# Essays on the Morphology of Palms

## VIII THE ROOT

P. B. Tomlinson

To study the root system of any plant is difficult and palms are no exception. These few notes indicate the main features of the morphology of palm roots in so far as they are known, and will probably serve only to emphasize our ignorance of this subject rather than to reveal any great store of knowledge. One difficulty in studying the roots of palms is that palms in cultivation frequently develop peculiarities of the root system which they may not show in nature. The first problem therefore may be to distinguish that which is normal from abnormal structures.

As in most monocotyledons the first seedling root, being unable to increase its diameter by secondary growth, is replaced by adventitious roots arising from the basal nodes of the seedling (Tomlinson, 1960). As the diameter of the stem increases by superposition of successively wider internodes, so does the potential area over which roots can be borne. Consequently, as the enlarging stem and crown makes increasing demands for water and dissolved mineral substances, these demands are met by the continual production of new roots and by the penetration of existing roots deeper and more distantly into the soil. This contrasts with a dicotyledonous tree in which the primary tap root normally persists but widens by secondary growth so that an ever-widening channel exists capable of maintaining an effective conduit for water supplied by the expanding root system and demanded by the increasing leafy crown. On the other hand, in adult palms the water demands of the leafy crown soon reaches a constant note, because this crown does not branch or increase in size, therefore, the demands made on the absorptive capacity of roots also soon reaches a constant rate.

The origin of the new adventitious roots is of great interest. They all arise at the periphery of the central cylinder. New root initials originate only in living tissues and since they are produced continuously throughout the life of the palm, there must be some growing tissues always active at the base of the trunk. This is quite remarkable when one considers that these tissues are all primary and are the oldest in the palm stem. Certainly the origin of roots in palms in relation to the great longevity of these tissues would be a rewarding study.

Vascular continuity between root and stem is maintained by intimate union of the vascular strands of root and stem, these fusions often being quite deep-seated. Since the vascular skeleton of the stem is itself a continuously ramifying n e t w o r k ultimately associated directly with green leaves at the crown there is thus built up a continuous conducting channel whereby water absorbed by the roots finds its way into the leaves via the xylem tissues. Conduction of complex foodstuffs, in both directions, takes place through the same network, but in the phloem tissue.

The extent of the palm root system in the soil is unknown. From observations of root systems exposed either by land slips, or, as with the coconut on sandy shores, by wind-erosion, the lateral extent of roots may be enormous. The persistence of certain palms in arid regions (albeit almost invariably in obvious water-courses) also suggests that the vertical penetration of palm roots may be considerable. The extent of the root system must also depend on the texture of the soil.

Palm roots have the basic monocotyledonous root structure. They grow apically and have a well-developed conspicuous root-cap. Roots of the first order are usually quite wide. Certain internal modifications may result from this. One peculiarity of these wide first-order roots is the absence of root hairs. They are replaced by large and often thick-walled surface cells which may not be good absorbers. Absorption seems primarily to be a function of the narrower branch roots, or secondary order roots, which do bear root hairs close to the growing tip. For this reason one essential for vigorous growth of the palm is probably a healthy system of actively growing roots, with the continual renewal of absorbing branch roots. This should also be borne in mind when a palm is transplanted.

One peculiarity of wider roots in palms is that the central stele may not be cylindrical, but fluted or even dissected into separate strands. It is interesting to note that all palm roots at their insertion onto the stem break into separate strands each of which individually fuses with a stem bundle. Thus the persistence of the dissected stele in wide roots is merely an extension into the root itself of structures normally restricted to that part of the root within the stem (Cormack, 1896; Drabble, 1904).

Whilst palm roots normally grow deeply into the soil when originating on the stem base, either below ground or at most a little above soil level, under exceptional circumstances or rarely as a normal condition they may behave otherwise. Commonly a dense cluster of roots is formed at the base of the trunk, a little above the soil surface. These roots have restricted growth but persist in a dormant state. This condition is common, for example, in *Phoenix*. Whether this root cluster is normal or abnormal, and, if abnormal, its cause is not known. However, Small (1936) has evidence that these clusters, at least in *Sabal*, represent the result of fluctuations in water level, the roots only growing out to the height of the trunk covered by flood water. The production of clusters of erect-growing roots at the base of the stem was considered by Cook (1941) to be a characteristic feature of *Thrinax* and related palms. He gave the name rhizotyle to these clusters and suggested that they serve to trap humus. Similar, but spiny, erect roots have been observed at the base of the stem in *Zombia*. This may indicate a transition to the condition in *Cryosophila*.

In *Cryosophila*, the root-spine palm, roots originate at all levels on the trunk, as well as at its base. The basal roots are normal, long absorbing and anchoring organs. The aerial roots early resemble normal roots in that they have a deep seated origin and a root cap, but they soon become erect, short, often branched and always rigid, pointed spines. The spines on the stem of *Mauritia armata* are similar, but shorter and stouter root-spines. In certain other palms, notably of the iriartoid group, thick props originate at successively higher levels on the stem. These are gigantic roots, each with a massive root cap and a complex stele which befits their giant size. They grow out from the stem at an angle, ultimately reaching the ground to function as stout buttresses. These iriartoid palms have a peculiar spindly method of stem growth which necessitates this mechanical buttressing (Tomlinson, 1960). Similar roots appear on a few unrelated palms with a normal stem construction, notably in *Verschaffeltia*. These roots may not be essential for support of the stem and may be distinguished as "aerial roots," although their anatomy and behavior is identical with that of "prop-roots."

One peculiar feature of many palm roots to which the early attention of plant anatomists and physiologists was drawn is the presence of small appendages called "pneumathodes." Each pneumathode is a lateral root with restricted growth. They are frequently seen on the exposed roots of pot-grown seedlings and most of the early literature on these organs describes them on palms cultivated in glass-houses in Europe. Their frequency and distribution in nature is not well known. Commonly pneumathodes are visible growing erect above the soil surface, but they also occur abundantly underground. In their internal anatomy these short branch roots differ from normal roots largely in having very loose surface tissues. This is apparently designed to facilitate gaseous exchange between the air and the internal atmosphere of the root. It should be noted that many palm roots, particularly those of swampy situations, have a longitudinal system of cortical air-canals with which the pneumathodes are continuous. The function of these pneumathodes as breathing organs is assumed rather than proved, but this interpretation seems likely. For example, in the *Raphia*-swamps of West Africa, the swamp surface is covered by a close carpet of erect-growing roots which are little more than giant pneumathodes. It is reasonable to suppose that these erect roots aerate the underground roots which grow in the oxygen-deficient mud. The situation is analogous to that of *Avicennia* with its breathing roots or pneumatophores, growing in mangrove swamps.

From this brief discussion of roots in palms, with its unhealthy proportion of speculation and supposition, it is evident just how ignorant we are of the structure and behavior of palm roots. Detailed studies on this subject would be of great value and would ultimately throw some light on the physiology and ecology of palms, subjects of great practical importance.

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## PALMS AT SUMMIT GARDENS, PANAMA CANAL ZONE

W. R. Lindsay

The present Summit Gardens, or Summit Park as it is now called, was started in 1923 as a plant introduction garden (The Canal Zone Experiment Gardens) for the Panama Canal Zone, Panama. The late David Fairchild of the United States Department of Agriculture and Thomas Barbour of Harvard University were both very active in securing its establishment and made many valuable plant contributions in its early stages. Holger Johansen was the first Agronomist and Director of the Gardens. He was most energetic and did an excellent