	1	6	6	6	nil	54·5	0
Polyalthia longifolia	1	5	5	5	nil	59·0	0
Sterculia urens	1	5	5	4	nil	27·6	0
Psidium guajara	1	5	5	5	nil	01·2	0
Ficus religiosa	1	4	4	4	nil	27·5	0
Total	5	25	25	24	nil		
Cycas circinalis	1	7	7	5	nil	85·7	0

five dicotyledonous trees and one gymnosperm. The results are given in Table 2, and require no comment.

It seems likely that monocotyledonous plants, having no secondary growth, behave very differently from dicotyledons. As M. H. Zimmermann (private communication) says: "because most monocots do not form new vascular tissue in the lower part of the trunk as dicots do, a cohesion mechanism alone would run into difficulties". The method is clearly important as others[4-6] have failed to demonstrate root pressure in palms.

A few simple experiments suggest that the observed root pressures suffice to drive sap up the stem about as easily as up a capillary tube. The distal part of a cut root of a fruited banana plant was seen to develop pressure. The plant was decapitated at 2·25 m. above ground-level, and the cut root reconnected with a rubber tube. Other agencies such as transpiration are probably less important than root pressure.

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[5] Bose, J. C., *The Motor Mechanism of Plants* (Longmans, Green and Co., London, 1928).

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