

ROOT

# DISCRIMINANT CLASSIFICATION OF KERALA SOILS IN RELATION TO INCIDENCE OF COCONUT SPOT (WILT) DISEASE: 1. SOIL MICRONUTRIENT ASPECTS

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## ABSTRACT

The analysis of the nutrient data on the soil samples in Kerala collected from the different root (wilt) disease categories depending on the condition of the palm and the area sampled suggested the list of essential nutrients for the discrimination of the soils associated with the categories in different soil types as:

1. Laterite	-	Fe, B, Mn, Mo, Cu, S and Zn
2. Alluvial	-	Fe, Mo and Zn
3. Reclaimed marshy	-	Fe, Zn, Cu, Mo, Mn and B
4. Coastal Sand	-	Fe, Zn, Cu and Mo
5. Sandy loam	-	Mn, Cu and Zn

The classificatory analysis of the above data on the essential nutrients showed that soils of the above categories can be grouped into three clusters namely Healthy, leading to sick and sick in case of laterite, reclaimed marshy, sandy loam and two clusters as follows: healthy and sick in case of alluvial and coastal sandy soils.

## INTRODUCTION

Investigations on soil factors associated with root (wilt) disease of coconut, starting in 1938 have been reviewed by Marar and Pandalai (1938), Menon (1961), Verghese (1961) and Lal (1964, 1968). They opine that soil sickness characterised by low pH, poor drainage, low microbial activity together with mineral deficiencies, particularly of Ca and Mg plays a decisive role in the incidence of disease. A systematic soil nutrient survey in relation to root (wilt) disease, comprising the whole of Kerala was conducted only recently (Pillai *et al.*, 1975). The survey covered the major coconut growing soil groups, namely: laterite, alluvial, reclaimed marshy, coastal sandy and sandy loam. The soil samples collected from different soil groups were categorised into seven classes based on the condition of the coconut palm and the areas sampled. They are as follows: 1) Healthy in healthy zone (H); 2) apparently healthy in transition zone (AHT); 3) apparently healthy in diseased zone (AHD); 4) foliar yellowing in transition zone (FYT); 5) foliar yellowing in diseased zone (FYD); 6) foliar yellowing with rubbery kernel in transition zone (RKT); and 7) foliar yellowing with rubbery

kernel in diseased zone (RKD). The soil samples were analysed for micronutrients following the standard procedure (Pillai *et al.*, 1975) and the results interpreted using analysis of variance of individual characters.

## MATERIALS AND METHODS

The method of classificatory investigation assumes the multivariate normal distribution but these data were found to be in disagreement with normal distribution. Using  $\text{Sin}^{-1} \sqrt{P}$  where P is the proportion of the nutrient, transformation was found to be suitable as the normalising transformation for the data of almost all the nutrients (Narasimhayya *et al.*, 1978). Depending upon the suitability of the transformation, the data over all the classifications of the micronutrients which did not show satisfactory fit of normal distributions were omitted in the first screening. This is done with the exception of those nutrients having high association with root (wilt) based on earlier studies (Pillai *et al.*, 1975). The suitable micronutrients were considered separately in different soil types (Table 1).

The data were subjected to angular transformation to normalize them. The contribution of each nutrient to the distance between any pair of classification was evaluated as the square of the standardized mean difference. Then the nutrients were ranked accord-

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ingly. The ranks were added over all possible pairs of classifications to give a measure of the overall contributions of the different nutrients for the discrimination of classifications in each soil type with reference to root (wilt) disease (Table 1). The nutrients which did not contribute significantly to the  $D^2$ -values were eliminated in the second screening after the evaluation of corresponding values. Based on the remaining essential nutrients, the  $D^2$ -values between all possible classification pairs were evaluated and tested for their significance in each soil type (Table 3). These classifications were grouped into clusters accordingly (Rao, 1952) keeping the significance of the distance in view.

## RESULTS

In each soil types, and from among the nutrients deleted, only those nutrients with significant  $X^2$ -values were considered essential for the calculation of the  $D^2$ -values between pairs of classifications (Table 2). Based on the results of tests of significance of the distance between the different pairs of classifications, they were grouped into three clusters in each soil type excluding alluvial and coastal sandy soils where there were only two clusters. The three clusters are Healthy (H), leading to sick (LS) and sick (S) while Healthy (H) and Sick (S) soils represent the two other clusters above cited. The formation of clusters along with inter and intra cluster distance is illustrated diagrammatically in Figures 1-5. The term sickness is used to convey the meaning of some imbalance of soil nutrients in association with the disease expression of palms in these soil types. The cluster formations are found to have closer agreement with the degree of incidence of the root (wilt) disease.

### Laterite soils

Molybdenum, Cu, Zn, and Fe in order of preference were the important contributors for the discrimination. Iron and Mn contents were highest and lowest in soils of H and RKD respectively; reverse trends were found in case of Cu and Mo; in case of S and Zn no regular trends were observed and B was found to be more or less same in all classifications. Table 2 shows that the distances between H category and any other classifications were highly significant thus, indicating that the soils under H category are quite different from those of others. The distances of AHT from AHD, FYD and RKD were highly significant whereas the distance from FYT was significant at 5% level only. These suggest that broadly the soils belonging to classifications within transition zone are nearer to each other and far apart from those of diseased zone and both of them are distinctly different from those of healthy zone. Therefore, these classifications can be grouped into three distinct clusters namely: (1) H consisting of Healthy; (2) LS consisting of AHT and (3) S consisting of all the rest. The change in cluster trend of the soils may be slow and the path may be from H to LS and LS to S. The distance between H and LS is found

to be minimum followed by that of LS and S and S and H (Fig. 1). From Table 3, it can be seen that Fe and Mn are maximum in H followed by LS and S in order. This suggests that the lower levels of these nutrients may be associated with the sickness of the soil. Copper is found to be least in healthy soils followed by LS and S. Molybdenum is more or less same in H and LS and higher in S. These suggest that the sickness of the soil may be associated with the comparatively higher concentration of Cu and Mo.

### Alluvial Soils

Zinc, Fe, Mo, Cu were contributing for the discrimination between classifications in the given order of preferences. Among the soil nutrients selected through first screening Zn, Mo and Fe were found to be the significant and essential contributors to  $D^2$ -values. The soil nutrient value of Zn is higher in H than S whereas a reverse trend was found in the case of Mo. No regular trend was observed in the soil nutrient values of Fe. Table 2 shows that the distance between H and others are highly significant. The soils of AHT were found to be significantly different from FYD at 5% level whereas the other distances were found to be non-significant. These suggest that broadly the soils of H are quite different from the rest. The disease classifications can be grouped into two distinct clusters (Fig. 2). From Table 3 it can be seen that the lower levels of Zn as well as the higher concentration of Mo in the soils were associated with the relative sickness of the soils.

### Reclaimed Marshy Soils

Zinc, Mn, Fe and Cu were in the order of importance for the discrimination between soils of the disease categories. The soils of H were significantly different from any other classification. The distances from AHT and AHD to FYD and RKD were found to be highly significant whereas the others non-significant. Based on the above tests of significance, the classifications were grouped in 3 clusters viz. (1) H consisting of healthy; (2) LS consisting of AHT and AHD; and (3) S consisting of FYD and RKD. The soils of H are found to be nearer to those of S when compared to the distances of these to those belonging to LS which is far from normal expectation. Depending on the method of reclamation, there is possibility of wide variation among the reclaimed soils and it may be accidental that H came closer to S than LS. Table 3 indicates the decreasing trends in the nutrient values of Fe, Zn and Mn; and the increasing trends in Cu and Mo with the sickness of the soil. This indicates that the disease may be associated with lower content of Fe, Zn and Mn and higher content of Cu and Mo.

### Coastal Sandy Soils

The important nutrients contributing towards the discrimination between the disease categories in order of preference are Zn, Fe, Mo and Cu. Among the nut-

rients selected at the first stage screening Zn, Fe, Mo and Cu were found to be the essential ones (Table 1) to the evaluation of the  $D^2$ -values. The nutrient values of soils in H are more than the others. The distances between H and others are found to be highly significant whereas the same between AHD and RKD is found to be significant at 5%. The other distances are non-significant. This shows that the classifications can be grouped into only two clusters (1) H consisting of healthy; and (2) S consisting of all others keeping the distinct characteristics of H away from others (Fig. 4). The lower concentration of the nutrients cited above may be associated with the disease in soils under S cluster.

#### Sandy Loam Soils

Among the initially selected nutrients Mn, Zn and Cu were found to be significant contributors for the evaluation of  $D^2$ -values (Table 1). The values of Zn and Mn content decrease with the degree of severity of the disease. In case of Cu, the soils of AHT and AHD were found to have lower levels compared to that of healthy but it is found to be more in the soils, FYD and RKD, where the disease symptoms are fully expressed. This may be due to frequent application of copper fungicides where the disease is observed. All the inter-classificational distances were found to be significant except FYD and RKD. On the basis of the above tests of significance, the soils were grouped as follows: (1) H consisting of healthy; (2) LS consisting of AHT and AHD; and (3) S consisting of FYD and RKD. Here the decrease in the concentration of Zn and Mn and increase in Cu may be associated with the degree of incidence of the disease.

### DISCUSSION

The results of the study clearly bring out the fact that the healthy soils in all the groups are distinctly different from others. This agrees with the observation of Pillai *et al.* (1975) that the nutrient status of healthy tracts vary from that of transition and disease affected tracts. The apparently healthy (transition) either remains as a separate cluster or links with apparently healthy (diseased). Other categories remain as one separate cluster in all soil types except in coastal sandy and alluvial soils where there are two clusters, healthy and all others grouped together.

When the distances between the clusters are critically examined, it is found that in sandy loam soils, LS is nearer to S than H to LS and S. This indicates that LS categories are deteriorating faster, approaching S categories. In the laterite soils LS cluster is nearer to H than H to S and LS to S. This may indicate the slow spread and degeneration of palms in laterite areas. But the field observations indicate a faster spread of the disease in the same areas (Pillai *et al.*, 1975). This may again explain the complexity of the disease and the

association of some other external environmental factors and planting practices, along with the soil degeneration, complicates the picture even further. In the reclaimed marshy soils the distance between H and LS is found to be maximum followed by LS and S whereas the distance between healthy and sick is found to be minimum. The situation appears to be peculiar and the wide variation in reclamation practices may explain the position to some extent. In the coastal sandy soil LS and S form one cluster and the distance between the H and S clusters is maximum. This brings out the fact that in the highly leached sandy soil with very low retention capacity of nutrients, the degree of degeneration is very fast.

The important nutrients that warrant consideration based on differences in nutrient contents in different clusters are Zn, Fe, Cu, Mo, B, Mn and S. It is observed that some of the nutrients assume importance when viewed in the light of accepted threshold values. Among all the nutrients Zn is found to be of maximum importance since the values for Zn in all soil groups of the healthy tract are well above the threshold values (Brown *et al.*, 1962) and is in the marginal or deficiency level in other categories. Iron content of healthy soils is also at a higher level in all the soils, but is not of much importance, since even in the diseased tract, the values are well above sufficiency level (Olsen and Carlson, 1950), except in sandy soil where it is marginally deficient in the disease affected tracts. Molybdenum levels are low (Grig, 1953) in all soil groups in different clusters, the minimum being observed in coastal sandy soil. The comparatively low Mn status observed in sick clusters deserve consideration. Copper is found to be above sufficiency level (Mitchell, 1965) in all clusters and soil groups, but does not assume toxic levels. Sufficiency level is also observed for Boron (Eaton and Wilcox, 1938) and Sulphur (Beaton, *et al.*, 1968).

The most important nutrients which should receive consideration are thus Zn, Mn and Mo. The study also reveals that the laterite and coastal sandy soils are different from others and would behave differently with respect to incidence and spread of the disease.

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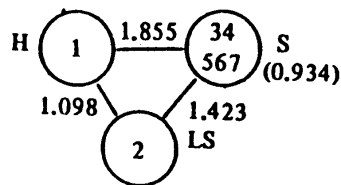


Fig. 1 Laterite soil

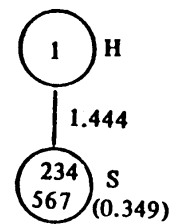


Fig. 2. Alluvial soil

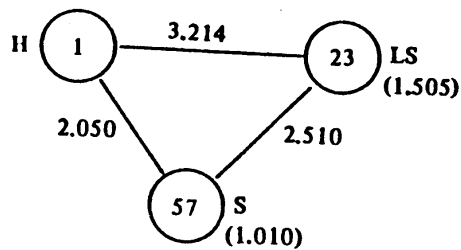


Fig. 3. Reclaimed soil

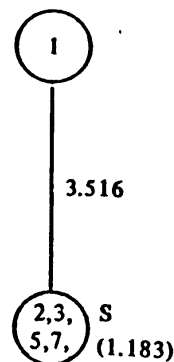


Fig. 4. Coastal sand

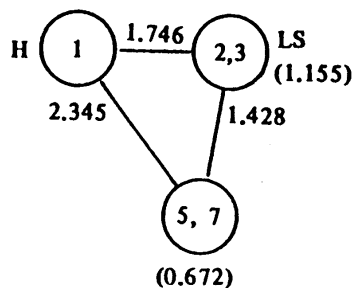


Fig. 5. Sandy loam

H . . Healthy  
S .. Sick  
LS.. Leading to sick

Formation of clusters in different soil types.

Table 1. Additional information ( $X^2$ ) due to the addition of individual nutrients to  $D^2$  and the sum of ranks over all possible pairs of classification

Additional $X^2$ /rank sums/ soil type	Fe	Zn	Cu	Mo	Mu	B	S
Laterite	90.00** (49)	32.53** (89)	44.63** (86)	89.58** (83)	38.34** (116)	34.45** (123)	30.28** (112)
Alluvial	31.11** (66)	60.33** (65)	7.83 (101)	55.34** (94)	3.21 (130)	4.90 (140)	-
Reclaimed marshy	20.58** (42)	140.70** (26)	23.42** (44)	15.72** (54)	30.27** (31)	12.45** (62)	-
Coastal sandy	69.47** (27)	154.00** (24)	9.56* (26)	26.12** (35)	4.20 (56)	0.45 (76)	-
Sandy loam	0.75 (62)	60.97** (22)	20.47** (40)	5.78 (60)	74.93** (36)	10.75 (37)	-

\*\*Significant at 1% level

\*Significant at 5% level

Table 2.  $D^2$  values between pairs of classification in different soil types

Soil type/ Classification/ Pair	Laterite	Alluvial	Reclaimed marshy	Coastal sandy	Sandy loam
1;2	1.205*	1.282*	10.963**	11.750**	2.559**
1;3	4.167**	1.207**	9.695**	13.050**	3.536**
2;3	1.899**	0.001	2.265	1.170	1.334*
1;4	2.544**	2.592**	-	-	-
2;4	1.544*	0.227	-	-	-
3;4	0.787	0.258	-	-	-
1;5	3.447	2.698**	2.786**	11.040**	4.596**
2;5	2.445**	0.273*	6.329**	1.270	1.032*
3;5	0.786	0.308	4.311**	0.470	2.122**
4;5	1.146	0.002	-	-	-
1;6	2.020*	2.448*	-	-	-
2;6	0.991	0.187	-	-	-
3;6	1.006	0.217	-	-	-
4;6	0.839	0.004	-	-	-
5;6	0.737	0.007	-	-	-
1;7	5.025**	-	5.639*	13.600**	6.116**
2;7	3.145**	-	9.429**	0.480	1.304*
3;7	0.707	-	5.290**	2.460*	3.692**
4;7	1.274	-	-	-	-
5;7	0.775	-	1.021	2.510	0.451
6;7	0.658	-	-	-	-

\*Significant at 5% level

\*\*Significant at 1% level

Table 3. Cluster means of essential micronutrients in different soil types

Soil Type	Cluster	Fe	Zn	Cu	Mo	Mn	B	S
Laterite	II	0.179 (9.734)	0.067 (1.381)	0.075 (1.735)	0.010 (0.029)	0.430 (56.275)	0.026 (0.206)	0.278 (23.477)
	LS	0.132 (5.297)	0.036 (0.394)	0.092 (2.561)	0.009 (0.028)	0.414 (52.247)	0.030 (0.278)	0.300 (27.373)
	S	0.125 (4.751)	0.045 (0.617)	0.102 (3.172)	0.012 (0.042)	0.323 (31.767)	0.029 (6.259)	0.225 (15.462)
Alluvial	II	0.145 (6.369)	0.087 (2.289)		0.009 (0.825)			
	S	0.124 (4.729)	0.045 (0.611)		0.12 (0.044)			
Reclaimed Marshy	II	0.229 (16.008)	0.080 (1.973)	0.074 (1.689)	0.011 (0.034)	0.162 (8.036)	0.027 (0.215)	
	LS	0.202 (12.533)	0.014 (0.059)	0.078 (1.846)	0.011 (0.037)	0.015 (16.818)	0.028 (0.246)	
	S	0.157 (7.515)	0.057 (0.979)	0.079 (1.893)	0.011 (6.040)	0.089 (2.423)	0.027 (0.225)	
Coastal sandy	II	0.129 (5.070)	0.080 (1.953)	0.063 (1.953)	0.005 (0.009)			
	S	0.090 (2.447)	0.027 (0.214)	0.047 (0.0682)	0.003 (0.003)			
Sandy loam	II		0.052 (0.833)	0.088 (2.376)		0.416 (52.789)		
	LS		0.038 (0.467)	0.056 (0.942)		0.202 (12.806)		
	S		0.015 (0.088)	0.088 (2.375)		0.176 (9.491)		

The values in parentheses are in ppm and other transformed values in degrees.