# Evaluating Root Degeneration in Coconut in Relation to Root (Wilt) Disease

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**ABSTRACT**

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Neither root degeneration nor root regeneration in healthy and root (wilt)-affected coconut palms was statistically significant. Eight, 11, and 6% of roots in West Coast Tall palms and 3, 3, and 4% of roots in locally grown Philippine palms were decayed in healthy trees, trees in the middle stage of the disease, and trees in the advanced stage of the disease, respectively. Observations confined to any sector of the root system were not representative of root characteristics.

The etiology of coconut root (wilt) disease remains elusive, but the disease syndrome strongly indicates a characteristic wilting. Studies have indicated that transmission of the causal agent occurs largely through the soil (5–7). It would be logical to suppose that the root system is the portal of infection and hence that roots degenerate considerably with the progress of the disease. Critical examination, however, reveals that reports of root degeneration associated with this disease remain controversial (12,13,15). We examined the condition of the root systems of coconut palms (*Cocos nucifera* L.) in relation to root (wilt) disease.

## MATERIALS AND METHODS

Root systems of 18 coconut palms were examined. Nine were 35-yr-old West Coast Tall (WCT) cultivar; the other nine were 20-yr-old Philippine cultivar. Of the nine palms in each group, three were healthy, three were in the middle stage of the disease (disease index between 35 and 50), and three were in the advanced stage of the disease (disease index above 50). They were categorized on the basis of foliar condition (2).

Four consecutive concentric zones 1 m wide were marked on the soil surface around the bole of each palm. A trench was dug by removing the soil and the roots in the fourth zone to a depth of 2 m. Soil from the third zone to a depth of 2 m was washed into the trench already dug at the fourth zone with force-driven water. After being thoroughly washed (Fig. 1), the main roots were cut and sorted into four categories: healthy young roots, healthy old roots, regenerated roots, and decayed roots. Young and old roots were differentiated on the basis of color (7). Roots with one or more stout branches emerging near a damaged tip (1) were regarded as regenerated. Roots demonstrating drying, cracks, blotches, etc. (7) were classified as decayed. Counts in each category for each zone were recorded separately. The data were analyzed with analysis of variance (ANOVA), after square root transformations were made.

## RESULTS

Average number of roots recorded in each category in the WCT palms is presented in Table 1 and in the Philippine palms in Table 2. Healthy WCT palms had significantly more roots than those in the middle and advanced stages of the disease. In the Philippine palms, total number of roots was uniform in healthy trees and trees in different stages of the disease.

Fifty to 55% of the roots in the WCT palms belonged in the healthy old category. In the Philippine palms, this category ranged from 60 to 75%. The difference between the number of healthy

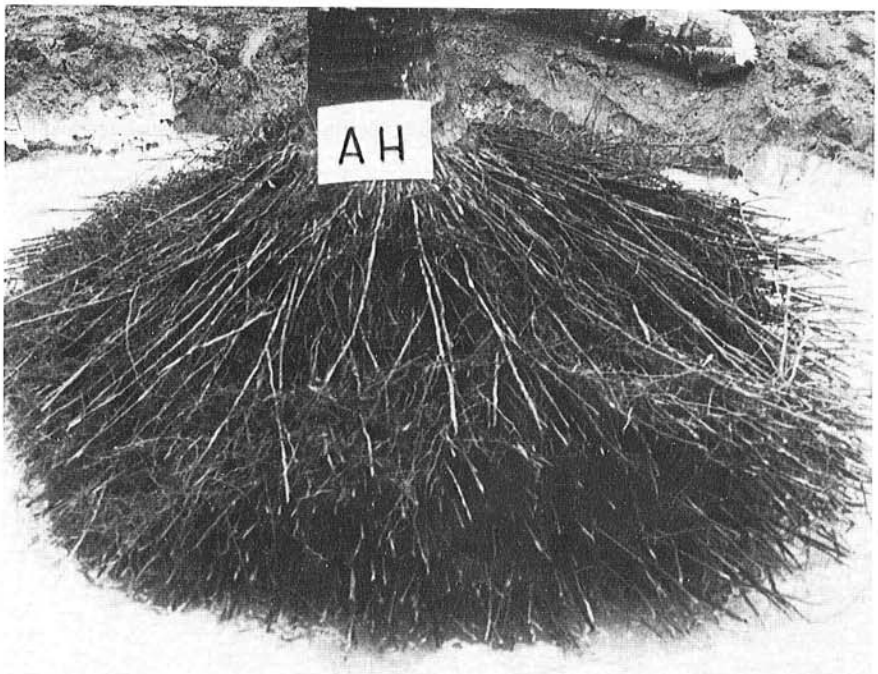


**Fig. 1.** Root system of apparently healthy (AH) Philippine palm in the first concentric zone (0–1 m from the bole).

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young and healthy old roots was significant ($P = 0.01$) for both types of palm.

Number of roots of WCT averaged 3,429, 1,072, and 628 in the first, second, and third concentric zones, respectively. Corresponding numbers for the Philippine palms were 3,663, 977, and 655. Root concentration in the first concentric zone of both cultivars was significant ($P = 0.01$).

Number of regenerated roots did not differ significantly either between types of palm or among the categories of healthy and diseased. Regenerated roots were distributed proportionately among the concentric zones.

Number of decayed roots averaged 159, 147, and 120 for WCT and 57, 64, and 47 for Philippine palms, in the first, second, and third concentric zones, respectively. This lack of concentration proportional to the corresponding total number of roots in each zone makes the interaction between the number of decayed roots and the concentric zones significant ($P = 0.01$). However, the interaction between the number of decayed roots and the condition of palms was not significant for either type of palm. Percentage of decayed roots in WCT palms was 8, 11, and 6 and in the Philippine palms 3, 3, and 4 for healthy, middle, and advanced stages of the disease, respectively.

Average number of roots in eight equal sectors of the root system in the first and second concentric zones of five palms ranged from 355 to 598 and from 86 to 188, respectively. The corresponding ranges of the coefficient of variation were 16–27 and 17–36. Evidently, the number of eighth sectors required to minimize the "margin of error" in sampling to within 20% ranged from two to four and two to five for the first and second concentric zones, respectively. Corresponding figures restricting the margin of error to within 10% are four to six and four to seven.

**Table 1.** Average number of roots in different zones of healthy and root (wilt)-affected West Coast Tall palms

| Condition of palms / Type of roots | Zone: Third meter Number | % | Second meter Number | % | First meter Number | % |
|---|---|---|---|---|---|---|
| Healthy | | | | | | |
| Healthy young | 210 | 27 | 334 | 23 | 644 | 15 |
| Healthy old | 351 | 44 | 638 | 44 | 2,219 | 52 |
| Regenerated | 44 | 6 | 271 | 18 | 1,273 | 30 |
| Decayed | 186 | 24 | 219 | 15 | 130 | 3 |
| Total | 791 | | 1,462 | | 4,266 | |
| In middle stage of disease | | | | | | |
| Healthy young | 71 | 20 | 160 | 24 | 312 | 9 |
| Healthy old | 199 | 57 | 283 | 43 | 2,002 | 55 |
| Regenerated | 16 | 5 | 66 | 10 | 1,041 | 29 |
| Decayed | 66 | 19 | 143 | 22 | 281 | 8 |
| Total | 352 | | 652 | | 3,636 | |
| In advanced stage of disease | | | | | | |
| Healthy young | 194 | 26 | 238 | 22 | 361 | 15 |
| Healthy old | 413 | 56 | 722 | 65 | 1,372 | 58 |
| Regenerated | 24 | 3 | 63 | 6 | 586 | 25 |
| Decayed | 109 | 15 | 80 | 7 | 65 | 3 |
| Total | 740 | | 1,103 | | 2,384 | |

**Table 2.** Average number of roots in different zones of healthy and root (wilt)-affected Philippine palms

| Condition of palms / Type of roots | Zone: Third meter Number | % | Second meter Number | % | First meter Number | % |
|---|---|---|---|---|---|---|
| Healthy | | | | | | |
| Healthy young | 53 | 8 | 161 | 17 | 592 | 13 |
| Healthy old | 531 | 82 | 669 | 71 | 2,608 | 59 |
| Regenerated | 27 | 4 | 42 | 4 | 1,157 | 26 |
| Decayed | 33 | 5 | 64 | 7 | 60 | 1 |
| Total | 644 | | 936 | | 4,417 | |
| In middle stage of disease | | | | | | |
| Healthy young | 71 | 11 | 70 | 7 | 394 | 11 |
| Healthy old | 466 | 74 | 756 | 81 | 2,602 | 75 |
| Regenerated | 39 | 6 | 58 | 6 | 442 | 13 |
| Decayed | 57 | 9 | 55 | 6 | 40 | 1 |
| Total | 633 | | 939 | | 3,478 | |
| In advanced stage of disease | | | | | | |
| Healthy young | 96 | 14 | 125 | 12 | 370 | 12 |
| Healthy old | 499 | 73 | 801 | 76 | 1,978 | 64 |
| Regenerated | 40 | 6 | 58 | 5 | 676 | 22 |
| Decayed | 52 | 8 | 73 | 7 | 71 | 2 |
| Total | 687 | | 1,057 | | 3,095 | |

## DISCUSSION

Under normal management conditions, the roots of an adult, bearing coconut palm growing in sandy loam soil are concentrated within a radius of 2 m; about 85% are less than 120 cm deep (3,10). This amply justifies our attempts to expose the root system within a radius of 3 m and 2 m deep.

The root habits of coconut palms vary greatly, depending on the nature of the seed nuts they were raised from (14). Moreover, the total number of roots of a palm ranges from 1,500 to 7,000 (1,14). Therefore, the observation that the healthy WCT palms had significantly more roots may not be relevant to their condition of health or disease. Uniformity in the number of roots observed in the Philippine palms irrespective of their condition further substantiates the reported role of seed nuts in determining the total number of roots of the palm (14). The fact that all the Philippine palms were 20 yr old may also contribute to the uniformity in the total number of roots.

Our observation that most roots in the WCT palms (50–55%) and in the Philippine palms (60–75%) were healthy old roots corroborates an earlier observation (7) in which the age of roots was determined on the basis of their color. In 15-yr-old palms, most roots were dark brown, and their number increased as the palm aged. However, neither color nor age of roots is indicative of their functional nature, because there are no dead roots and only some of them could be dormant (14). Our observations on the maximum concentration of roots in the first concentric zone agree with earlier ones (3,10).

Our data on the ability of trees to regenerate roots and the rate of root decay in healthy and diseased palms necessitate a reexamination of earlier reports on the root symptoms. One study reported considerable deterioration of the root system and decrease in production after infection by the root (wilt) disease (7). Root systems of diseased palms were reported to be inferior in the number of roots, their distribution, length, etc. (8). Another study reported root decay up to 92% from root (wilt) disease (13). Other reports, however, showed that root symptoms (root rot) did not correspond with foliar symptoms of the root (wilt) disease (4,12). The reported symptom of drying of most roots and rootlets was hardly present when fresh holes were dug for examination (5). Roots did not rot except when in contact with water, although there was reason to think that the roots would be

dysfunctional (15). Another study found that root decay was insignificant in palms in the early stage of the disease (9). Our observation that root decay was not statistically significant in either type of palm in different stages of disease substantiates the view that root decay does not form part of the characteristic symptoms of the root (wilt) disease.

Earlier reports of a high percentage of root rot were based on observation of the condition of roots in one-eighth of the root system. Our data show that the margin of error when only one-eighth of the root system is sampled is high. The practice of calculating the total number of roots of a palm after counting the roots in one-fourth or one-fifth of the system gave erratic results (11). The relevance of the observation that the branch roots of coconut are short-lived and are replaced frequently (14) cannot be overlooked when the degree of root rot associated with root (wilt) disease is assessed. Misinterpretation of this natural phenomenon may also make the assessment erroneous.


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