RP-354

Indian Coco. J. 12: 87-100, 1959.

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 soils

BY

K. M. PANDALAI, H. SANKARASUBRAMONEY & K. P. V. MENON
Central Coconut Research Stations, Kasaragod & Kayangulam

INTRODUCTION

In previous papers Sankarasubramoney *et al.*, (1954, 1955, 1956) and Pandalai *et al*, (1958 a, b) have discussed various aspects of soil conditions in relation to the root and leaf diseases of the coconut palm in Travancore-Cochin. They have reported certain interesting correlations particularly with reference to the pH, available potash, iron and calcium contents which are lower in the diseased coconut areas than in the healthy areas. The values for total exchangeable bases and percentage base saturation were also lower in the diseased areas than in the healthy areas. The exchangeable hydrogen content alone appeared to be higher in the soils of the diseased areas. They also observed that a large proportion of the localities in the diseased group had water-table or some impermeable layer near the soil surface.

In common with most agricultural crops, moisture is a great limiting factor in the successful cultivation of the coconut palm A proper supply of moisture either through well distributed rainfall, percolation water or irrigation and sufficient drainage are essential for the proper growth of the coconut. From root absorption experiments Copeland (1931) has calculated that the palm can absorb 24 litres (54 lb.) of water per day, but from the determinations of evaporation from the leaves he is inclined to place this figure from 28 to 45 litres Espino and Juliano (1924) studied the absorption of culture solutions through roots and showed that this was more rapid during rainless days than during rainy days and they place the water requirements at about 16 litres (36 lb.) per day The wind makes a decided difference in the transpiration of the leaves but makes a much greater one when the leaves are in full sunshine as is more usual in the dry seasons. According to Copeland *(loc. lit.)*, one leaflet loses in a dry day about 10.8 gms. of water. This estimate varies from 28.1 kgms. to 74 kgms. as the daily loss of water from a mature palm. Duthie (1938) compared the soil moisture relationships in the soils from healthy coconut beds and from beds carrying palms liable to wilting. In heavy clay soils he found that the slow lateral movement of water and moisture availability were key factors leading to the appearance of diseases. The wilting point in a clay soil may occur when there is less than 13 per cent. moisture present in that soil especially in the presence of sodium and magnesium salts, high concentrations of which hinder absorption through the roots.

Copeland *(loc. cit.)* who investigated in detail the water relationships of the palms during drought conditions has reported that after a prolonged drought in one of the districts of the Philippines, it took the palms several years to recover from the drought-injured vitality. This indicates the importance of available water supplies for the coconut palm for normal health and productivity. He is, therefore, inclined to lay greater stress on the need to maintain the proper physical composition of the soil more than its chemical composition so long as there is an assured moisture supply in the soil readily available to the palms.

Differences in the soil moisture greatly modify fertilizer requirements. Generally soils in dry regions are not so leached as those of humid regions and contain more nutrients. Further, moisture supply in these regions according to Ignatieff (1952) is usually a greater limiting factor than nutrient supply. Indeed irrigation can change the fertilizer need completely. It is interesting that factors that inhibit normal growth such as nutrient deficiency, drought, or disease raise considerably the water requirements of plants. Manuring is known to increase the efficacy of water use. One pound of water has been observed to serve to produce more dry matter on a good soil under favourable weather conditions than under adverse conditions of soil and weather.

Available potassium is a nutrient factor which together with the water supply appears to act as limiting factors in the growth of the coconut palms since these are known to interact in many ways (Pandalai and Menon, 1957). Under inadequate moisture availability potash absorption has been never shown to be optimum even in potash rich soils. These considerations show that soil moisture conditions and their fluctuations could have important bearing in the root and leaf diseases of the coconut palm in the Travancore-Cochin area. Evaluation of the moisture status of the different soils from healthy and diseased coconut areas was, therefore, made as a routine in the general scheme of soil analysis in the general plan to investigate the soil aspects in relation to the incidence of disease, and the results are presented in this paper.

MATERIALS AND METHODS

The details of the coconut areas, the soils and the condition of the palms, the analytical methods adopted, etc. have all been described in earlier papers of this series *(loc. cit.)*. Hygroscopic moisture was determined by placing a weighed quantity of the air dry soil in a weighing bottle in an air oven at 105°C for a period of sixteen hours and then determining the loss in weight. The loss on ignition was determined by igniting the oven dry soil contained in a crucible in a muffle furnace for 30-40 minutes at a bright red heat and then determining the loss in weight. The percentage of combined water was arrived at by subtracting from the percentage loss on ignition the percentage of organic matter as described by Wright (1939).

RESULTS AND CONCLUSIONS

The mean values for the percentages of combined water and hygroscopic moisture in the soil samples examined are given in the Tables 1 and 2. Table 3 gives the details about the number of localities examined under each group and soil type which has got a water table or some other impermeable layer nearer the surface than six feet.

In Tables 4 to 11, given as Appendix, are presented the percentage of ignition loss, combined water and hygroscopic moisture in the soil samples belonging to the different types of soils under the two categories, healthy and diseased areas. Loss on ignition is determined as a "single value" constant and includes the organic matter and the

THE COMBINED WATER, HYGROSCOPIC WATER, LOSS ON IGNITION AND WATER-TABLE ASPECTS OF COCONUT SOILS

TABLE I

Showing the percentage of combined water

Group	Horizon	Soil type			
		Sandy	Alluvial loam	Red loam	Laterite
Diseased	A	0.62	6.01	2.19	6.92
	B	0.66	6.66	2.67	7.48
	C	—	—	—	9.58
Healthy	A	0.77	4.16	2.37	9.47
	B	0.74	4.37	3.50	10.10
	C	—	—	—	10.23

TABLE 2.

Showing the percentage of hygroscopic moisture

Group	Horizon	Soil type			
		Sandy	Alluvial loam	Red loam	Laterite
Diseased	A	0.67	3 26	1.65	3.82
	B	0.83	4.23	1.62	3.54
	C	—	—	—	4.00
Healthy	A	0.76	2.71	3.64	7.10
	B	0.67	3.05	5.12	8. 10
	C	—	—	—	7.97

TABLE 3

Showing the number of localities which have a water-table or other impermeable layer nearer the surface than six feet

Group	Type	Total no. of localities examined	No. of localities where water-table is nearer than 6 feet	No. of localities where there is an impermeable layer nearer than 6 feet
Diseased	Sandy	10	6	–
	Alluvial loam	8	7	–
	Red loam	5	–	–
	Laterite	5	–	3
Healthy	Sandy	8	–	–
	Alluvial loam	6	–	3
	Red loam	5	–	–
	Laterite	5	–	1

combined water in the soil colloids. The combined water is a measure of the colloid content of the soil.

The following conclusions can be drawn from the results given in Tables 1 and 2:–

1. there is a slightly greater percentage of combined water in the soils of healthy areas belonging to the sandy, red loam and laterite types as compared with the diseased areas;

2. in the case of alluvial loam soils the percentage of combined water is higher in the soils from diseased areas;

3. there is a greater percentage of hygroscopic moisture in the soils from healthy areas belonging to the red loam and laterite types; and

4. soils from both the horizons of the alluvial loam type and the B horizon of the sandy type belonging to the diseased groups have a higher percentage of hygroscopic moisture than the corresponding soils from the healthy group.

Both combined water and hygroscopic moisture are factors which reflect only the capacities of the soils to retain moisture. This is specially so in the case of combined water which is directly proportional to the colloidal matter content of the soil. Although neither the combined water nor the hygroscopic moisture is available to plants and these values indicate only the moisture retaining capacities of the soils under examination, these do orientate soil conditions and plant growth to a considerable extent and it would certainly be interesting to see how these react as predisposing conditions in the soil for the onset of the disease in the palms. However, it would appear from the results presented above that neither of these factors has got any direct correlation with disease incidence in the coconut soils studied.

From the results given in Table 3 can be seen that of the twenty-eight localities examined under the diseased group, thirteen have water tables which are within six feet of the surface. Three localities have got impermeable rock barriers above the six feet depth. Under the healthy group, out of a total number of twenty-four localities examined none has a water-table as near the surface as six feet and only four localities have got other impermeable layers within the six feet depth.

The coconut palm requires for healthy growth at least six feet depth of well drained top soil. The presence of the water-table nearer to the soil surface naturally amounts to a state of water logging. The presence of an impermeable layer may, in addition to restricting the development of the root system of the palm, cause the formation of a secondary water-table during certain seasons and in this way also cause a condition of water logging. In such areas, during the wet seasons the moisture may be expected to persist above the field capacity, and adversely affect palms growing there. In such situations the palms develop only a shallow root system which is not able to maintain the palms well supplied with moisture and nutrients during the dry summer months when the top soil gets thoroughly dry. The retention of excess of soil moisture within the root zone of the palm exerts on it serious indirect detrimental effects also. Soil aeration becomes inadequate. This condition restricts microbiological activity in the soil and thus the availability of nutrients such as nitrates. In fact De and Sarkar (1936), Wallihan (1936) as well as Wallis and Sturges (1944) have shown that in water-logged soils, denitrification takes place bringing about a rapid loss of applied nitrates. Excess of soil water can cause loss of nutrients also by surface erosion. It is known that the uptake of all plant nutrients especially potash is reduced in water-logged soils. Bain and Chapman (1940), Smith and Cook (1940) and Muller (1946) are among those who have emphasised the essentiality of adequate aeration for the development of healthy root systems. An excess of soil moisture affects plants not only by reduced oxygen supply but also by increased partial pressure of carbon dioxide round the root zone. Oxidation of organic matter will be impeded as also the inorganic soil constituents. Such conditions according to Hoeffer (1945) and Leeper (1947), can lead to an increase in the exchangeable divalent manganese in the soil an excess of which has been shown to be phytotoxic. Daji (1948) has shown that the soils in the localities where the 'band' disease of arecanut is prevalent have a high content of toxic and available manganese as compared to areas which are disease free. Usually an increase in the ferrous iron content of the soil is the result of anaerobiosis due to moisture excess in the soil. This as well as the reduced forms of some organic compounds existing in water-logged soils according to Schreiner (1923), are specially phytotoxic. Acharya (1935) has proved that the anaerobic decomposition of organic matter results in the formation of organic acids like acetic and butyric acids, and gases like methane and hydrogen which also have toxic action on plants. These acids in the absence of sufficient supply of bases in the soils, lower the pH of the ground water. Observations made on the fluctuations in the water-tables in pits dug in the low-lying coconut areas at the Central Coconut Research Station, Kayangulam, have shown that often the water-level rises to only below two feet from the soil surface and the pH of the water even reached the range of 3.6 and 4.4. At this stage the sub-soil water was shown by Pandalai *et al.* (1957) to contain appreciable quantities of organic acids, acetic and butyric acids among them having been identified.

It is well known that a high soil moisture content favours the activity of certain plant root pathogens. Monteith (1924) showed that 'club rot' of crucifers is favoured by a soil moisture content of 60 per cent. and above. The 'root rot' of sugarcane studied by Carpenter (1934) and the banana 'wilt' described by Wardlaw (1941) are other fungal diseases which are favoured by high soil moisture content. Briton Jones (1929) in Trinidad found a definite correlation between lack of drainage and incidence of "bronze leaf wilt" in the coconut, and Bain (1940) has confirmed this. Martyn

(1945) has recorded a disease of the coconut palm in Jamaica similar to the leaf disease of palms in South India as being favoured by high soil moisture content. Dwyer (1940) has attributed the coconut root disease and maturation wilt in New Guinea to physiological derangement of the palm as a result of either excess or non-availability of water in the soil. A root disease of the coconut palm in the low-lying areas in Ceylon subject to water logging during the wet weather has been recorded by Park (1928). Menon and co-workers (1949, 1952) have found that the coconut root infecting fungi are capable of inducing disease symptoms in young seedlings which are maintained under water-logged conditions for forty-eight hours after inoculation. All these aspects have been discussed in detail by Menon and Pandalai (1958).

From the above discussion and from the fact that a large proportion of areas where the disease is prevalent are characterised by high water tables it would appear that a water-logged condition of the soil might be one of the main factors which predisposes the coconut palm to disease attack.

SUMMARY

1. The results of studies on some aspects of moisture availability, moisture excess and moisture deficiency as well as water-table of soils in the healthy and diseased areas in relation to the incidence of the root and leaf diseases of the coconut palms have been presented and discussed.

2. A higher percentage of combined water in the healthy areas in sandy, red loam and laterite areas compared to diseased areas (the reverse being the case in the alluvial loams) as well as a higher percentage of hygroscopic moisture in the healthy areas in red loam and laterite were found to be rather characteristic.

3. From the facts that a large proportion of the areas where the disease is prevalent have high water tables, it has to be concluded that water logging of the soil is a prominent factor which predisposes disease conditions in the palms.

4. The need for providing facilities for preventing water logging of coconut soils by securing good drainage conditions and preventing continued water stagnation at the root zone has been emphasised.

REFERENCES

1. Acharya, C. N., (1935) *Biochem. Jour.*, **29**: 528, 953, 1116, 1459.
2. Bain, F. M., (1937) Report on the coconut growing areas of Jamaica. *Dept. Sci. Agr. Jamaica Bull.*, No. 22.
3. Bain, F. M. and Chapman, H. D., (1940) *Soil Science*, **50**: 357.
4. Briton Jones, H. R., (1929) *Supplement to Tropical Agriculture*, Oct., 1929.
5. Carpenter, C. W., (1934) *Hawaii Plant Rec.*, **38**: 279.
6. Copeland, E. B., (1931) "*The Coconut*", 3rd edition revised. MacMillan & Co., London.
7. Daji, J. A., (1948) *Curr. Sci.*, **17**: 259.
8. De, P. K. and Sirkar, S. N., (1936) *Soil Science*, **42**: 143.
9. Duthie, D. W., (1938) Coconut wilt in Essequibo and Pomeroon Districts. *Agrl. Jour. Br. Guiana*, **9**: 147-152.
10. Dwyer R. E. P., (1940) Some investigations on Coconut diseases associated with Soil conditions in New Guinea. *New Guinea Agrl. Gazette*, **6**: 2-38.
11. Espino, R. B. and Juliano, J. B., (1924) Absorption of culture solution by coconut palm roots. *Philipp. Jour. Sci.*, **25**, No. 1.
12. Hoffer, G. N., (1945) *Better crops with Plant Food*. **29**: 19.
13. Ignatieff, V., (1952) "*Efficient use of Fertilizers*", F. A. O. Leonard Hill Ltd., London, page 73.
14. Leeper, G. W., (1947) *Soil Science*, **63**: 79.
15. Menon, K. P. V. and Pandalai, K. M., (1958) "*The Coconut Palm — A Monograph*". Indian Central Coconut Committee, Ernakulam.
16. Menon, K. P. V. and Nair, U. K., (1949) *Indian Coconut J.*, **3**: 5.
17. Menon, K. P. V., Nair, U. K. and Pandalai, K. M., (1952) Influence of water logged soil conditions on root parasites of the coconut palm. *Indian Coconut J.*, **5**: 71-79.
18. Muller, C. H., (1946) *U. S. Dept. Agric. Tech. Bull.*, 923.
19. Pandalai, K. M. and Menon, K. P. V., (1957) On the use of potash as a fertilizer with its effect on yield, quality and disease resistance in the Coconut Palm. *Indian Coconut J.*, **10**: 12-28.
20. Pandalai, K. M., Sankarasubramoney, H. and Menon, K. P. V., (1957) Problem of seasonal foliar yellowing in the Coconut Palm. *Indian Coconut J.*, **11**: 19-28.

    ,, (1958) Studies on soil conditions in relation to the "Root" and "Leaf" diseases of the coconut palm in Travancore-Cochin.

    Part IV. *Indian Coconut J.*, **11**: 49-66.

    ,, — do — — do — Part V. Ibid. 87—101.
21. Park, M., (1928) Investigations on Root diseases of Coconuts. *Trop. Agriculturist*, **70**: 402-407.

22. Sankarasubramoney, H., Pandalai, K. M. and Menon, K. P. V. (1954) Studies on Soil conditions in relation to the "Root" and "Leaf" diseases of the coconut palm in in Travancore-Cochin. Part I. *Indian Coconut J.*, 8: 5-25.

(1955) — do — Part II. Ibid. 9: 20-29.

(1956) — do — Part III. Ibid. 9: 90-100.

23. Schreiner, O., (1923) *Jour. Amer. Soc. Agron.* 15: 270.

24. Smith, F. W. and Cook, R. L., (1940) *Soil Sci. Soc. Amer. Proc.*, 5: 402.

25. Wallihan, E. F., (1937) *Soil Sci. Soc. Amer. Proc.*, 2: 259.

26. Wardlaw, C. W., (1941) *Nature.* 147: 380.

27. Willis, W. H. and Sturgis, M. B., (1944) *Soil Sci. Soc. Amer. Proc.*, 9: 106.

28. Wright, C. H., (1939) *"Soil Analysis"*. Thomas Murley & Co., London: 11-12.

APPENDIX

TABLE 4

Showing the percentage of ignition loss, combined water and hygroscopic moisture in the soil samples belonging to the type SANDY (SANDY LOAM)

Lab. No.	DISEASED AREAS Ignition loss	Combined water	Hygroscopic moisture	HEALTHY AREAS Lab. No.	Ignition loss	Combined water	Hygroscopic moisture
1	0.76	0.36	0.77	19	1.97	0.96	1.43
2a	1.01	0.55	1.63	20	1.58	0.94	1.58
2b	0.90	0.72	1.87	21	0.88	0.75	0.35
3	0.94	0.29	0.48	22a	0.56	0.38	0.33
4	0.86	0.36	0.55	22b	0.24	0.06	0.15
5a	0.90	0 15	0.94	23	0.73	0.62	0.34
5b	1.10	0.44	1.38	24	0.64	0.49	0.37
6a	0.52	0.22	1.35	25a	1.98	1.31	0.81
6b	0.71	0.40	1.51	25b	1.90	1.47	0.99
6c	0.93	0.50	1.13	26	1.54	1.35	1.23
7	0.94	0.80	0.98	27a	0.56	0.36	0.23
8	0.55	0.46	0.61	27b	0.32	0.20	0.35
9	1.49	0.72	0.55	28a	0.53	0.47	0.32
10	1.34	0.70	0.58	28b	0.69	0.63	0.28
11	0.68	0.36	0.35	28c	0.47	0.44	0.41
12	1.94	1.19	1.03	29	0.98	0.64	0.26
13	1.44	0.85	0.70	30a	1.37	1.27	0.37
14	0.75	0.30	0.43	30b	0.64	0.56	0.14
15	1.56	1.35	0.59				
16	1.14	0.99	0.43				
17	0.92	0.71	0.44				
18	0.96	0.75	0.55				

TABLE 5

Showing in abstract form the results given in Table 4

Factor		Diseased A horizon	Diseased B horizon	Healthy A horizon	Healthy B horizon
Ignition loss	Mean Range	1.03 0.55 – 1.56	1.08 0.72 – 1.94	1.16 0.44 – 1.97	0.95 0.56 – 1.58
Combined water	Mean Range	0.62 0.29 – 1.35	0.66 0.36 – 1.19	0.77 0.28 – 1.39	0.74 0.22 – 1.35
Hygroscopic moisture	Mean Range	0.67 0.35 – 1.17	0.83 0.43 – 1.75	0.76 0.26 – 1.43	0.67 0.24 – 1.58
No. of values		10	8	6	6

TABLE 6

Showing the percentage of ignition loss, combined water and hygroscopic moisture in the soil samples belonging to the type ALLUVIAL LOAM

	DISEASED AREAS			HEALTHY AREAS			
Lab. No.	Ignition loss	Combined water	Hygroscopic moisture	Lab. No.	Ignition loss	Combined water	Hygroscopic moisture
31	12.71	10.58	4.31	47	7.89	6.37	5.86
32	12.70	10.76	4.65	48a	9.36	8.56	9.35
33	10.95	8.54	7.21	48b	9.07	8.19	8.23
34	11.57	9.15	7.53	49a	6.14	4.91	3.13
35	5.04	3.52	2.23	49b	6.47	5.54	3.60
36	9.87	7.74	5.02	50a	3.81	3.06	2.31
37a	7.80	5.89	3.40	50b	4.01	3.34	2.43
37b	8.20	6.47	3.80	51a	3.83	3.12	2.00
38	7.80	6.31	3.97	51b	5.80	4.53	2.95
39a	6.27	4.83	2.60	51c	4.75	4.00	2.25
39b	9.33	7.46	3.97	52a	4.63	3.89	2.56
40	4.83	3.76	1.77	52b	4.12	3.61	2.11
41	4.16	3.58	1.63	53	3.97	2.81	1.32
42	3.72	3.35	1.47	54	4.77	3.78	1.75
43	5.11	4.30	1.84	55	4.04	3.20	1.37
44	4.67	4.63	6.42	56	5.05	4.70	1.86
45	5.98	5.22	1.98	57	4.91	3.75	1.96
46	8.06	7.64	2.98	58	3.35	2.40	1.19

TABLE 7

Showing in abstract form the results given in Table 6

Factor		Diseased		Healthy	
		A horizon	B horizon	A horizon	B horizon
Ignition loss	Mean Range	7.47 4.16-12.71	7.78 3.72-12.70	5.15 3.97-7.89	5.18 3.55-9.22
Combined water	Mean Range	6.01 3.52-10.58	6.66 3.35-10.75	4.16 2.81-6.37	4.37 2.40-8.38
Hygroscopic moisture	Mean Range	3.26 1.63-7.21	4.23 1.47-7.53	2.71 1.32-5.86	3.05 1.19-8.79
No. of values		8	8	6	6

TABLE 8

Showing the percentage of ignition loss, combined water and hygroscopic moisture in the soil samples belonging to the type RED LOAM

	DISEASED AREAS				HEALTHY AREAS		
Lab. No.	Ignition loss	Combined water	Hygroscopic moisture	Lab. No.	Ignition loss	Combined water	Hygroscopic moisture
59	3.29	2.92	1.80	68	2.55	0.70	2.18
60	2.03	1.85	3.11	69	2.23	1.06	2.46
61a	2.65	2.36	1.91	70a	2.06	0.51	0.69
61b	2.80	2.53	1.68	70b	3.74	2.01	1.31
62a	2.07	1.70	0.91	71a	4.84	2.56	1.33
62b	2.10	1.99	1.03	72	3.65	2.72	3.01
63	2.17	1.83	1.19	73a	4.05	3.26	4.72
64	2.51	2.09	1.06	74	4.34	3.49	5.30
65	3.55	3.17	1.59	75a	4.95	4.02	8.78
66	2.56	2.22	1.31	75b	5.64	4.87	10.39
67a	3.37	3.02	1.81	76	4.61	3.70	6.71
67b	3.74	3.43	1.96	77a	5.48	4.88	6.16
				77b	6.01	5.39	6.92

TABLE 9

Showing in abstract form the results of Table 8

Factor		Diseased		Healthy	
		A horizon	B horizon	A horizon	B horizon
Ignition loss	Mean	2.50	3.00	3.61	4.67
	Range	2.03–3.29	2.17–3.56	2.55–4.61	2.23–5.75
Combined water	Mean	2.19	2.67	2.37	3.50
	Range	1.85–2.92	1.83–3.23	0.70–3.70	1.06–5.15
Hygroscopic moisture	Mean	1.65	1.62	3.64	5.12
	Range	0.97–1.80	1.19–1.89	1.00–6.71	1.57–9.53
No. of values		5	4	5	5