

Studies on Soil Conditions in Relation to the 'Root' and 'Leaf' Diseases of the Coconut Palm in Travancore - Cochin.

Part III. Total available and exchangeable potassium contents of coconut soils

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PREVIOUS publications in this series (Sankarasubramoney et. al. 1955 and 1956) have dealt in detail with the nitrogen and phosphorus status of coconut soils. It has been shown that the status of these two elements in the soil is not correlated with the incidence of coconut palm diseases. In the present paper the potassium content of

coconut soils with special reference to the disease aspect has been considered.

As in the case of nitrogen and phosphorus, the amount of potash required by coconuts has been computed by different workers, on the basis of the figures of analysis of leaves and fruits. In Table I are given a few of these values.

Table I

1.	435.37	K gms/hectare	Copeland. 1921
2.	38	lbs./acre	Pillai. 1919
3.	117	lbs./acre	Eckstein et. al. 1927
4.	85	lbs./acre	Jacob & Coyle 1926.
5.	123	lbs./acre	Georgi & Teik. 1932
6.	60	lbs./acre	Patel. 1938
7.	24	lbs./acre	Cooke. 1950

Pandalai et. al. (1953) have set forth arguments to show that the potash requirement of coconut palms is far greater than that of most other trees. This can be easily understood from the fact that the leaves of coconuts contain as much as two per cent of potash on a dry weight basis. The importance of potash in the nutrition of the coconut palm has also been proved by experiments conducted by Salgado (1953) in Ceylon

Potash is known to have important roles in such plant processes as

cell division, assimilation, respiration, formation of proteins, translocation of carbohydrates and reduction of nitrates. It is also of utmost importance in the water relationships of plants (Millar 1953). Recently Fujiwara and Iida (1955) have dealt with the biochemical and nutritional aspects of potassium with special reference to its effects on the respiration of higher plants. Deficiency of potassium may lead to deterioration of the plant's health in general, thus increasing its susceptibility to pests and diseases. In fact, in most

STUDIES ON SOIL CONDITIONS IN RELATION TO THE 'ROOT' AND 'LEAF'
DISEASES OF THE COCONUT PALM IN TRAVANCORE-COCHIN.

cases of potassium deficiency, it is this increased susceptibility to pests and diseases that becomes apparent at first. External modifications may be revealed only later on. It has been suggested by Schaffnit and Volk (1930) that the relationship between potassium deficiency and parasitism is especially pronounced in perennial plants. The weakening of the root system which results due to potassium deficiency, increases susceptibility to root diseases. Deficiency of the element is also known to affect adversely the formation and translocation of carbohydrates and the utilisation of nitrogen by the plant. The plant's water relationships are also adversely affected—a larger quantity of water being necessary for the production of unit weight of dry matter. The rate of transpiration is higher in the case of potash starved plants. This leads to wilting of the plant when the roots are not able to supply enough water to cope up with the transpirational loss. At a later stage this might lead to marginal scorching of the leaves. Hoblyn (1931) has reported that in all cases of leaf scorch examined in the field, the scorched tree is generally one with a low potash status.

The symptoms exhibited by coconut palms affected by the 'root' disease as described by Menon and Nair (1952) very closely approximate to those attributed to a defi-

ciency of potassium. The coconut palm is known to be a potash loving plant and so, effects of a deficiency of the element may naturally be expected to have a more deleterious effect on coconuts than on other plants. The rather large quantities of potassium which coconuts will remove from the soil may lead to a deficiency of this element, unless it is adequately replenished. Even in the case of healthy palms, it has been observed that of the three major plant nutrients, viz., nitrogen, phosphorus and potassium, the best responses are obtained with applications of potassium (Patel 1938).

The facts stated above point to the importance of potassium in the nutrition of the coconut palm, and in this paper are presented the results of an examination of soils in Travancore-Cochin, with particular reference to the correlation between the potassium status of the soils and the incidence of coconut palm diseases. Details regarding the soil samples have already been given in Part I of this series. In Tables 2 to 5 are presented the values for total potash, available potash and exchangeable potassium in the soil samples examined. In Tables 6 and 7 are given the mean values for the percentage of total and 1% citric acid soluble (available) potash and in Table 8 are presented the mean values for exchangeable potassium (in mgm. equivalents per 100 gms. of soil).

Table 2

Percentage of total potash and available potash and exchangeable potassium (in mgm. equivalents per 100 gms. of soil) in the soil samples belonging to the type *Sandy Loam*.

DISEASED AREAS				HEALTHY AREAS			
Lab. No.	Total K ₂ O%	Avail K ₂ O% -able	Exchangeable K (mgm. eq/ 100 gms.)	Lab. No.	Total K ₂ O%	Avail K ₂ O% -able	Exchangeable K (mgm. eq/ 100 gms.)
1	Trace	Trace	Trace	19	Trace	Trace	Trace
2 (a)	Trace	Trace	Trace	20	Trace	Trace	Trace
2 (b)	Trace	Trace	Trace	21	Trace	Trace	Trace
3	Trace	Trace	Trace	22 (a)	Trace	Trace	Trace
4	Trace	Trace	Trace	22 (b)	Trace	Trace	Trace
5 (a)	Trace	Trace	Trace	23	Trace	Trace	Trace
5 (b)	Trace	Trace	Trace	24	0.023	Trace	Trace
6 (a)	Trace	Trace	Trace	25 (a)	0.044	0.009	Trace
6 (b)	Trace	Trace	Trace	25 (b)	0.019	0.013	Trace
6 (c)	Trace	Trace	Trace	26	0.038	0.013	Trace
7	Trace	Trace	Trace	27 (a)	Trace	Trace	Trace
8	Trace	Trace	Trace	27 (b)	Trace	Trace	Trace
9	Trace	Trace	Trace	28 (a)	Trace	Trace	Trace
10	Trace	Trace	Trace	28 (b)	Trace	Trace	Trace
11	0.011	Trace	Trace	28 (c)	Trace	Trace	Trace
12	0.038	Trace	Trace	29	0.012	Trace	Trace
13	0.006	Trace	Trace	30 (a)	0.013	Trace	Trace
14	0.004	0.002	Trace	30 (b)	0.004	Trace	Trace
15	0.047	0.005	Trace				
16	0.004	Trace	Trace				
17	0.065	Trace	Trace				
18	0.022	Trace	Trace				

Abstract of Table 2

Factor	Diseased		Healthy		
	A Horizon	B	A	B	
Total K ₂ O	Mean	0.013	0.009	0.005	0.010
	Range	0-0.047	0-0.038	0-0.032	0-0.038
Available K ₂ O	Mean	0.001	Trace	0.002	0.002
	Range	0-0.005	0-0.002	0-0.011	0-0.013
Exchangeable K No. of readings	Mean	Trace	Trace	Trace	Trace
	Range	0-0	0-0	0-0	0-0
		10	8	6	6

STUDIES ON SOIL CONDITIONS IN RELATION TO THE 'ROOT' AND 'LEAF'
DISEASES OF THE COCONUT PALM IN TRAVANCORE-COCHIN.

Table 3

Percentage of total potash and available potash, and exchangeable potassium (in mgm. equivalents per 100 gms. of soil) in the soil samples belonging to the type *Alluvial Loam*.

DISEASED AREAS				HEALTHY AREAS			
Lab. No.	Total K ₂ O%	Avail-able K ₂ O%	Exchangeable K (mgm. eq/100 gms.)	Lab. No.	Total K ₂ O%	Avail-able K ₂ O%	Exchangeable K (mgm. eq/100 gms.)
31	0.197	0.009	Trace	47	0.158	0.008	Trace
32	0.193	Trace	Trace	48 (a)	0.221	Trace	Trace
33	0.078	Trace	Trace	48 (b)	Trace	Trace	Trace
34	0.065	Trace	Trace	49 (a)	0.022	Trace	Trace
35	0.119	0.002	Trace	49 (b)	0.025	0.008	Trace
36	0.110	Trace	Trace	50 (a)	Trace	Trace	Trace
37 (a)	0.089	Trace	Trace	50 (b)	0.005	Trace	Trace
37 (b)	0.111	Trace	1.32	51 (a)	0.088	0.022	Trace
38	0.078	Trace	1.00	51 (b)	0.118	0.007	Trace
39 (a)	0.047	Trace	Trace	51 (c)	0.126	0.010	Trace
39 (b)	0.053	Trace	Trace	52 (a)	0.074	Trace	Trace
40	0.053	Trace	Trace	52 (b)	0.084	Trace	Trace
41	0.002	Trace	Trace	53	0.045	0.008	Trace
42	0.011	Trace	Trace	54	0.300	0.005	0.72
43	0.061	Trace	Trace	55	0.232	0.009	2.32
44	0.068	0.003	Trace	56	0.232	0.004	2.51
45	0.092	0.003	1.00	57	0.342	0.011	2.52
46	0.151	Trace	1.20	58	0.181	0.012	1.98

Abstract of Table 3

Factor	Diseased		Healthy		
	A Horizon	B	A	B	
Total K ₂ O	Mean	0.087	0.093	0.153	0.151
	Range	0.002-0.197	0.011-0.193	0.024-0.342	0.003-0.300
Available K ₂ O	Mean	0.002	Trace	0.008	0.005
	Range	0-0.009	0-0.003	0-0.013	0-0.012
Exchangeable K	Mean	0.21	0.28	0.8	0.87
	Range	0-1.00	0-1.20	0-2.52	0-2.51
No. of readings		8	8	6	6

Table 4

Percentage of total potash, and available potash, and exchangeable potassium (in mgm. equivalents per 100 gms. of soil) in the soil samples belonging to the type *Red Loam*.

DISEASED AREAS				HEALTHY AREAS			
Lab. No.	Total K ₂ O%	Avail-able K ₂ O%	Exchangeable K (mgm.eq/100 gms.)	Lab. No.	Total K ₂ O%	Avail-able K ₂ O%	Exchangeable K (mgm.eq/100 gms.)
59	0.095	Trace	Trace	68	Trace	Trace	Trace
60	0.088	Trace	Trace	69	0.015	Trace	0.015
61 (a)	0.116	Trace	Trace	70 (a)	Trace	Trace	Trace
61 (b)	0.080	Trace	Trace	70 (b)	0.015	Trace	Trace
62 (a)	0.059	Trace	Trace	71 (a)	0.035	Trace	0.25
62 (b)	0.005	Trace	Trace	71 (b)	0.132	0.006	0.97
63	0.019	Trace	Trace	72	0.029	Trace	Trace
64	0.034	Trace	Trace	73 (a)	0.032	Trace	Trace
65	0.065	Trace	Trace	73 (b)	0.032	Trace	Trace
66	0.050	Trace	Trace	74	0.046	Trace	Trace
67 (a)	0.023	Trace	Trace	75 (a)	0.046	Trace	Trace
67 (b)	0.023	Trace	Trace	75 (b)	Trace	Trace	Trace
				76	0.048	Trace	Trace
				77 (a)	Trace	Trace	Trace
				77 (b)	Trace	Trace	Trace

Abstract of Table 4

Factor	Diseased		Healthy	
	A: Horizon	B	A	B
Total K ₂ O	Mean 0.060	0.051	0.026	0.031
	Range 0.033-0.095	0.019-0.098	0.008-0.048	0.015-0.084
Available K ₂ O	Mean Trace	Trace	Trace	0.001
	Range 0-0	0-0	0-0	0-0.003
Exchangeable K	Mean Trace	Trace	Trace	0.11
	Range 0-0	0-0	0-0	0-0.56
No. of readings	5	4	5	5

STUDIES ON SOIL CONDITIONS IN RELATION TO THE 'ROOT' AND 'LEAF'
DISEASES OF THE COCONUT PALM IN TRAVANCORE-COCHIN

Table 5

Percentage of total potash and available potash and exchangeable potassium (in mgm. equivalents per 100 gms. of soil) in the soil samples belonging to the type *Laterite*

DISEASED AREAS				HEALTHY AREAS			
Lab. No.	Total K ₂ O%	Avail-able K ₂ O%	Exchangeable K (mgm.eq/100 gms.)	Lab. No.	Total K ₂ O%	Avail-able K ₂ O%	Exchangeable K (mgm.eq/100 gms.)
78	0.222	Trace	Trace	90	0.088	0.015	Trace
79	0.199	Trace	Trace	91	0.139	0.004	Trace
80	0.171	Trace	Trace	92	0.128	Trace	Trace
81	0.012	0.001	Trace	93	0.088	0.012	Trace
82	Trace	Trace	Trace	94	0.139	Trace	Trace
83	Trace	Trace	Trace	95	0.212	0.012	Trace
84	Trace	Trace	Trace	96	0.145	Trace	Trace
85	Trace	Trace	Trace	97	0.124	Trace	Trace
86	0.076	0.020	Trace	98	0.063	0.013	Trace
87	0.083	0.012	Trace	99	0.042	0.010	Trace
88 a)	0.097	0.005	Trace	100	0.034	0.011	Trace
88 b)	0.069	0.008	Trace	101	0.053	0.007	Trace
89	0.113	Trace	Trace	102	0.172	Trace	Trace
				103	0.155	Trace	Trace
				104	0.185	Trace	Trace

Abstract of Table 5

Factor	Diseased			Healthy			
	A. Horizon	B	C	A	B	C	
Total K ₂ O	Mean	0.085	0.071	0.085	0.114	0.118	0.128
	Range	0.012-0.222	0.083-0.199	0.083-0.171	0.042-0.172	0.034-0.155	0.053-0.212
Available K ₂ O	Mean	0.004	0.003	0.002	0.007	0.003	0.006
	Range	0-0.020	0-0.012	0-0.007	0-0.015	0-0.011	0-0.013
Exchangeable K	Mean	Trace	Trace	Trace	Trace	Trace	Trace
	Range	0-0	0-0	0-0	0-0	0-0	0-0
No. of readings		5	4	3	5	5	5

Table 6. Total potash (%)
(Mean values)

Group	Horizon	Soil Type			
		Sandy	All. Loam	Red Loam	Laterite
Diseased	A	0.013	0.087	0.060	0.085
	B	0.009	0.093	0.051	0.071
	C	—	—	—	0.085
Healthy	A	0.005	0.153	0.026	0.114
	B	0.010	0.151	0.031	0.118
	C	—	—	—	0.128

Table 7. Available potash (%)
(Mean values)

Group	Horizon	Soil Type			
		Sandy	All. Loam	Red Loam	Laterite
Diseased	A	0.001	0.002	Trace	0.004
	B	Trace	Trace	Trace	0.003
	C	—	—	—	0.002
Healthy	A	0.002	0.008	Trace	0.007
	B	0.002	0.005	0.001	0.003
	C	—	—	—	0.006

Table 8. Ex. potassium (mgm. eq./100 gms.)
(Mean values)

Group	Horizon	Soil Type			
		Sandy	All. Loam	Red Loam	Laterite
Diseased	A	Trace	0.21	Trace	Trace
	B	Trace	0.28	Trace	Trace
	C	—	—	—	Trace
Healthy	A	Trace	0.81	Trace	Trace
	B	Trace	0.87	0.11.	Trace
	C	—	—	—	Trace

STUDIES ON SOIL CONDITIONS IN RELATION TO THE 'ROOT' AND 'LEAF'
DISEASES OF THE COCONUT PALM IN TRAVANCORE-COCHIN.

The following conclusions can be drawn from the results presented above

1. There is a greater percentage of total potash in the soil samples from both the horizons of the red loam type, and the A horizons of the sandy type in the diseased group, as compared to corresponding samples in the healthy group. In the case of laterite and alluvial loam types, samples from healthy areas have a higher status of total potash than those from diseased areas.

2. Regarding available potash, all the samples examined are rather deficient. However, samples from the healthy areas of all the types have a higher status of available potash than corresponding samples from diseased areas.

3. As far as exchangeable potassium is concerned, there is no significant difference between healthy and diseased areas of the sandy and laterite types. But samples from healthy areas of the alluvial and red loam types have a better status of this constituent than those from corresponding diseased areas.

The general conclusion appears to be that the soils of diseased areas have a lower status of available and exchangeable potassium than soils from healthy areas, and that a deficiency of this element in the soil, in an available form, might be one of the factors which favour onset of pathological conditions in the coconut palm.

It is well known that symptoms of potash deficiency vary according to the extent of the shortage of the element. In trees a slight deficiency leads to somewhat restricted shoot growth,

and the shoots are thin, while, in the case of severe deficiencies, no shoot growth occurs and there is dying off of entire branches. There may be browning of leaf tips, marginal scorching and development of brown spots (Wallace 1951). According to Eckstein et. al. (*loc. cit*) symptoms of a deficiency of potash in the plant become noticeable only some time after the concentration of potash in the plant becomes so low that normal functioning of metabolic processes is no longer possible. This fact might have some relation to the observation that the external symptoms of 'root' disease become clearly manifest only some time after the onset of the disease, and that young seedlings are rarely found to be affected. The same authors have also stated that in potash deficient plants, the root portions are more seriously damaged than the aerial portions. Wallace (1928) has shown that a deficiency of potash has a greater detrimental effect on the root development of biennial and perennial plants than of annuals. Another symptom of potash deficiency is that the leaves lack substance and appear flaccid. The marked deterioration of the root system and the flaccidity of leaflets exhibited by palms affected by the 'root' disease, might possibly be the result of a deficiency of potassium in the soil.

Bain (1937) working on the 'bronze leaf wilt' of coconut palms in Trinidad, had reported that the potash and phosphate status of diseased palms was lower in relation to the nitrogen status. The same worker, reporting on a similar disease of

coconut palms in Jamaica (1940) had recommended an improvement in the potassium status of the soils of diseased areas, to enable the trees to put up better resistance to drought conditions. On the other hand Dwyer (1939) has reported that examination of soil samples from healthy coconut areas and areas where 'frond choke' disease was prevalent, failed to reveal any correlation between disease incidence and deficiencies of any of the major nutrients. The bronzing and chlorosis of oil palms in West Africa have been tentatively ascribed to a deficiency of potassium by Hale (1947).

It is also possible that potassium deficiency might be an indirect cause of the diseases, in that it may reduce the resistance of the palms to attack by parasites. It is a well known fact that potash deficiency makes plants more susceptible to diseases and pests, and that certain diseases caused by parasitic root fungi can be controlled by applications of potassic fertilisers. Thus Young (1938) and Smith (1940) have shown that applications of potash reduce incidence of cotton wilt caused by the fungus *Fusarium vasinfectum*. A reduction in the percentage of infection by the potato wart organism has been claimed by Leszenko and Szymanski (1938) to follow application of potash salts to artificially inoculated field plots in Poland. It is considered quite probable that a deficiency of potassium might be a factor which predisposes coconut palms to attack by plant pathogens.

The conclusion arrived at regarding the potash status of coconut

soils and incidence of the diseases cannot be considered as final. This has to be confirmed by leaf analysis, pot culture trials and field experiments. However, it is interesting to note that the results of an examination of leaf samples from healthy and diseased palms reported by Sankarasubramoney et. al. (1952) appear to support this conclusion. It has been recorded that in leaf samples from diseased palms there is an accumulation of nitrogen, phosphorus and magnesium, and that there is no difference between leaf samples from healthy and diseased palms in their contents of calcium and potassium. It is now well known that certain plants when affected by some diseases, have the property of accumulating nutrients in their leaf tissues. For example Rhind et. al. (1937) have recorded a higher mineral metabolism of sesamum plants affected by phyllody. In the same way, diseased coconut palms appear to accumulate nutrients in their leaf tissue. The fact that out of the five elements determined, only three were found to be in excess in diseased leaves can be explained by the hypothesis that the soils on which the diseased palms were growing, were deficient in the other two elements. It is to be presumed that if sufficient quantities of calcium and potassium were present in the soil, an accumulation of these elements also might be expected in the leaves of diseased palms.

Summary

(1) Careful analysis of soil samples has shown that there is a significant difference between healthy and diseased areas in their status of

STUDIES ON SOIL CONDITIONS IN RELATION TO THE 'ROOT' AND 'LEAF'
DISEASES OF THE COCONUT PALM IN TRAVANCORE-COCHIN.

available and exchangeable potassium. There is a higher concentration of these factors in the samples from healthy areas, as compared to samples from diseased areas, although the difference is not so marked in the case of exchangeable potassium.

(2) The symptoms exhibited by palms affected by 'root' disease appear to have resemblance to those generally attributed to a deficiency of potassium.

(3) Lack of accumulation of potassium in the leaf tissues of diseased palms as evidenced by leaf analysis, tends to give support to the conclusions mentioned earlier.

(4) Pot culture and field trials are considered necessary before these conclusions can be considered as final. These trials are in progress.

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References

1. Sankarasubramoney, H., Pandalai, K. M., and Menon K. P. V. 1955. *Ind. Coc. J.* Vol. VIII. No. 1. P. 5.
2. Sankarasubramoney, H., Pandalai, K. M., and Menon K. P. V. 1956, *Ind. Coc. J.* Vol. IX No. 1. P. 20.
3. Pillai, N. K. 1919. *Agri. J. India.* Vol. 14. P. 608.
4. Eckstein, O., Burno, O., and Turrentine, J. W. 1937. '*Potash Deficiency Symptoms*', 2nd edition. M. B. H. Berlin.
5. Jacob, A., and Coyle, V. 1926. Cited by R. E. P. Dwyer in *New Guinea Agricultural Gazette* (1940) Vol. 6 P. 24.
6. Pandalai, K. M., Sankarasubramoney, H., and Menon K.P.V. *Ind. Coc. J.* VII. No. 1. P. 20. (Reprinted in Potash Reviews, August 1955: International Potash Institute, Berne, Switzerland).
7. Salgado, M. L. M. 1953 *Tropical Agriculturist.* Vol. CVII-P. 92.
8. Miller, E. V. 1933. '*Within the living Plant*'. Blackiston Co., Inc. P. 173.
9. Fujiwara and Iida, S. 1955. *Tohoku J. Agric. Res* Vol. 6 P. 57. (Also, Potash Reviews Nov. 1955. International Potash Institute, Berne).
10. Schaffnit, E., and Volk, A. 1930. *Phytopathology., Zeitchr.* Vol. 1. P. 535.
11. Hoblyn, T. 1931. *J. Pomology and Hort. Sci.* Vol 9. P. 303.
12. Menon, K. P. V., and Nair U. K. 1952. *Ind. Coc. J.* Vol. 5 No. 2 P. 71.
13. Patel, J. S. 1938. '*The Coconut*' A Monograph. Government Press, Madras.
14. Wallace, T. 1951, '*Diagnosis of mineral deficiencies in plants*'. H. M. S. O. London.
15. Wallace T. 1928 *J. Pomology and Hort. Sci.* Vols. 6 and 7.
16. Bain, F. M. 1957. '*Bronze leaf wilt disease of coconut palms*'. Trinidad Government Printing Office.
17. Bain, F. M. 1940. '*Report on the coconut growing areas of Jamaica*'. *Dep. Sci. Agri. Jamaica. Bull.* No. 22.

SANKARASUBRAMONEY, K. M. PANDALAI AND K. P. V. MENON

18. Dwyer, R. E. P. 1939. *New Guinea Agri. Gazette.* Vol. 5. No. 3. Page 51.
19. Hale, J. B. 1947. *J. Agri. Sci.* Vol. 37. P. 236.
20. Young, V. H. 1938. *Ark. Agri. Exp. Sta. Bull.* 358.
21. Smith, A. L. 1940. *Phytopathology.* Vol. 30. P. 707.
22. Leszezenke, P., and Szymanski, W. 1938. *Rev. Appl. Mycol* Vol. 18, P. 199.
23. Sankarasubramoney, H., Pandalai, K. M., and Menon, K. P. V. 1952. *Ind. Coc, J.* Vol. 6. No. 1. P. 7.
24. Rhind, D., Odell, F. D., and Thetsu, W. 1937, *Ind. J. Agri. Sci.* Vol. 7. P. 823.
25. Georgi C. D. V. and Teik G. L. 1932. *Malayan Agri. J.* 20 P. 358.
26. Cooke F. C. 1950. *Ceylon Coconut Quart.* 1 P. 17