28. Chemical studies on the leaf and root (wilt) diseases of coconuts in Travancore-Cochin

II. Nutrient content of leaves of healthy and diseased trees

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INTRODUCTION

RESULTS of detailed investigations on soil conditions in relation to the Leaf and Root (Wilt) diseases of coconuts in Travancore-Cochin have been reported in previous communications from the Soil Chemistry Division, Central Coconut Research Station, Kayangulam - vide Menon *et al.* (1950), Sankarasubramoney *et al.* (1954, 1955, 1956) and Pandalai *et al.* (1958). Continuing these investigations, it was felt worthwhile to study the nutrient content of coconut leaves in healthy and diseased conditions. The results of these studies are presented in this paper.

MATERIALS AND METHODS

During a survey of the coconut tracts of Travancore - Cochin reported by Verghese *et al.* (1957) and Verghese (1959) healthy and diseased coconut areas were located. Leaf samples from healthy and diseased trees were collected according to the procedure previously standardised in the Soil Chemistry Laboratory, Central Coconut Research Station, Kayangulam, i.e. in a tree with n number of leaves, the $(\frac{1}{2}n + 1)$th leaf was selected for sampling and leaflets from the fortieth to fiftieth of this leaf, being most representative in respect of nutrient content, were collected. The sample thus collected was dried, powdered to pass through an 80-mesh sieve and analysed for nitrogen, phosphoric acid, potash, lime, magnesia and silica according to the methods of Piper (1944).

RESULTS

Coconuts are grown in Travancore-Cochin in several more or less well defined tracts, the more important of which are the coastal sandy

TABLE 1.

Showing analytical values for leaf samples from healthy and diseased coconut palms in four typical classes of soils

Healthy							Diseased						
Lab. No. 1956	N %	P_2O_5 %	K_2O %	CaO %	MgO %	Silica %	Lab. No. 1956	N %	P_2O_5 %	K_2O %	CaO %	MgO %	Silica %
SANDY SOIL													
4	1.38	0.38	0.68	0.46	0.44	0.30	47	2.74	0.58	0.62	0.61	0.20	5.61
19	1.61	0.30	0.86	0.32	0.30	0.17	56	2.49	0.49	1.42	0.62	0.22	5.27
51	2.23	0.62	1.26	0.47	0.13	2.40	90	1.81	0.33	2.20	0.32	0.12	3.57
60	1.51	0.28	2.00	0.34	0.11	3.05	157	1.94	0.38	1.21	0.41	0.42	3.95
163	2.20	0.42	1.32	0.41	0.46	3.11	160	2.19	0.50	1.60	0.36	0.42	5.79
170	1.76	0.37	2.35	0.69	0.49	2.62	166	1.72	0.46	2.09	0.65	0.33	6.06
191	1.90	0.41	2.01	0.62	0.28	5.55	173	1.77	0.40	1.68	0.38	0.32	5.37
198	2.10	0.43	1.68	0.56	0.42	3.90	177	2.53	0.61	1.40	0.51	0.14	7.11
213	2.10	0.37	1.73	0.43	0.52	3.32	180	2.55	0.61	1.15	0.78	0.37	5.46
217	2.07	0.39	1.55	0.44	0.28	2.24	183	2.04	0.49	1.92	0.51	0.46	2.51
							187	2.17	0.51	2.73	0.70	0.27	5.94
							195	1.78	0.41	1.93	0.50	0.28	5.55
							209	2.08	0.49	1.68	0.47	0.19	5.12
							220	1.86	0.45	1.36	0.47	0.14	5.81
							223	2.32	0.45	2.32	0.40	0.17	4.48
							234	2.22	0.45	1.32	0.40	0.18	8.58
							236	2.14	0.40	1.88	0.38	0.40	2.56
Av:	1.88	0.39	1.53	0.44	0.34	2.67		2.12	0.47	1.67	0.49	0.26	5.22
LOAMY SOIL													
8	1.31	0.46	0.93	0.47	0.10	0.37	75	2.10	0.56	1.61	0.43	0.44	5.07
15	1.55	0.44	1.44	0.53	0.29	0.23	82	1.93	0.34	0.88	0.37	0.18	3.97
78	2.25	0.40	0.85	0.41	0.35	4.10	94	1.94	0.38	1.21	0.41	0.42	3.95
86	1.90	0.33	0.68	0.42	0.20	3.07	128	1.57	0.38	1.36	0.30	0.21	6.60
							148	2.31	0.41	2.18	0.57	0.13	3.04
Av:	1.75	0.41	0.98	0.46	0.24	1.94		1.97	0.41	1.45	0.42	0.28	4.53
CLAYEY SOIL													
23	1.27	0.34	1.66	0.34	0.33	0.16	27	1.51	0.41	—	0.29	0.28	0.36
30	1.67	0.31	1.53	0.29	0.30	—	34	2.25	0.40	1.23	0.95	0.68	—
38	1.86	0.24	0.75	0.48	0.32	—	63	1.67	0.29	0.22	0.52	0.20	6.07
43	1.81	0.32	1.51	0.36	0.38	—	69	1.86	0.36	1.92	0.31	0.29	5.18
66	2.04	0.36	1.96	0.24	0.30	2.49	72B	2.19	0.46	2.28	0.48	0.62	1.49
72A	1.70	0.33	1.33	0.18	0.33	4.00	99	1.89	0.35	1.54	0.60	0.30	3.64
104	1.84	0.32	1.27	0.44	0.17	3.64	100	1.61	0.26	1.58	0.69	0.47	4.22
111	2.06	0.14	2.74	0.44	0.22	3.20	108	2.42	0.09	1.51	0.33	0.52	3.57
205	2.11	0.44	1.34	0.31	0.52	4.00	201	2.41	0.47	2.01	0.45	0.72	5.71
232	1.75	0.31	0.97	0.40	0.26	4.11	202	2.18	0.42	1.53	0.54	0.91	5.54
							228	1.96	0.36	2.21	0.28	0.22	2.11
Av:	1.81	0.31	1.51	0.35	0.31	3.09		2.00	0.35	1.61	0.49	0.47	3.73
LATERITE SOIL													
116	1.85	0.49	1.16	0.56	0.36	5.01	113	1.68	0.43	0.86	0.63	0.27	4.91
124	1.81	0.36	1.02	0.44	0.31	3.18	120	1.99	0.52	2.27	0.60	0.40	6.62
130	1.90	0.34	1.38	0.73	0.34	3.42	132	1.58	0.33	0.92	0.76	0.21	3.28
144	2.10	0.34	1.10	0.63	0.25	2.93	136	2.56	0.37	1.67	0.51	0.58	5.40
151	1.97	0.40	1.19	0.61	0.69	2.65	140	2.05	0.31	2.15	0.54	0.26	5.05
							154	2.19	0.42	1.90	0.61	0.32	7.49
Av:	1.92	0.39	1.17	0.59	0.39	3.44		2.01	0.40	1.63	0.59	0.34	5.46

tract, the clayey reclaimed areas of the backwaters, the midland or upland regions lying between the backwaters and the hill slopes with sandy loam soil, laterite and loamy regions of the hill slopes and banks of rivers with deltaic alluvial soil. A rapid reconnaissance survey of these areas showed that the soil of these regions can be grouped under four typical classes, viz. sandy, loamy, clayey and laterite soils. The analytical values of the leaf samples collected from healthy and diseased trees grouped under these four classes of soils are presented in Table 1.

It will be seen from Table 1 that generally there is more of nutrients in the leaf when the trees are diseased. The accumulation of nutrients in diseased coconut leaves has also been reported by Sankarasubramoney *et al.* (1952).

The average values for the different soil classes are brought out and presented in Table 2.

TABLE 2.

Showing the average values for the nutrient content of leaves of healthy and diseased trees growing in four typical classes of soils

	Sandy soil		Loamy soil		Clayey soil		Laterite soil	
	H	D	H	D	H	D	H	D
N %	1.88	2.12 (+12.76)	1.75	1.97 (+12.57)	1.81	2.00 (+10.52)	1.92	2.01 (+4.69)
P_2O_5 %	0.39	0.47 (+2.05)	0.41	0.41 —	0.31	0.35 (+12.90)	0.39	0.40 (+2.56)
K_2O %	1.53	1.67 (+9.15)	0.98	1.45 (+4.80)	1.51	1.61 (+6.62)	1.17	1.63 (+39.31)
CaO %	0.44	0.49 (+11.36)	0.46	0.42 (—8.70)	0.35	0.49 (+45.17)	0.59	0.59 —
MgO %	0.34	0.26 (—25.53)	0.24	0.28 (+16.66)	0.31	0.47 (+45.61)	0.39	0.34 (—12.82)
Silica %	2.67	5.22 (+95.50)	1.94	4.53 (+133.60)	3.09	3.78 (+22.32)	3.44	5.46 (+58.72)

Note 1. H = Healthy.
D = Diseased.

2. The figures in brackets represent the percentage increase (+) or decrease (—) of the nutrient element in the diseased leaf over its content in the healthy leaf.

N. P. K.

It will be seen from the above Table that there is more of nitrogen, phosphoric acid and potash in diseased leaves of all soil classes. Thus the nitrogen content of diseased leaves is 5 to 13 per cent more than that of healthy ones. Potash content is similarly greater to the extent of 5 to 39 per cent. Phosphoric acid is not much affected, there being no change in the case of loamy soil, two to three per cent in sandy and laterite soils and 13 per cent in clayey soil. When all the soil classes are taken together, the over-all increase with regard to the three major nutrients, the big trio, viz. nitrogen, phosphoric acid and potash are 10.19, 4.38 and 14.97 per cent respectively.

Calcium and Magnesium

The results for calcium and magnesium are not consistent. Thus the calcium status is the same in laterite soil, 11.36 and 45.17 per cent higher in sandy and clayey soils respectively, whereas in the case of loamy soils there is actually a decrease of 8.70 per cent. Similarly loamy and clayey soils have higher values for magnesium to the extent of 16.66 and 45.71 per cent respectively, while in sandy and laterite soils there is a decrease of 25.53 and 12.82 per cent respectively.

Silica

The silica content of the diseased leaves is higher in all classes of soils, the values for sandy, loamy, clayey and laterite soils being 95.50, 133.60, 22.32 and 58.72 per cent respectively with an over-all increase of 77.54 per cent when all the classes of soils are taken together. It will be seen from Table 1 that higher values for silica are obtained for almost all the samples examined.

DISCUSSION

The higher nitrogen content of the diseased leaves is note-worthy. The injurious effects of too much nitrogen have been stressed by many workers. Among these effects may be mentioned (1) delayed maturity by stimulation of vegetative growth with very dark green leaves which are often crinkled, soft and sappy, (2) dropping of flower buds, (3) succulent growth with poor mechanical resistance, (4) dwarfing or retardation of growth, (5) clorosis of foliage followed by burning or necrosis, (6) weakening of straw by increasing the length of internodes, (7) browning or corrosion of roots, (8) gummosis and "die back" in citrus or stone fruit, (9) lowering of quality in fruits or cereals and (10) increase in susceptibility to infection probably due to a change in the physiological condition within the plant and thinning of the cell walls which may subject the plant to greater risk of fungal and bacterial diseases and insect infestation. Excess of phosphate over the amount required by the crop sometimes depresses crop yield particularly on light soils in dry years and has been attributed to hastening of the maturation process and consequent reduction of vegetative growth. Excess of potassium will reduce considerably the amount of other cations the crop can take particularly magnesium and calcium. The calcium/potassium antagonism postulated by Ehrenberg (1919) is noteworthy in this connection.

The limiting values for nutrient content of plant material below which the development of deficiency symptoms may be expected or above which toxicity symptoms may appear have been worked out for a very large number of crops, *vide*. Goodall and Gregory (1947), Ulrich (1948), Wallace (1951) and others. Critical levels for the coconut palm are not so far known. Without examining a fairly large number of healthy palms, it is not possible to arrive at these standards. However, in view of the higher content of nitrogen in diseased palms found in these studies it is ventured to suggest that excess of nitrogen may be a factor for disease incidence. It is just possible that the nitrogen content of apparently healthy trees may also be on the excess side and that these trees may in course of time get diseased.

Nutrient uptake

Apart from the availability of nutrients in the soil solution, nutrient uptake by plants depends not on a single mechanism but on an interaction of several processes combined with metabolic utilization of the nutrients. Among these factors may be mentioned diffusion, ionic exchange, adsorption, respiration, enzyme activity, presence of complexing agents, activators, stimulants, inhibitors and toxic substances, aerobic or anaerobic conditions, osmotic pressure, chelation, hydrogen ion concentration, competition and antagonism between nutrients, donnan equilibrium effects, temperature and light, water supply, oxidation-reduction potentials etc. The absorption and utilization of nutrient salts by the plant is the net result of these mechanisms. Such being the case, the determination of the fertility status of the external medium-soil-and the nutritional requirements of crops worked out on the basis of analytical values of the soil may not alone be quite appropriate and may with advantage be combined with analysis of plant tissues. Greater importance has of late been given to the fact that the composition of the leaves of a plant reflects to some extent the nutrient conditions in the soil and that the analysis of the leaf may often disclose a deficiency or excessive consumption of a nutrient element or lack of balance between the nutrients.

Nutrient balance

A proper nutrient balance is highly necessary for healthy plant growth. This has been greatly stressed by the foliar diagnosis school of workers and they have used the ratios between the different nutrient elements in plant tissue for the interpretation of results of plant analysis.

The ratios obtained for healthy and diseased coconut leaves in the present study are shown in Table 3.

TABLE 3

Showing ratios of nutrient content of healthy and diseased leaves

	Sandy soil		Loamy soil		Clayey soil		Laterite soil	
	H	D	H	D	H	D	H	D
N/K_2O	1.23	1.27	1.79	1.36	1.20	1.24	1.64	1.23
N/P_2O_5	4.82	4.51	4.27	4.81	5.84	5.71	4.92	5.02
K_2O/P_2O_5	3.92	3.55	2.37	3.54	4.88	4.60	3.01	4.08
$N/(N+P_2O_5+K_2O)$	0.49	0.50	0.56	0.51	0.50	0.51	0.55	0.51
$P_2O_5/(N+P_2O_5+K_2O)$	0.10	0.11	0.13	0.11	0.09	0.09	0.11	0.10
$K_2O/(N+P_2O_5+K_2O)$	0.40	0.39	0.31	0.38	0.42	0.41	0.34	0.40
$N:P_2O_5:K_2O$	5:1:4	5:1:4	4:1:2	5:1:4	6:1:5	6:1:5	5:1:3	5:1:4
N/SiO_2	7.04	4.06	9.02	4.35	5.86	5.29	5.58	3.68
K_2O/CaO	3.48	3.41	2.13	3.45	4.31	3.29	1.98	2.76
$K_2O/CaO+MgO)$	1.96	2.23	1.40	2.07	2.29	1.68	1.19	1.75

Given the necessary environmental conditicns for the proper functioning of the several mechanisms involved in plant metabolism, the uptake and utilization of the nutrients and consequently their content in the tissue depend on the plant food available in the soil. It may be noted in this connection that on the basis of past experience in coconut manuring the Kerala and Madras States where more than two thirds of the entire acreage and production of coconuts in India have been concentrated, fixed the N: P: K ratio in standard manure mixtures for the coconut palm at 1 : 1 : 2 and 2 : 1 : 4 respectively. The Indian Central Coconut Committee has recommended the ratio 1.0 to 1.5:1:1.5 to 3.0. The manures recommended in Ceylon (*Coconut Research Institute, Ceylon, Leaflet No. 9*) are shown in Table 4.

TABLE 4

Manurial chart for bearing palms on different types of soil (lb. of fertilizer per palm, once every two years)

Nutrient	White cinnamon sand and coarse marine sand		Loams and sandy loams		Clay soils		Laterite (Cabouks)		Laterite gravel Hal-borella	
	A	B	A	B	A	B	A	B	A	B
Nitrogen	0.7	0.6	0.6	0.5	0.6	0.5	0.7	0.6	0.6	0.5
Phosphoric acid	0.9	0.75	0.75	0.6	0.75	0.6	0.9	0.75	0.9	0.75
Potash	1.5	1.25	1.25	1.0	1.0	0.75	1.5	1.25	1.5	1.25

A = Estates which have not been manured for a long period.

B = Estates which have been regularly manured.

The N:P:K ratio for the different soils works out to 1:1.2 to 1.5: 1.5 to 2.5. The need for a proper nutrient balance has thus been recognised both in India and Ceylon where systematic investigations on coconut manuring has been in progress for a long time.

On the basis of the ratio of nutrients recommended above for the manuring of the coconut palm, the palms under the present study are in a state of unbalanced nutrition. The content of nitrogen is much greater than that of potash or conversely the supply of potash is not adequate to keep up with the high level of nitrogen. Similar observations have been made by other workers. Thus Bain (1937) working on the 'Bronze leaf wilt' of coconut palms in Trinidad had reported that the phosphate and potash status of diseased palms were lower in relation to the nitrogen status. Menon and Nair (1949) found a state of unbalanced nutrition in trees affected by the Leaf and Root (Wilt) diseases and they were of the view that such a condition *inter-alia* favoured disease incidence. Improper nutrient balance, continued for a very long time, may be the cause or a predisposing factor in disease incidence. The fact that more or less the same state of affairs is found in healthy trees also would mean that these trees are only apparently healthy and may show disease symptoms sooner or later. The time factor for disease incidence has been noted by many workers.

N / Silica

A comparatively higher content of silica (Tables 1 and 2) and the lower N:SiO_2 ratio (Table 3) found uniformly in diseased leaves of palms in all classes of soils are quite significant. Munter (1919) used the ratio of nitrogen to silicon in wheat straw for assessing its nitrogen status. Silica is known to have several beneficial effects on plant growth. With regard to diseases, silica plays an important role in protecting plants from attacks of fungi, rusts, mildew, plant lice and various parasitic organisms. Just as in the case of other nutrients, the limiting values of silicon content of coconut leaves above which toxicity symptoms may develop is not known. Due to high soil temperatures and acid soil conditions silicic acid may be dissolved and taken into the palm in large quantities particularly when other plant foods are not available in the soil. Nutritional unbalance may thus be brought about and continuance of this for a long period may result in disease infection. It may also be noted that silicated cell walls of the leaf will not offer any protection against fungal parasites that enter through the stomata. In this connection it is suggested that excessive silicon nutrition may be one of the factors responsible for the sporadic outbreak of the Leaf and Root (Wilt) diseases in a virulent form in certain situations with granite rock underlying within very short distance from the surface, sometimes even less than one foot. The problem requires further study.

Accumulation of nutrients

The presence of comparatively higher quantities of the main nutrient factors in the tissue of diseased coconut leaves may be due to a derangement of the physiological processes of the diseased palm resulting in the improper metabolic utilization of the nutrient ions. Heald (1937) has observed that the accumulation of substances in the plant in proportion to their utilization may lead to pronounced morphological changes. It is also possible that the mechanisms involved in the translocation of the plant foods from the leaves to other parts of the palm may not be functioning properly. The operation of "Carrier" mechal nisms in plants has been postulated by many workers. The Osterhou-hypothesis (Osterhout, 1947), the Lundegardh hypothesis (Lundegardh, 1939, 1954), the 'redox pump' theory postulated by Conway (1953) and the Goldacre hypothesis (Goldacre, 1952)-based on differences in chemico-physical characteristics and the formation and breakdown of complexes between the nutrient ions and some organic carrier molecules on opposite sides of cell membranes-linking of salt uptake with protein synthesis (Steward and Millar, 1954), lecithin carrier mechanism postulated by Bennet-Clark (1956), the membrane vesiculation theory of Bennet (1956), phosphorylation mechanisms, etc. may be mentioned in this context. A breakdown or decrease in the activity of the transport system producing thereby differential absorption, improper metabolic utilization and unbalance of nutrients may be a cause or predisposing factor of the Leaf and Root (Wilt) diseases of coconuts in Travancore-Cochin. Intensive research in this direction appears to be necessary.

ACKNOWLEDGEMENTS

The help rendered by Shri. M. K. Chandrasekharan Nair, Shri. A. S. Mathew and Shri. S. Robert Cecil, Research Assistants, Central Coconut Research Station, Kayangulam, in the analysis of the leaf samples is gratefully acknowledged.

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