

SOILS AND NUTRITION

S.R. CECIL and P.G.K. AMMA

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, Lal and Shanta, 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, Sankarasubramoney and Pandalai (1950) and Menon, Nair and Pandalai (1952) 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 drainage, poor aeration, low microbial 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, Sankarasubramoney and Menon, 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, Pandalai and Menon (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 S status lower in the diseased tracts. Verghese (1959) 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, Pandalai and Menon (1952), Verghese, Sankaranarayanan and Menon (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, Sankaranarayanan and Menon (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 micronutrient 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 1).

Table 1. 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 fertility 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, Radha and Pandalai (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, Verghese and Sankaranarayanan, 1959) and Chilean nitrate (John, Channey and Verghese, 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 P₂O₅) and K (highest level - 2.724 kg K₂O) 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); Cecii (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) who observed that the hybrid responded favourably to higher levels of NPK for its growth and early flowering. However, the dose of 500 g N, 300 g P₂O₅ and 1000g 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 2). A comparative study on the performance of WCT (Cecil, 1981) and COD x WCT (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 3).

Zinc and Mo both as soil application and foliar sprays 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 2. 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 3. 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	CODxWCT	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.

REFERENCES

- AMMA, P.G.K., CECIL, S.R., PILLAI, N.G., MATHEW, A.S. and NAMBIAR, P.T.N. 1982. Performance of Dwarf x Tall hybrid coconut in root (wilt) affected areas of Kerala under different fertilizer schedules. *Proc. PLACROSYM* 5: 405-410.
- ANONYMOUS, 1966. Annual Report for 1966. Central Coconut Research Station, Kayangulam. pp. 64.
- ANONYMOUS, 1981. Annual Report for 1978. Central Plantation Crops Research Institute, Kasaragod, India. pp. 242.
- ANONYMOUS, 1986. Annual Report for 1985. Central Plantation Crops Research Institute, Kasaragod, India. pp. 212.
- BIDDAPPA, C.C. 1984. Distribution pattern of heavy metals in coconut crown under root (wilt) diseased and healthy conditions. *J. Plant. Crops* 12: 133-139.
- BIDDAPPA, C.C. 1985. Identification of heavy metal deposit in the cabbage tissues of diseased coconut palms (*Cocos nucifera* L.) by using electronmicroprobe X-ray micro analyser. *Curr. Sci.* 54: 679-682.
- BIDDAPPA, C.C. and CECIL, S.R. 1984. Electron microprobe X-ray microanalysis of diseased coconut (*Cocos nucifera* L.) roots. *Plant and Soil* 79:445-447.
- BIDDAPPA, C.C. and KHAN, H.H. 1985. A note on the heavy metal status of coconut growing soils of Kerala. *J. Indian Soc. Soil Sci.* 33: 915-916.

- CECIL, S.R. 1969. Nutritional aspects of the coconut palm in health and disease. M.Sc. Thesis (Unpublished). University of Kerala, Trivandrum.
- CECIL, S.R. 1975. Mineral composition of coconut leaves in relation to root (wilt) disease. *J. Plant. Crops* **3**: 34-37.
- CECIL, S.R. 1981. Mineral nutrition of the coconut palm (*Cocos nucifera* L.) in health and disease with special emphasis on calcium and magnesium, Ph. D. Thesis (Unpublished). University of Kerala, Trivandrum.
- CECIL, S.R. and VERGHESE, E.J. 1959. Chemical studies on the leaf rot and root (wilt) disease of coconuts in Travancore-Cochin. III. Reduction products formed under water-logged conditions. Preliminary investigations. *Proc. First. Conf. Cocon. Res. Workers*. Trivandrum, India.
- CECIL, S.R., PILLAI, N.G., AMMA, P.G.K., MATHEW, A.S. and NAMBIAR, P.T.N. 1982. Effect of major nutrients on the incidence of root (wilt) disease in coconut. *Proc. PLACROSYM* **5**: 474-481.
- CHETTIAR, M.R., VERGHESE, E.J. and SANKARANARAYANAN, M.P. 1959. Chemical studies on the leaf and root (wilt) diseases of coconuts in Travancore Cochin. V. The effect of lime and ash on disease conditions. *Proc. First Conf. Cocon. Res. Workers, Trivandrum, India*.
- DAVIS, T.A. 1969. A 2⁷ confounded design for a manurial experiment on coconut. *Sankhya, Indian Inst. Statist. Sec. B.* **31**: 85-102.
- DAVIS, T.A. and PILLAI, N.G. 1966. Effect on magnesium and certain micronutrients on root (wilt) affected and healthy coconut palms in India. *Oleagineux* **21**: 669-674.
- JOHN, C.M. and JACOB, K. 1959. Fertilizer demonstrations on coconut in West Coast - review. *Proc. First. Conf. Cocon. Res. Workers. Trivandrum, India*.
- JOHN, P.C., CHANNEY, P.V. and VERGHESE, E.J. 1959. Chemical studies on the leaf and root (wilt) diseases of coconuts in Travancore - Cochin. VI. Chilean nitrate as a curative for diseased palms and as a fertilizer for coconut seedlings. *Proc. First. Conf. Cocon. Res. Workers, Trivandrum, India*.
- KHAN, H.H., BIDDAPPA, C.C., JOSHI, O.P. and CECIL, S.R. 1985. Micronutrient distribution in the crowns of healthy and root (wilt) diseased palms. *J. Plant. Crops* **13**: 65-69.
- LAL, S.B. 1964. Advances in research on the root (wilt) disease. Problems of Kerala. *Proc. Second Sessn. FAO Tech. Wkg. Pty. Cocon. Prod. Prot. & Processg.* Colombo, Sri Lanka.
- LAL, S.B. 1968. Root (wilt) disease - resume of work done since 1964. *Proc. Third Sessn. FAO Tech. Wkg. Pty. Cocon. Prod. Prot. & Processg.* Jogjakarta, Indonesia.
- MATHEW, A.S., JOSE, A.I., ABRAHAM JOSE, CECIL, S.R. and AMMA, P.G.K. 1986. Effect of zinc and molybdenum on root (wilt) affected coconut palms. *Agric. Res. J. Kerala* **24**: 169-174.
- MENON, K.P.V. 1961. Diseases of undetermined causes with special reference to root (wilt) disease of South India. *Proc. First Sessn. FAO Tech Wkg. Pty. Cocon. Prod. Prot. & Processg.* Trivandrum, India.
- MENON, K.P.V. and NAIR, U.K. 1949. The root (wilt) disease of coconut in Travancore Cochin. *Indian Cocon. J.* **3**: 5-10, 40-44.
- MENON, K.P.V. and NAIR, U.K. 1952. Scheme for the investigation of the root and leaf diseases of the coconut palm in South India. Consolidated final report of the work done from 8th March 1937 to 31st March 1948. *Indian Cocon. J.* **5**: 81-100.
- MENON, K.P.V., NAIR, U.K. and PANDALAI, K.M. 1952. Influence of water-logged soil conditions on some fungal parasites on

- the roots of the coconut palm. *Indian Cocon. J.* 5: 71-79.
- MENON, K.P.V., SANKARASUBRAMONEY, H. and PANDALAI, K.M. 1950. Investigations on the diseases of the coconut palm in Travancore Cochin State : Studies on soil conditions in relation to disease incidence. *Indian Cocon. J.* 3: 81-87, 99-103.
- NAIR, U.K. and RADHA, K. 1959. Manuring cum spraying for the control of coconut palm diseases. *Proc. First Conf. Cocon. Res. Workers*, Trivandrum, India.
- PANDALAI, K.M. 1959. Some aspects of nutritional disturbances in relation to certain disorders in the coconut palm. *Proc. First Conf. Cocon. Res. Workers*, Trivandrum, India.
- PANDALAI, K.M., SANKARASUBRAMONEY, H. and MENON, K.P.V. 1958a. Studies on soil conditions in relation to the root and leaf diseases of the coconut palm in Travancore Cochin. Part IV. Total and exchangeable calcium and magnesium contents of coconut soils. *Indian Cocon. J.* 11: 49-66.
- PANDALAI, K.M., SANKARASUBRAMONEY, H. and MENON, K.P.V. 1958b. Studies on soil conditions in relation to the root and leaf diseases of the coconut palm in Travancore Cochin. Part V. Exchangeable cations, cation exchange capacity and pH of coconut soils. *Indian Cocon. J.* 11: 87-101.
- PANDALAI, K.M., SANKARASUBRAMONEY, H. and MENON, K.P.V. 1959a. Studies on soil conditions in relation to the root and leaf diseases of the coconut palm in Travancore Cochin. Part VI. The combined water hygroscopic water loss on ignition and water table aspects of coconut palms. *Indian Cocon. J.* 12: 87-100.
- PANDALAI, K.M., SANKARASUBRAMONEY, H. and MENON, K.P.V. 1959b. Studies on soil conditions in relation to the root and leaf diseases of the coconut palm in Travancore Cochin. Part VII. The mechanical composition of coconut soils of healthy and diseased areas. *Indian Cocon. J.* 12: 101-113.
- PILLAI, N.G. 1959. Physiological aspects of nutrition in the coconut palm. M.Sc. Thesis (unpublished), University of Kerala, Trivandrum.
- PILLAI, N.G., LAL, S.B. and SHANTA, P. 1973. Distribution and intensity of root (wilt) disease of coconut in Kerala. *J. Plant. Crops* 1(Suppl.): 107-112.
- PILLAI, N.G. AND PUSHPADAS, M.V. 1965. Kari soils are out of bounds for root (wilt). *Cocon. Bull.* 19: 33-39.
- PILLAI, N.G., WAHID, P.A., KAMALADEVI, C.B., RAMANANDAN, P.L., CECIL, S.R., AMMA, P.G.K., MATHEW, A.S. and NAMBIAR, C.K.B. 1975. Mineral nutrition of root (wilt) affected coconut palm. Proc. Fourth Sessn. *FAO Technical Wkg. Pty. Cocon. Prod. Prto. & Processg. Kingston*, Jamaica.
- SAHASRANAMAN, K.N., RADHA, K. and PANDALAI, K.M. 1964. Effect of manuring and intercultivation on the yield of coconut in relation to leaf rot and root (wilt) diseases. *Indian Cocon. J.* 18: 3-11.
- SANKARASUBRAMONEY, H., PANDALAI, K.M. and MENON, K.P.V. 1952. On the nutritive content of soil and plant tissues in relation to the root and leaf diseases of the coconut palm. *Indian Cocon. J.* 6: 7-18.
- SANKARASUBRAMONEY, H., PANDALAI, K.M. and MENON, K.P.V. 1954. Studies on soil conditions in relation to the leaf and root diseases of coconut in Travancore Cochin. Part I. Nitrogen, organic matter content and C/N ratio of coconut soils. *Indian Cocon. J.* 8: 5-25.
- SANKARASUBRAMONEY, H., PANDALAI, K.M. and MENON, K.P.V. 1955. Studies on soil conditions in relation to the leaf and root

- diseases of coconuts in Travancore Cochin Part. II. Total phosphoric acid, available phosphoric acid and iron content of coconut soils. *Indian Cocon. J.* **9**: 20-29.
- SANKARASUBRAMONEY, H., PANDALAI, K.M. and MENON, K.P.V. 1956. Studies on soil conditions in relation to the leaf and root diseases of coconuts in Travancore Cochin. Part III. Total, available and exchangeable potassium contents of coconut soils. *Indian Cocon. J.* **9**: 90-100.
- VARKEY, T., AMMA, P.G.K., RAMANANDAN, P.L. and NAMBIAR, P.T.N. 1979. Foliar yellowing in coconut palms in healthy and root (wilt) affected areas. *J. Plant. Crops* **7**: 117-120.
- VERGHESE, E.J. 1959. Chemical studies in leaf and root (wilt) diseases of coconuts in Travancore Cochin. I. Some interesting observations on the incidence of disease. *Proc. First Conf. Cocon. Res. Workers.* Trivandrum, India.
- VERGHESE, E.J. 1961. Statement of work done on the chemical aspects of the root (wilt) disease of coconut in Travancore-Cochin. *Proc. First Sessn. FAO Tech. Wkg. Pty. Cocon. Prod. Prot. & Processg.* Trivandrum, India.
- VERGHESE, E.J. 1966. Fertility status of coconut soils with special reference to the leaf and root (wilt) diseases of the coconut palms in Kerala. *Agric. Res. J. Kerala* **4** (2): 49-60.
- VERGHESE, E.J., SANKARANARAYANAN, M.P. and MENON, K.P.V. 1957. A note on the strontium content of coconut leaves and soils in relation to leaf and root (wilt) diseases of coconut in Travancore-Cochin. *Indian Cocon. J.* **10** (2): 25-31.
- VERGHESE, E.J., SANKARANARAYANAN, M.P. and MENON, K.P.V. 1959 a. Chemical studies on the leaf and root (wilt) diseases of coconut in Travancore-Cochin. II. Nutrient content of leaves of healthy and diseased palms. *Proc. First Conf. Cocon. Res. Workers.* Trivandrum, India.
- VERGHESE, E.J., SANKARANARAYANAN, M.P. and MENON, K.P.V. 1959b. Chemical studies on the leaf and root (wilt) diseases of coconuts in Trivandrum-Cochin. III. Cadmium content of coconut soils and leaves. *Proc. First Conf. Cocon. Res. Workers.* Trivandrum, India.
- WAHID, P.A., KAMALAM, N.V., VENUGOPAL, V.K., KATARIA, S.K., GOVIL, R., KAPOOR, S.S. and LAL, M. 1983. X-ray fluorescence spectra of root (wilt) affected coconut palm. *J. Plant. Crops.* **11**: 91-100.

S. Robert Cecil
Scientist (SQ)
CPCRI
Kasaragod 671 124
Kerala

Mrs. P.G. Kamalakshy Amma
Scientist
CPCRI Regional Station
Kayangulam
Krishnapuram 690 533
Kerala