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# 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. | 135.37 | 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

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 deficiency 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 $K_2O$% | Avail -able $K_2O$% | Exchangeable K (mgm. eq/ 100 gms.) | Lab. No. | Total $K_2O$% | Avail -able $K_2O$% | 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 | Traee | 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 | | | | |
| 9 | Trace | Trace | Trace | 27 (b) | Trace | Trace | Trace |
| 10 | Trace | Trace | Trace | 28 (a) | Trace | Trace | Trace |
| 11 | 0.011 | Trace | Trace | | | | |
| 12 | 0.038 | Trace | Trace | 28 (b) | Trace | Trace | Trace |
| 13 | 0.006 | Trace | Trace | 28 (c) | Trace | Trace | Trace |
| 14 | 0.004 | 0.002 | Trace | | | | |
| 15 | 0.047 | 0.005 | Trace | 29 | 0.012 | Trace | Trace |
| 16 | 0.004 | Trace | Trace | 30 (a) | 0.013 | Trace | Trace |
| 17 | 0.065 | Trace | Trace | | | | |
| 18 | 0.022 | Trace | Trace | 30 (b) | 0.004 | Trace | Trace |

**Abstract of Table 2**

| Factor | | Diseased | | Healthy | |
|---|---|---|---|---|---|
| | | A Horizon | B | A | B |
| Total $K_2O$ | Mean | 0.013 | 0.009 | 0.005 | 0.010 |
| | Range | 0–0.047 | 0–0.038 | 0–0.032 | 0–0.038 |
| Available $K_2O$ | Mean | 0.001 | Trace | 0.002 | 0.002 |
| | Range | 0–0.005 | 0–0.002 | 0–0.011 | 0–0.013 |
| Exchangeable K | Mean | Trace | Trace | Trace | Trace |
| No. of readings | Range | 0–0 | 0–0 | 0–0 | 0–0 |
| | | 10 | 8 | 6 | 6 |

**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 $K_2O$% | Available $K_2O$% | Exchangeable K (mgm. eq/100 gms.) | Lab. No. | Total $K_2O$% | Available $K_2O$% | 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 $K_2O$ | 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 $K_2O$ | 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 $K_2O$% | Available $K_2O$% | Exchangeable K (mgm.eq/100 gms.) | Lab. No. | Total $K_2O$% | Available $K_2O$% | Exchangeable K (mgm.eq/100 gms.) |
| 59 | 0.095 | Trace | Trace | 68 | Trace | Trace | Trace |
| | | | | 69 | 0.015 | Trace | 0.015 |
| 60 | 0.088 | Trace | Trace | | | | |
| 61 (a) | 0.116 | Trace | Trace | 70 (a) | Trace | Trace | Trace |
| 61 (b) | 0.080 | Trace | Trace | 70 (b) | 0.015 | Trace | Trace |
| | | | | 71 (a) | 0.035 | Trace | 0.25 |
| 62 (a) | 0.059 | Trace | Trace | 71 (b) | 0.132 | 0.006 | 0.97 |
| 62 (b) | 0.006 | Trace | Trace | | | | |
| 63 | 0.019 | Trace | Trace | 72 | 0.029 | Trace | Trace |
| | | | | 73 (a) | 0.032 | Trace | Trace |
| 64 | 0.034 | Trace | Trace | 73 (b) | 0.032 | Trace | Trace |
| 65 | 0.065 | Trace | Trace | | | | |
| | | | | 74 | 0.046 | Trace | Trace |
| 66 | 0.050 | Trace | Trace | 75 (a) | 0.046 | Trace | Trace |
| 67 (a) | 0.023 | Trace | Trace | 75 (b) | Trace | Trace | Trace |
| 67 (b) | 0.023 | Trace | Trace | | | | |
| | | | | 76 | 0.048 | Trace | Trace |
| | | | | 77 (a) | Trace | Trace | Trace |
| | | | | 77 (b) | Trace | Trace | Trace |

**Abstract of Table 4**

| Factor | A. Horizon | Diseased B | Diseased A | Healthy B |
|---|---|---|---|---|
| Total $K_2O$ | 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 $K_2O$ | 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 |

**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 $K_2O$% | Available $K_2O$% | Exchangeable K (mgm.eq/100 gms.) | Lab. No. | Total $K_2O$% | Available $K_2O$% | 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 $K_2O$ | 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 $K_2O$ | 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 |

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 possibily 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 Leszesenko and Szymanski (1938) to follow application of potash salts to artificially innoculated 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 seasamum 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

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.

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. Leszczuke, P., and Szymanski, W. 1958. *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