

SOILS AND NUTRITION

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The coconut root (wilt) disease has been found to occur on all soil types of Kerala under varying ecological conditions ranging from foot hills of the Western Ghats to the coastal plains (Pillai *et al.*, 1973). Investigations on soil conditions and nutritional factors associated with the disease were initiated in 1939 (Menon and Nair, 1949). Menon and Nair (1949), Menon *et al.* (1950) suggested that the disease might also be associated with nutritional deficiencies. They reported that the soils of disease affected areas were generally deficient in major nutrients, particularly K, and had a lower content of exchangeable cations and a low pH and cation exchange capacity (CEC). The silica/sesquioxide ratio was reported to be higher.

Soil sickness characterised by low pH, inadequate activity and nutrient imbalances together with mineral deficiencies, probably those of K, Ca and Mg were reported to have a decisive role on the incidence of the disease (Menon *et al.*, 1950, 1952; Pandalai *et al.*, 1958a, 1958b; Menon, 1961; Verghese, 1961; Lal, 1964; 1968). An intensive study of the major soil groups of erstwhile Travancore Cochin State representing healthy and diseased pockets was conducted by Sankarasubramoney *et al.* (1954, 1955, 1956) and Pandalai *et al.* (1958a, 1958b, 1959a, 1959b). Their studies showed that in general, the soils in disease

affected areas were low in available K, total Ca and Fe, exchangeable Ca and Mg, total exchangeable cations, CEC, pH and percentage base saturation. Waterlogging was found to favour disease incidence and majority of the diseased areas had a high water table. Cecil and Verghese (1959) observed that the reduction products formed in soils under waterlogged conditions were not responsible for disease incidence. Verghese (1966) indicated the association of faulty nutrient ratios in soils, particularly K/Mg, K/Ca and N/K with disease incidence. Pillai and Pushpadas (1965) observed that coconuts growing on Kari tracts (peaty soil) having high acidity, often in the pH range of 3-4, had less incidence of disease.

Pillai *et al.* (1975) carried out a nutritional survey of all the districts of Kerala and studied the major and micro-nutrient status of all soil groups of the State. There was no consistent difference in major and micro-nutrient status of soils between healthy and diseased areas. However, the total N status was generally higher and the available N status lower in the diseased tracts. Verghese (1959b) suggested that probably the mineralogical composition of rocks and some toxic products of weathering could be responsible for the disease and the possibility of water acting as their carrier. Biddappa and Khan (1985) studied the heavy metal

status of coconut growing soils of Kerala and found that the contents of Diethylene triamine-penta acetic acid (DTPA) extractable Ba, Cr, Cd, Pb, Sr and V were significantly higher in diseased soils as compared to healthy.

Menon and Nair (1952) were the first to examine the major nutrient status of leaves in relation to the disease. Subsequent studies by Sankarasubramoney *et al.* (1952), Verghese *et al.* (1959a), Pillai (1959) and Pandalai (1959) showed that there was a tendency for N, P and K to get accumulated in the leaf tissues of diseased palms and the accumulation increased with the advancement of the disease. Compared to healthy, the diseased palms contained more of N, P, K and silica to the extent of 5.0 to 13.0; 0.0 to 13.0; 5.0 to 39.0 and 59.0 to 134.0 per cent respectively (Verghese *et al.*, 1959a). Cecil (1969) suggested that the nutrient accumulation was only apparent, possibly the result of a low dry matter content of leaf tissues consequent on disease incidence.

Verghese *et al.* (1957, 1959b) ruled out the possibility of Cd and Sr toxicity in the disease complex. Cecil (1975) found that the N, P and K contents did not differ between healthy and diseased palms in the early stage of infection. But Ca and Mg contents of healthy palms in disease free areas were significantly higher than those of apparently healthy or diseased palms in the affected tracts. He also reported that the palms in the diseased areas were in a state of imbalanced nutrition with wider ratio of N/Mg, P/Mg,

K/Mg and Ca/Mg indicating a lower content of Mg in proportion to other major nutrients. A comprehensive study on the nutritional factors of the disease by Pillai *et al.* (1975) indicated that the palms in the disease affected areas, whether apparently healthy or visibly diseased, were in a state of imbalanced nutrition, possibly the result of a relatively higher content of N, P and K on the one hand and a lower content of Ca, Mg and S on the other.

Khan *et al.* (1985) did not observe any relationship between the micro-nutrient composition of diseased palms and the disease index compared to healthy palms. Biddappa and Cecil (1984) and Biddappa (1985) studied the deposition of heavy metals in the root and cabbage tissues respectively, of diseased palms by employing scanning electron X-ray microprobe analyser. High deposition of Al, Mn, Cu and Co in the diseased roots and Cr, Ti, Pb, Bi and Ga in the cabbage tissues of diseased palms were also observed compared to healthy tissues. This was also confirmed by the chemical analysis of a large number of soil and tissue samples under identical conditions (Table 15).

Table 15. Heavy metal concentration in cabbage tissues of healthy and root (wilt) diseased palms (Biddappa, 1985)

Condition of the palms	Heavy metal concentrations ($\mu\text{g/g}$)				
	Bi	Cr	Pb	Ti	Ga
Healthy	7	6	tr	12	10
Diseased	19	34	2.8	17	29

Biddappa (1984) also observed higher contents of heavy metals in the crown of diseased compared to healthy palms. Wahid *et al.* (1983) studied the non-nutrient elemental composition in soil (0-30 cm) and plant tissues of healthy and root (wilt) diseased palms from a few selected locations employing energy dispersive X-ray fluorescence technique and found that Ni and Sr were present at a higher concentration in the root of diseased palms compared to healthy.

The first field fertiliser trial conducted at Kayangulam (Menon and Nair, 1952) indicated that N and K were the limiting factors in the disease affected gardens. John and Jacob (1959) reported that in disease affected areas of West Coast, NPK application along with fungicides and insecticides markedly increased the yield. Nair and Radha (1959) and Lal (1964) reported reduction in the foliar yellowing and increase in yield of diseased palms by applying NPK, lime and farm yard manure and spraying with Bordeaux mixture, micro-nutrients and magnesium. Sahasranaman *et al.* (1964) found that application of NPK fertilizers higher than the optimum dose generally aggravated the symptoms and reduced the yield of diseased palms while lower levels helped to maintain an economic yield. The results of a trial with three levels of NPK, two levels of Ca and Mg on diseased palms showed that the lowest level of NPK tried viz., 350-300-600 g along with 500 g MgO per palm per year could be the economic dose for the management of diseased palms (Anon., 1981). Application of lime and ash (Chettiar *et al.*, 1959) and Chilean nitrate

(John *et al.*, 1959) showed no positive effect on the disease. Continued application of three levels of N (highest level - 1.362 kg N), P (highest level - 0.908 kg P_2O_5) and K (highest level - 2.724 kg K_2O) in factorial combinations was not effective in either curing the disease or preventing fresh incidence on young healthy palms (Cecil, 1969).

Davis and Pillai (1966) and Davis (1969) reported that the application of micronutrients and Mg did not prevent fresh incidence of disease. However, Mg application had decidedly a favourable response on the yield of diseased palms. Similar responses of Mg treatment on diseased palms were also reported by Varkey *et al.* (1979); Cecil (1981) and Anon. (1981). Concluding his nutritional studies, Cecil (1981) recommended the application of Magnesium for the management of diseased palms. The pre-bearing age was reduced by 9 months by the addition of Mg, and the response of Mg was more pronounced on diseased palms compared to healthy ones. Lal (1968) reported that the yellowing associated with the disease might be largely due to Mg deficiency. Cecil (1981) and Cecil *et al.* (1982) based on field fertility trials concluded that the disease was not caused by deficiency of any major nutrients. Application of sulphur, calcium sulphate and magnesium sulphate along with NPK was found to increase the yield of affected palms (Lal, 1964). The foliar yellowing associated with the disease decreased markedly when the palms were sprayed with 2.0% magnesium sulphate solution at quarterly intervals (Anon., 1966; Varkey *et al.*, 1979).

The nutritional requirement of Chowghat Orange Dwarf (COD) x West Coast Tall (WCT) hybrids in the root (wilt) affected area was investigated by Amma *et al.* (1982). The dose of 500 g N, 300 g P₂O₅ and 1000 g K₂O along with 500 g MgO per palm per year could be taken as ideal for optimum productivity of the hybrid under rainfed conditions. The seedlings which received fertilizers, started yielding 3 years earlier than those grown under control (Table 16). A comparative study on the performance of WCT (Cecil, 1981) and CODxWCT (Amma *et al.*, 1982) under rainfed conditions and regular fertilization with N, P, K, Ca and Mg, since field planting shows that the

hybrid was superior to WCT with respect to reduced disease incidence and increased nut yield (Table 17).

Zinc and Mo both as soil application and foliar spray had no effect on incidence or intensity of the disease, even though the tissue levels of Zn and Mo increased considerably (Mathew *et al.*, 1986).

A systematic micronutrient manurial experiment consisting of all combinations of two levels each of Fe, Mn, Cu, Zn, B and Mo since field planting had shown that the disease was not related to micronutrient nutrition of the palm (Anon., 1986).

Table 16. Effect of fertilizers on precocity and yield of hybrid palms in root (wilt) affected areas (Amma, P.G.K. unpublished)

Year after planting	Mean yield of nuts/palm/yr. under different treatments					
	(NPK)* ₁	(NPK)* ₂	(NPK)* ₃	Mean of (NPK)	FYM only	Absolute control
5th	58.9	64.5	44.2	55.9	Nil	Nil
6th	97.5	106.3	98.8	100.9	18.3	Nil
7th	80.3	79.2	68.1	75.9	20.8	Nil
8th	87.7	90.3	95.4	91.1	19.9	10.1
9th	112.5	110.2	92.3	105.0	44.9	26.7
10th	77.0	55.2	53.4	61.9	46.4	27.7
11th	112.8	107.8	89.6	103.4	50.1	29.8
12th	33.5	19.8	26.5	26.6	34.9	24.1
13th	151.2	130.5	130.7	137.5	92.9	59.0
Mean	90.1	84.9	77.7	84.2	34.2	24.2

* (NPK)1 = 0.5 kg N, 0.3 kg P₂O₅ and 1.0 kg K₂O /palm/year

* (NPK)2 = 1.0 kg N, 0.6 kg P₂O₅ and 2.0 kg K₂O/palm/year

* (NPK)3 = 1.5 kg N, 0.9 kg P₂O₅ and 3.0 kg K₂O/palm/year

* 12th year (1984) - after the unprecedented drought in 1982-83.

Table 17. Comparative performance of COD x WCT and WCT in root (wilt) affected area. (Cecil 1981; Amma *et al.*, 1982)

Year after planting	Cumulative disease incidence (%)		Nut yield/palm (Nos.)	
	COD x WCT	WCT	COD x WCT	WCT
4th year	1.8	2.2	-	-
5th year	3.6	4.3	55.9	-
6th year	5.0	8.8	100.9	-
7th year	5.0	22.5	75.9	16.8
8th year	8.9	29.3	91.1	39.6
9th year	22.1	35.5	105.0	49.4
10th year	22.8	42.6	61.9	44.8
11th year	40.9	50.7	103.4	62.9
* 12th year	41.1	62.2	26.6	52.1
Cumulative yield/palm upto the 12th year.			620.7	265.6

* 12th year (1984) - after the unprecedented drought in 1982 - 83.

The effect of slow release fertilizers in coconut growing soils of root (wilt) affected area was evaluated by Amma *et al.* (1993). The results of the study revealed that slow release N source are superior to ordinary untreated urea for gradual supply of nitrogen to the soil. When urea mixed with indigenous materials like coir dust, neem cake etc ammonification/nitrification was taking place at very low pace, resulting in higher status of $\text{NH}_4\text{-N}/\text{NO}_3\text{-N}$ in the soil for a longer period.

The field experiment to study the effect of different organic manures on the growth and productivity of root (wilt) affected palms is in progress (Anon., 1996). The study

revealed that by application of organic manures alone or in combination with inorganic fertilizers, the incidence of root (wilt) disease could not be controlled/arrested. By the end of fifth year of planting 21.8 percent of the palms had contracted the root (wilt) disease. However the growth parameters of the palms like height, girth at collar, number of leaves produced/year, length of the oldest functioning leaf were found to be significantly higher under the treatment of organic manures along with inorganic fertilizers.

Valiathan *et al.* (1992) reported lower level of magnesium and higher concentration of cerium in the leaves of root (wilt) diseased

coconut palms than in the healthy - looking palms. From the Table 18 it is clear that the element lanthanum also showed higher levels in the diseased than in the healthy palms. According to the authors, the reciprocal enhancement of cerium, the most bioactive member of the lanthanide series, is consistent with the synergistic role of magnesium deficiency which increases the cytotoxicity of metals by various mechanisms, including the increase in membrane permeability. They could visualize the similarity in the reciprocal relationship between magnesium and cerium in the diseased palms and the relationship in the cardiac tissues of patients with endomyocardial fibrosis.

Besides the macro and micronutrients, rare earth elements (REEs) like lanthanum (La), Cerium (Ce), Praseodymium (Pr), Neodymium (Nd), Samarium (Sm) and

Gadolinium (Gd) were also estimated in the root (wilt) diseased, apparently healthy and healthy palms (Wahid, 1998 personal communication). Among these, the foliar levels of Gd were significantly less in palms of the disease affected tract than in palms of the disease free tract, indicating the deficiency of Gd in the disease endemic areas. This was observed in pooled analysis and in the soil type-wise analysis of laterite soil. The author had also reported significantly less ratios between nutrient - REEs namely Ca/Ce, Mg/Ce, Mn/Ce, Zn/La and Zn/Ke in palms growing on alluvial soil in the disease affected tract than in healthy palms growing on the same type of soil in the disease free tract. According to the author the diseased tract and disease free tract are geochemically different and perhaps it is due to this, that the disease is confined to a particular region.

Table 18. Elemental concentration in the palms after Valiathan *et al.*, 1992

Element	Healthy looking controls				Statistical significance
	Diseased (n=30)	Kollam and Alappuzha (n=30)	Bombay (n=3)	Manavalakurichi (n=10)	
Mg	252±95.7	261±94	336.7±162	377.4±80.1	DG lower than 3 (P<0.001).
Ce	856±320	622±215	16.9±5.8	195.7±81.4	DG higher than 1, 2 and 3 (P<0.001). 1 higher than 2 and 3 (P<0.001).
La	476±170	359±116	<2	70.4±29	DG higher than 2 and 3 (P<0.001)

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