Fertility status of Coconut Soils with special reference to the "Leaf" and "Root (Wilt)" diseases of the Coconut palm in Kerala

E. J. VERGHESE*

Division of Chemistry, Agricultural College & Research Institute, Vellayani

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The "Leaf" and "Root (Wilt)" deseases of the coconut palm in the Travancore and Cochin areas of Kerala State were noticed more than 85 years ago in three *foci* of infection about 30 miles away from each other in Central Travancore. The diseases are said to have become significantly manifest after the great floods of 1882 when the land was water-logged for a considerable period. By 1960 (Gregory, 1960; Menon, 1961) about 70 lakhs, nearly one third of the best coconut growing tracts of Travancore and Cochin were affected by the diseases, leadings, to an annual loss of over two crores of rupees to the coconut industry of the Kerala State where more than two third of the entire acreage and production of coconuts of the Indian Union are concentrated.

Symtamatology

The symptamatology of the "Leaf" disease has been described by Radha (1961). The characteristic symptom is rotting of the distal ends of leaflets of the central spindle. The leaf as it unfolds has a fan like appearance owing to the drying and shrivelling of the leaflets which fall off in the wind. In severe cases, the leaf fails to unfold, due to cementing of the rotted leaflets. The characteristic symptoms of the "Root (wilt)" disease, as described by Menon (1961) are:-1) general slow wilting of the leaves, 2) flaccidity of the leaflets accompanied by abnormal bending, 3) marginal tip necrosis of leaflets and 4) abnormal button shedding.

Though the two diseases are considered different, they are often found affecting the same tree. A tree affected by the diseases is illustrated in Plate I.

Review of Literature

Verghese (1961 a, 1961 b) and Menon (1961) have presented the salient features of the investigations on the physiological, chemical and pathological aspects of the diseases carried out till 1961. Earlier, Menon *et al* (1950), Sankarasubramoney *et al* (1954, 1955, 1956) and Pandalai *et al* (1958 a, 1958 b, 1959 a, 1959 b) had found certain differences in soil conditions between healthy and diseased coconut areas.

The results of a continuation of these studies with special reference to the fertility status of healthy and diseased coconut

* Professor, University Grants Commission scheme.

regions having sandy, loamy, clayey and laterite soils are presented in this paper.

Materials and Methods

A rapid reconnaissance soil survey of Travancore and Cochin disclosed the fact that coconut palms are grown in four main soil types viz., sandy, loamy, clayey and laterite soils. Coconut palms grow in healthy and diseased condition in all these soils. Soil samples were therefore collected from healthy and diseased regions for comparative study. A total number of 185 soil samples was collected from representative sites and analysed for moisture, loss on ignition, total nitrogen, total and available phosphoric acid and potash, total calcium and total magnesium, by standard methods. The data were statistically evaluated. The interrelationships of the nutrients were also worked out and analysed statistically.

Resnlts and Discussion

The results of analysis and statistical evaluation of data of the 185 soil samples studied are summarised and presented in Tables I to IV. The results are discussed below.

Moisture and Loss on ignition

Moisture is a great limiting factor in crop growth. Differences in moisture content of soils materially affect fertilizer requirements and utilisation. In fact, water is the best manure. But too much water is harmful in many ways, especially in having a favourable effect on plant root pathogens.

It may be noted in this context that the coconut diseases under study first appeared after the great floods of 1882 and ever since, water-logging has been considered as a probable predisposing factor for the incidence of diseases. The diseases are more acute in areas with poor soil aeration or areas subject to frequent flooding. Similar observations have been reported for many agricultural crops. With regard to the coconut, high moisture content has been found to favour the incidence of diseases in other coconut growing countries also (Britton Jones, 1928, 1929, 1940; Bain 1934, 1937; Dwyer, 1940; Martin 1955).

The results of the present study when exmined in the light of the above observations, are indicative of the role of excess soil moisture in disease incidence. The diseased tracts of all the four soil types studied contain appreciably greater amounts of moisture compared to the healthy areas. Though the results are not statistically significant, the diseased tracts contain on an average 20.0 percent more of moisture and may be taken as a positive trend.

Loss on ignition is an estimate of soil organic matter and the combined water which is known to be a measure of the colloid content of the soil. As in the case of hygroscopic moisture, values for these properties are also higher in the diseased condition. The results are significant for loamy and clayey soils.

The above findings are definite indications of moisture favouring the onset of diseases. But further detailed studies are necessary to determine how the moisture retaining capacity of these soils orientate soil conditions favourable for the action of pathogenic organisms or other factors responsible for the induction and/or spread of the diseases.

Nitrogen

From Tables I to IV it can be seen that compared to healthy areas the diseased tracts contain more nitrogen. The difference is not, however, very marked in the

TABLE I

Nutrient content and nutrient ratios of soil of healthy and diseased coconut areas
(Sandy soil)

No.	Head of analysis	Healthy			Diseased			Signi-ficant or not
		Mean	Variance	No. of obser-vations	Mean	Variance	No. of obser-vations	
1.	Moisture	0.6255	0.2511	37	0.8475	0.6358	58	N. S.
2.	Loss on ignition	1.2253	0.9200	37	1.2555	1.0696	58	N. S.
3.	Total Nitrogen	0.0313	0.0004	37	0.0315	0.0136	58	N. S.
4.	Acid soluble P_2O5	0.0331	0.0135	37	0.0422	0.0014	58	N. S.
5.	Acid soluble K_2O	0.0732	0.0062	37	0.1047	0.0054	58	N. S.
6.	Acid soluble CaO	0.0377	0.0014	37	0.0332	0.0014	58	N. S.
7.	Acid soluble MgO	0.0643	0.0044	37	0.0590	0.0026	58	N. S.
8.	Available P_2O5	0.0147	0.0002	37	0.0144	0.0003	58	N. S.
9.	Available K_2O	0.0036	0.00003	37	0 0074	0.00005	58	S.
10.	pH	5.79	0.48	37	5.44	0.10	58	N. S.
11.	$\frac{N}{K_2O}$	0.8000	0.6060	37	0.5590	0.2470	58	N. S.
12.	$\frac{K_2O}{CaO}$	3.0480	17.2770	37	3.9930	16.5500	58	N. S.
13.	$\frac{K_2O}{MgO}$	1.6270	2.4130	37	2.3870	12.7240	58	N. S.
14.	$\frac{K_2O}{CaO + MgO}$	0.9340	0.8640	37	1.2070	0.8920	58	N. S.
15.	$\frac{\text{Available } K_2O}{CaO+MgO}$	0.0780	0.0133	37	0.1270	0.0270	58	N. S.

Note:—(1) The nutrient values are expressed in Table I to IV as percentage, on oven dry basis.

(2) N. S. = Not significant, S. = Significant at 5% level.

case of sandy soil which has a low nitrogen content. It may be noted that the availbility of higher amounts of nitrogen in the soil will lead to its greater absorption and in the diseased condition a greater content of this nutrient may be present in the leaf as was actually found by Verghese *et al* (1959). Too much nitrogen, may increase the susceptibility of the plant to infection probably due to a change in the physiological condition within the plant and the thinning of the cell walls which would subject the plant to greater risk of fungal and bacterial diseases and insect infestation, Excess nitrogen has been known to favour disease incidence in many crop plants. The critical levels have not, however, been worked out particularly in the case of a perennial crop like the coconut. Though the differences in nitrogen content obtained in the present investigation are not significant statistically, they are appreciable and may be considered as a definite positive trend. It is possible that the combined effect of excess moisture and nitrogen may set in soil and physiological conditions conducive to the incidence of diseases.

Total and available Phosphoric add

The differences between healthy and diseased areas in respect of total and available phosphoric acid are not common to all the four soil types, as obtained in the case of moisture, loss on ignition and nitrogen. Thus the contents of phosphoric acid, total and available, are more in diseased loamy soil. The reverse is the case in laterite, healthy containing more of both. In the sandy soil total phosphoric acid is more in the diseased but available more in the healthy. The result for clayey soil present an exactly opposite picture. The differences are significant only in the case of loamy soil. Such variations from soil to soil and their relationship to the diseases are difficult to explain. Phosphoric acid probably has no bearing on disease incidence. Tn this connection it is of interest to refer to the several manurial trials on the response of phosphoric acid carried out in the coconut growing countries. The effect has been rather erratic and varying from soil to soil.

Total and available Potash

The earlier work of Sankarasubramoney *et al* (1956) had shown that there is a greater percentage of total potash in the soil samples of the sandy and red loam types in the diseased group but a higher potash status in the healthy alluvial loam and laterite areas. Similar results were obtained in the present study for sandy and loamy soils. In the laterite area also there is more of potash in the diseased state, quite contrary to earlier finding. But the results are not significant. The only significant result obtained in the present investigation is for the clayey soil where total potash content is higher in healthy areas.

It has come out prominently in the present investigation that available potash is significantly higher in the healthy loamy and laterite areas. In the case of clayey soil also there is a definite positive, though not significant, trend in this direction. In sandy soil this nutrient is significantly more in the diseased tract. But Sankarasubramoney *et al* (1956) had reported high available potash content in healthy areas of all soil types. The sandy soil generally behaves peculiarly and differently in many ways. The reason is unknown. The clay fraction of the soils may offer an explanation and this aspect has to be further studied.

The adverse effects of potash deficiency are many and various. Particular mention

TABLE II

Nutrient content and nutrient ratios of soil of healthy and diseased coconut areas
(Loamy soil)

No.	Head of Analysis	Healthy			Disease			Significant or not
		Mean	Variance	No. of observations	Mean	Variance	No. of observations	
1.	Moisture	1.37	3.20	12	2.8050	1.9620	11	N. S.
2.	Loss on ignition	4.55	22.03	12	9.6020	25.9020	11	S,
3.	Total Nitrogen	0.0461	0.00056	12	0.0822	0.0088	11	N. S.
4.	Acid soluble P_2O5	0.0392	0.00186	12	0.1127	0.0048	11	S.
5.	Acid soluble K_2O	0.0762	0.00169	12	0.1190	0.0037	11	N. S.
6.	Acid soluble CaO	0.0287	0.00027	12	0.0344	0.0003	11	S.
7.	Acid soluble MgO	0.0387	0.0024	12	0.1094	0.0053	11	S.
8.	Available P_2O5	0.00104	0.0000025	12	0.00204	0.0000038	11	S.
9.	Available K_2O	0.0109	0.000256	12	0.00789	0.0000249	11	S.
10.	PH	5.79	0.22	12	5.52	0.15	11	S,
11.	$\frac{N}{K_2O}$	1.026	1.481	12	1.201	2.886	11	N. S.
12.	$\frac{K_2O}{CaO}$	2.857	2.027	12	3.966	4.882	11	N. S.
13.	$\frac{K_2O}{MgO}$	4.391	21.375	12	1.387	0.382	11	S,
14.	$\frac{K_2O}{CaO+MgO}$	1.508	0.665	12	0.955	0.157	11	N. S.
15.	$\frac{\text{Available } K_2O}{CaO+MgO}$	0.101	0.019	12	0.073	0.004	11	S.

may be made of the effects on parasitism which is specially pronounced in perennial plants, the plant's water relationships and the weakening of the roots. These with other well known effects eventually lead to wilting and disease infection. The data obtained in the present study show that the non-availability of potash is a major factor for the incidence of the "Leaf" and "Root (wilt)" diseases. Similar results have been reported by Bain (1937, 1940) working on the "Bronze Leaf wilt" and similar diseases of coconut palms in Trinidad and Jamaica.

Lime and Magnesia

Pandalai *et al* (1958 a) had found that generally there is a greater amount of lime in healthy coconut areas. Total magnesium was higher in the diseased areas of sandy and alluvial loam, the reverse being the case with red loam and laterite. Contrary results have been obtained in the present investigation. Both total calcium and magnesium are significantly more in the diseased areas having loamy and clayey types of soil. In the other cases the results are not significant.

It may be noted, however, that the contents of these nutrients in the soils of Kerala which is a region subject to heavy rainfall, are very low. The 185 samples examined have on an average total lime (CaO) content of 0.04 percent and total magnesium (MgO) content of 0.11 percent. More intensive work is necessary to decide whether variations in these low contents of lime and magnesium will have a bearing on the out break of such severe diseases as the "Leaf" and "Root (wilt)" and whether the use of soil amendmends—lime or dolomite lime-could reduce the severity of the diseases or prevent their occurrence.

pH.

As in most other cases, the pH variations are not also uniform for all the four types of soil. Diseased sandy and loamy types are more acidic. The differences, however, are 0.35 and 0.27 pH unit respectively. On the contrary, in the clayey and laterite soils the healthy regions show a higher degree of acidity, the variations being 0.03 and 0.17 pH unit. It is doubtful that such differences could set in conditions for the incidence of the diseases. Hence, the statement that diseased areas are more acidic and the explanations advanced on that basis by earlier workers cannot be taken for granted.

Nutrient Ratios

Of late, the importance of balanced nutrition has received much greater attention since the translocation and utilisation of nutrient elements are not merely mechanical processes, but the final result of many complex factors related to the plant, the growing medium and the environment. According to Schuffelin and Middleburg (1953) the thermodynamic considerations of the Donnan-equilibria hold good for the ionic exchange interrelationships in soils and crops. Thus increase in the absorption of one of the ions results in the reduction in absorption of some other ion. Advocates of the technique of foliar diagnosis judge the net result of the ion exchange system by considering the nutrient content and ratios in the plant tissue. The nutrient interrelationships with special reference to the coconut have been reviewed by Menon and Pandalai (1958). These considerations led Verghese *et al* (1959) to study the nutrient ratios of N, P_2O_5, K_2O, CaO and MgO in the leaves of healthy and diseased coconut palms. They have reported differences in these ratios and suggested nutrient imbalance as a probable

TABLE III

Nutrient content and nutrient ratios of soil of healths and diseased Coconut areas

(Clayey soil)

No.	Head of analysis	Healthy			Diseased			
		Mean	Variance	No. of observations	Mean	Variance	No. of observations	Significant or not
1.	Moisture	1.7360	1.5667	41	2.1560	1.750	14	N. S.
2.	Loss on ignition	4.2938	6.4871	41	7.2240	10.426	14	S.
3.	Total Nitrogen	0.0629	0.0023	41	0.0939	0.0061	14	N. S.
4.	Acid soluble P_2O_5	0.0608	0.0031	41	0.0597	0.0013	14	N. S.
5.	Acid soluble K_2O	0.1285	0.0107	41	0.0149	0.0306	14	S.
6.	Acid soluble CaO	0.0435	0.0023	41	0.0958	0.0161	14	S.
7.	Acid soluble MgO	0.0782	0.0098	41	0.1886	0.0781	14	S.
8.	Available P_2O_5	0.0052	0.0001	41	0.0089	0.0006	14	N. S.
9.	Available K_2O	0.0114	0.0015	41	0.0094	0.000054	14	N. S.
10.	pH	5.65	0.32	41	5.68	0.23	14	N. S.
11.	$\frac{N}{K_2O}$	0.849	1.491	41	0.993	0.532	14	N.S.
12.	$\frac{K_2O}{CaO}$	4.643	14.721	41	4.083	8.100	14	N. S.
13.	$\frac{K_2O}{MgO}$	2.574	4.591	41	1.112	0.566	14	S.
14.	$\frac{K_2O}{CaO+MgO}$	1.772	2.067	41	1.498	3.262	14	N. S.
15.	$\frac{\text{Available } K_2O}{CaO+MgO}$	0.171	0.029	4]	0.114	0.017	14	N. S.

TABLE IV

Nutrient content and nutrient ratios of soil of healthy and diseased Coconut areas
(Laterite soil)

No.	Head of analysis	Healthy			Diseased			
		Mean	Variance	No. of observations	Mean	Variance	No. of observations	Significant or no
1.	Moisture	2.720	0.432	5	3.312	0.270	7	N. S
2.	Loss on ignition	9.356	3.125	5	11.018	6.986	7	N. S
3.	Total Nitrogen	0.0709	0.0003	5	0.0968	0.0022	7	N. S.
4.	Acid soluble P_2O_5	0.1463	0.0035	5	0.0803	0.0076	7	N. S
5.	Acid soluble K_2O	0 2221	0.0011	5	0.3140	0.0096	7	N. S.
6.	Acid soluble CaO	0.0505	0.0012	5	0.0138	0.00034	7	N. S
7.	Acid soluble MgO	0.1050	0.0004	5	0.1608	0.0165	7	N. S.
8.	Available P_2O_5	0.0998	0.00009	5	0.00504	0.000096	7	S
9.	Available K_2O	0.0334	0.0007	5	0.00924	0.00003	7	S.
10.	pH	5.46	0.14	5	5.63	0.04	7	N. S.
11.	$\frac{N}{K_2O}$	0.326	0.008	5	0.351	0.059	7	N. S.
12.	$\frac{K_2O}{CaO}$	5.994	17.685	5	0.175	0.044	4	S.
13	$\frac{K_2O}{MgO}$	2.185	0.298	5	2.832	1.908	7	N. S.
14.	$\frac{K_2O}{CaO+MgO}$	1.517	0.158	5	2.663	2.133	7	N. S.
15.	$\frac{\text{Available } K_2O}{CaO+MgO}$	0.210	0.028	5	0.072	0.001	7	N. S.

factor for disease incidence. To see if such a situation existed in the soil also, the ratios between the nutrients studied in the present work were statistically analysed. These results are also included in Tables I to IV.

The ratios are rather narrow except probably for $\frac{K_2O}{CaO}$ and $\frac{K_2O}{MgO}$.

It is very interesting to note that thess are the ratios which have come out statie- tically significant in some cases. The $\frac{K_2O}{MgO}$ ratio in loamy and clayey soils and the $\frac{K_2O}{CaO}$ ratio in laterite soil are signifi- cantly higher in the healthy areas. The available $\frac{K_2O}{CaO+MgO}$ ratio in loamy son is also significantly higher in the healthy tract. N/K_2O ratio, though not significant, gives a higher trend of values in the loamy, clayey and laterite soils for the diseased tracts, sandy soil behaving differently as in other cases. Though the values for this ratio are themselves narrow, they are comparatively wider in the diseased condition of loamy, clayey and laterite soils. A wide N/K_2O ratio is known to increase leaf scorching. Prevot and Olagnier (1957) found a marked antagonism between potassium and magnesium in the coconut palm.

Whether the nutrient ratios obtained in the present study are themselves faulty and present a picture of unbalanced nutrient supply and availability, it is not possible to say unless critical levels are worked out. Sufficient data are not now available on this aspect. It is, however, suggested that impaired nutrient balance is a causative factor of the diseases. The experience of a large number of coconut growers of the Kerala State, who have found it possible to keep the diseases under control by balanced and adequate manuring is another pointer in this direction.

Summary and Conclusions

185 soil samples collected from representative sites of coconut gardens having sandy, loamy, clayey and laterite soils and where coconut palms are growing healthy or affected by the "Leaf" and "Root (wilt)" diseases, were analysed for major nutrients, with a view to studying if differences in nutrient status could explain the incidence of the diseases. The nutrient values and the values for the ratios of the different nutrients were statistically evaluated. The results are discussed in the light of earlier work and future lines of work suggested.

The following conclusions were drawn:–

1. Moisture, loss on ignition and nitrogen are generally more in diseased tracts.
2. The total and available phosphoric acid content do not show a uniform pattern of difference.
3. There is a greater percentage of total potash in the soil samples of the sandy, loamy and laterite types in the diseased group and a higher potash status in the healthy clayey soil.
4. Available potash is significantly higher in the healthy loamy and laterite areas.
5. Lime and magnesium contents are very low in all the samples examined.
6. Variations in pH values between healthy and diseased areas are of a low order. Soil acidity may not be a causative factor for the incidence of diseases.

7. Sandy soil behaves differently from loamy, clayey and laterite soils in many ways.

8. Faulty nutrient ratios, particularly $\frac{K_2O}{MgO}$, $\frac{K_2O}{CaO}$ and $\frac{N}{K_2O}$ ratios are possibly the causative factors.

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