

ON THE NUTRITIVE CONTENTS OF THE LEAF TISSUES OF THE COCONUT PALM IN HEALTH AND IN DISEASE

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INTRODUCTION

THE idea of using the concentration of nutrients present in the plant as an index of their availability in the soil has been repeatedly put forward by different workers in various countries. Thus in Germany, Wagner¹ in 1920 determined the potassium and phosphate requirements of meadow soils by the analysis of hay. Gilbert² in 1927 proposed taking the composition of plant sap as an 'index of fertiliser needs'. Lagatu³ in 1930 undertook an investigation of leaf diagnosis ("Diagnostique foliare"), in studying grape vines and potatoes. The investigations of Mitchell⁴ in 1936 on conifers lead to the belief that much valuable information regarding tree nutrition and the chemical aspects of site quality could be obtained from leaf analysis. Thomas⁵, Thomas and Mack⁶, Moser⁷, Beauchamp⁸, Boynton et al⁹, Chapman¹⁰, etc. in N. America are among those who pursued the idea of plant analysis. The last named worked on rubber trees and suggested taking the

percentage of potassium, phosphoric acid and nitrogen in the leaves as a measure of the fertiliser requirements of the trees. Many more instances of the above kind are described in Mitchell's¹¹ book.

The possibility of correlating the chemical composition of plant tissues, and the yield of the plant at the time of analysis, with the fertiliser needed to obtain maximum economic yields, has received extensive attention, as shown by the work of Weinhold¹² as early as 1862, and Hellreigel¹³, 1867. They were among the pioneers to test the relation of plant composition to yield and nutrient availability. In the early stages, the whole plant was the test tissue for analysis, but ultimately, the leaf has been chosen as the tissue which would give analytical figures of indicative value. A good deal of interest has thus been aroused recently in the method of determination of the manurial requirements of crop plants from the amounts of nutrients contained in their leaves. Leaf analysis is now an accepted method for the determination of the nutritional status and manurial requirements of soils. Also, leaf analysis has been widely applied to the growing crop to find out the nature and extent of any deficiency which might be responsible for disease conditions of the crop. In the control of such diseases also, the analysis of the leaf tissue has proved very useful in judging the time

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of application and the quantity of nutrient to be applied to overcome the deficiency. Lagatu and Maume¹⁴, Thomas¹⁵, Mitchell (loc. cit)

It is quite natural to expect that the nutrient content of a particular plant tissue would have certain connections with the nutrient status of the soil on which the plant grows. It is known that the supplies of nutrients in the soil are not inexhaustible. What has been removed from the soil by cropping has ultimately to be resorted in order to prevent decline of yields as well as to preserve soil fertility. This requirement can be computed from plant analysis data which can show how much of the nutrients are taken up from the soil by the plant and how much released as fruits, etc., without being returned to the soil. Moreover, since soil conditions are intimately associated with plant growth it is possible that the healthy or diseased condition of a crop might be the result of the availability or otherwise of optimum conditions for healthy plant growth in the soil.

The results of a preliminary examination of soils by Menon and co-workers¹⁶ had tended to show that deficiency of plant food ingredients in the soil might be one of the factors responsible for the root disease of the coconut palms prevalent in S. India. It was decided to confirm this result by systematic foliar diagnosis methods. Hewitt¹⁷ has recently discussed in detail the interesting possibilities of this method. Hale¹⁸ has studied the mineral composition of leaflets in relation to the chlorosis and browning of oil palms in W. Africa. Among others who have used the foliar diagnostic technique may be mentioned Wander and Brode¹⁹ who determined the availability of potassium in the soil

by spectrographic analysis of leaves, Scarseth²⁰, Ulrich²¹, Chapman and Brown²² who used the method for citrus, Harrington²³ who used it for beans, Plice²⁴ who used it for trees, Tyner and Webb²⁵ who used it for maize and Goodall²⁶ who used it for apple trees.

What follows, is a brief account of the work done by us in this station, with special reference to the major nutrient status of the leaf tissues of the coconut palm. Leaf tissues from healthy and diseased (root disease) palms have been examined in detail to find whether a deficiency condition of any one of the major nutrients could be a factor inducing onset of the disease. The safest procedure in these studies would be to compare extremely diseased trees with a range of the more healthy ones of comparable age that can usually be found growing nearby, and with comparable really satisfactory trees from elsewhere as suggested by Roach²⁷.

MATERIALS AND METHODS

For this study, the leaf tissue has been chosen since the leaf forms the important site of growth processes and metabolic activity. Twelve palms, growing in the same garden at Kayangulam were selected. The trees were of approximately the same physiological age. The soil in the garden was of the sandy type and poor in its content of all the major nutrients. Three of the twelve palms were quite healthy, three in the early stage of the disease, three in the middle stage of the disease and the remaining three in the advanced stage of the disease. (Disease in this case was the "root disease" mentioned in earlier papers, although in a few palms this was also accompanied by leaf disease). It may be mentioned here, that this differentiation in the stages of the disease was based mainly on visual

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symptoms, and the following classification was followed in deciding to which stage of the disease the particular tree belonged.

Healthy.—Leaves growing to full length and entirely green; i.e., free from any yellow spots.

Early stage of disease.—Brown or yellow patches on the older leaves showing commencement of the disease.

Middle stage of disease.—The outermost eight to ten leaves showing a distinct yellowing.

Advanced stage of disease.—Almost all the leaves except the innermost ones showing a severe yellowing. Yields very low and in most cases nil.

Samples of leaf were drawn from these trees for four consecutive years. The sampling was done during the months of July—August, i.e., just after the S. W. monsoons, thus giving due consideration to the emphasis, attached by certain workers, notably Halais²⁹ on the importance of adequate rainfall prior to sampling to obtain reliable results. Previous workers who had examined the leaf tissues of other palms, notably Hale (loc-cit) had arrived at the conclusion that there is significant variation in the nutrient content of different leaves, but not of different leaflets in the same leaf. Hence for the study described here samples were taken from the inner, middle, and outer leaves of each tree. The inner leaf was taken as the latest fully developed green leaf, the outer leaf was the oldest but still not dried up leaf,

and the middle leaf was the one which was midway between these two. Leaflets were selected at random from the whole length of the leaf, dried, crushed and a complete sample taken. In all cases, the leaflets were sampled along with their midribs. The crushed samples were dried in an air oven at 105°C. and stored in air tight containers.

The methods of analysis adopted for the determination of the major nutrients were those described by Piper²⁸ in his "Soil and Plant Analysis".

The dry ashing method was used to convert the material to ash, and the ash was then dissolved in hydrochloric acid and the extract used for the determination of calcium, magnesium, phosphoric acid and potash. Calcium was determined by the volumetric oxalate method, magnesium by the gravimetric pyrophosphate method, and phosphate was estimated as the molybdate. Potash was determined by the gravimetric cobaltinitrite method. Nitrogen in the dry sample was estimated by the Kjeldahl method. In all cases the results have been expressed as percentages of the oven dry material.

PRESENTATION OF RESULTS

In table I are presented the results of analysis of the leaf samples. Each figure represents the average of four years' values. Results of the statistical analysis of the above values are given in tables 2, 3, 4, 5 and 6. The values have also been given a graphical representation in Figs. 1 to 5.

TABLE I
Nutrient content of coconut leaves from healthy and diseased palms (Average of 4 years values)

o—Sample from leaf in outer whorl.
 m—Sample from leaf in the middle whorl.
 i—Sample from leaf in the inner whorl.

Stage	Tree No.	Mg O %			Ca O %			P ₂ O ₅ %			K ₂ O %			N %		
		o	m	i	o	m	i	o	m	i	o	m	i	o	m	i
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Healthy	65	0.25	0.23	0.22	0.60	0.57	0.47	0.34	0.34	0.34	0.49	0.51	1.06	1.39	1.48	1.01
	107	0.25	0.28	0.24	0.36	0.28	0.18	0.29	0.35	0.44	0.32	0.75	1.39	1.25	1.62	1.05
	198	0.23	0.19	0.20	0.42	0.36	0.32	0.26	0.23	0.41	0.16	0.55	1.30	1.32	1.63	1.03
Early stage of root disease	39	0.14	0.28	0.27	0.39	0.60	0.37	0.23	0.38	0.55	0.38	1.05	1.95	1.09	1.74	1.39
	172	0.16	0.20	0.23	0.54	0.39	0.39	0.25	0.36	0.47	0.22	0.66	1.43	1.49	1.73	1.30
	220	0.11	0.21	0.19	0.31	0.37	0.29	0.26	9.41	0.42	0.27	0.83	1.61	1.30	1.97	1.16
Middle stage of root disease	84	0.20	0.27	0.20	0.52	0.46	0.55	0.37	0.34	0.46	0.17	0.47	1.49	1.24	1.67	1.21
	128	0.25	0.16	0.24	0.60	0.43	0.42	0.40	0.51	0.94	0.73	0.81	2.76	1.82	1.99	2.48
	151	0.20	0.24	0.27	0.44	0.47	0.54	0.38	0.41	0.55	0.66	1.08	1.91	1.53	1.70	1.68
Advanced stage of root disease	76	0.36	0.30	0.29	0.46	0.42	0.30	0.46	0.34	0.67	0.13	0.55	1.42	1.46	2.04	1.88
	126	0.28	0.31	0.39	0.48	0.44	0.87	0.44	0.45	0.77	0.29	0.65	1.64	1.41	1.77	2.02
	206	0.16	0.57	0.27	0.37	0.33	0.30	0.36	0.50	0.83	0.29	0.78	1.70	1.44	1.50	1.34

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TABLE 2
Statistical examination of the analytical data
Lime (Ca O)

Stages	Leaf			Stage mean	Significance 0.05%		Critical difference	
	Outer	Middle	Inner		Leaves	Stages	Leaves	Stages
Healthy ..	0.460	0.403	0.323	0.395	} Not significant	} Not significant
Early stage of disease ..	0.413	0.453	0.350	0.405				
Middle stage of disease ..	0.520	0.453	0.503	0.492				
Advanced stage of disease ..	0.437	0.397	0.490	0.441				

TABLE 3
Magnesia (Mg O)

Healthy ..	0.210	0.233	0.220	0.221	} Not significant	Yes	..	0.82
Early stage of disease ..	0.137	0.230	0.230	0.199				
Middle stage of disease ..	0.217	0.223	0.237	0.226				
Advanced stage of disease ..	0.267	0.393	0.317	0.326				

TABLE 4
Nitrogen (N)

Healthy ..	1.320	1.577	1.030	1.309	} Yes	Yes	0.22	0.2(8)
Early stage of disease ..	1.293	1.813	1.283	1.463				
Middle stage of disease ..	1.530	1.787	1.790	1.702				
Advanced stage of disease ..	1.437	1.770	1.747	1.651				

TABLE 5
Phosphoric acid (P₂ O₅)

Healthy ..	0.297	0.307	0.397	0.334	} Yes	Yes	0.154	0.084
Early stage of disease ..	0.247	0.383	0.480	0.370				
Middle stage of disease ..	0.383	0.420	0.650	0.484				
Advanced stage of disease ..	0.420	0.430	0.757	0.536				

TABLE 6
Potash (K₂O)

Healthy ..	0.323	0.603	1.250	0.725	} Yes	Yes	Just grazes the level of significance	0.38	0.35
Early stage of disease ..	0.290	0.847	1.663	0.933					
Middle stage of disease ..	0.520	0.787	2.053	1.120					
Advanced stage of disease ..	0.237	0.660	1.587	0.824					

Lime (CaO).—There seems to be no statistically significant difference in the lime content of different leaves of the same tree or the same leaves of healthy and diseased trees.

Magnesia (MgO).—There is a significant difference between healthy and diseased trees there being a greater content of MgO in the latter case. The gradation appears to be Advanced → Middle → Healthy → Early; the greatest quantity being in all the leaves of trees in the advanced stage of the disease. There seems to be no significant difference between the different leaves of the same tree.

Nitrogen (N).—There is a significant difference between healthy and diseased trees. There is more of nitrogen in the leaves of trees in the advanced and middle stages of the disease than in those of healthy trees. There is also a significant difference between the different leaves of the same tree; the highest content being in the middle leaves. But trees in the middle and advanced stages of disease appear to be exceptions since the inner leaves of these trees also contain as much nitrogen as the middle leaves.

Phosphoric acid (P₂O₅).—There is a significant difference between the healthy and diseased trees. There is a greater quantity of phosphoric acid in all the leaves of trees in the middle and advanced stages of the disease, as compared with the leaves of healthy trees, and those in the early stage of the disease. There is also a significant difference between different leaves of the same tree. The inner leaves especially of diseased trees contain more phosphoric acid than the outer and middle leaves.

Potash (K₂O).—There is a small significant difference between healthy and diseased trees. The inner leaves of trees

in the middle stage of disease contain more potash than the leaves of trees in the other stages. There is also a significant difference between leaves of the same tree; the inner leaves having a higher concentration than the outer and middle leaves.

These conclusions are very well illustrated in the graphs 1 to 5.

DISCUSSION

The main point of importance arising from the results presented above is the fact that there is a general tendency for most of the nutrients especially N, P and K, the main fertiliser ingredients to accumulate in the leaf tissues of the diseased coconut palm. Rhind, Odell and Thetsu³⁰ discussing certain aspects of phyllody of the sesamum in Burma, recorded a higher mineral metabolism of the diseased plants. This may be due to two factors. Either the physiological processes which convert the plant sap constituents into prepared plant foods or plant products do not occur in the optimum manner, or there is a lack of adequate translocation of these prepared products to the other parts of the plant which require them or store them. Whether the accumulation of important plant food ingredients in the diseased leaf tissue is the result of impaired physiological processes, or whether this condition is due to inadequate translocation facilities are the main points on which more data is required before clear-cut conclusions could be drawn. Work to elucidate these aspects is now in progress. Taking for example the nitrogen constituent of the plant sap; if the different forms in which the nitrogen is existing in the leaf tissue could be estimated, we could have a clear idea as to which of the above processes is impaired. Thus if the nitrogen

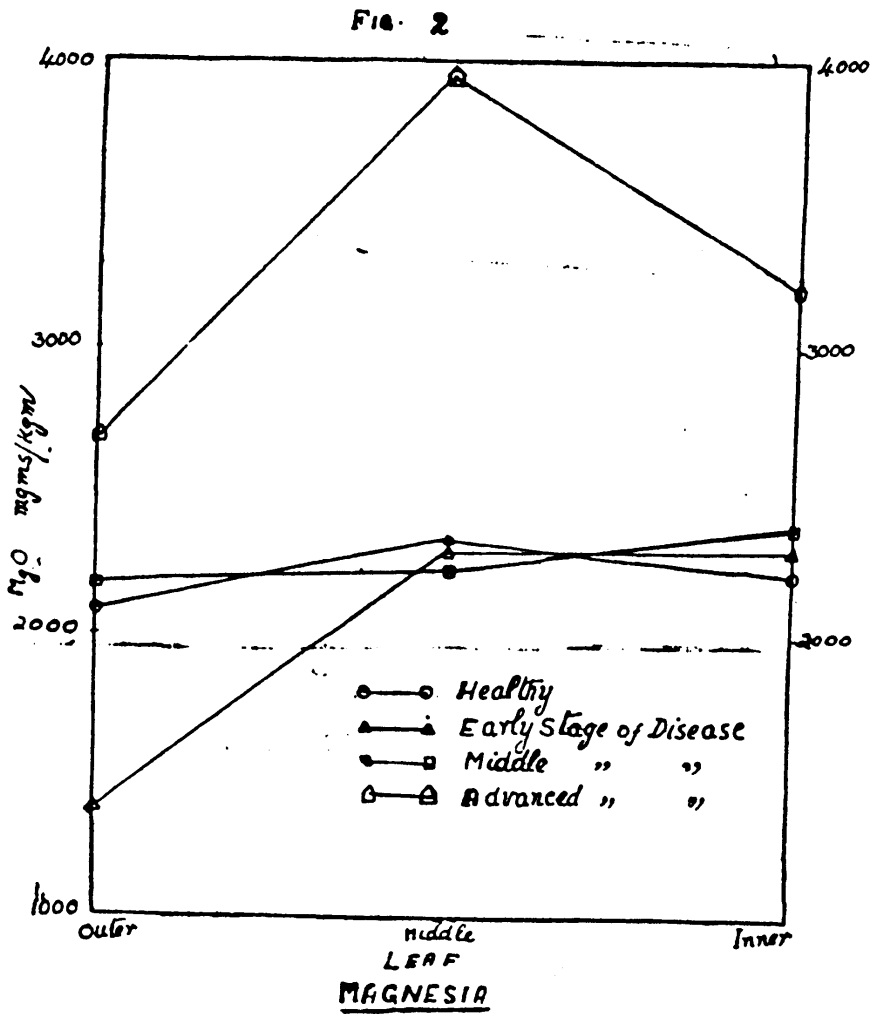
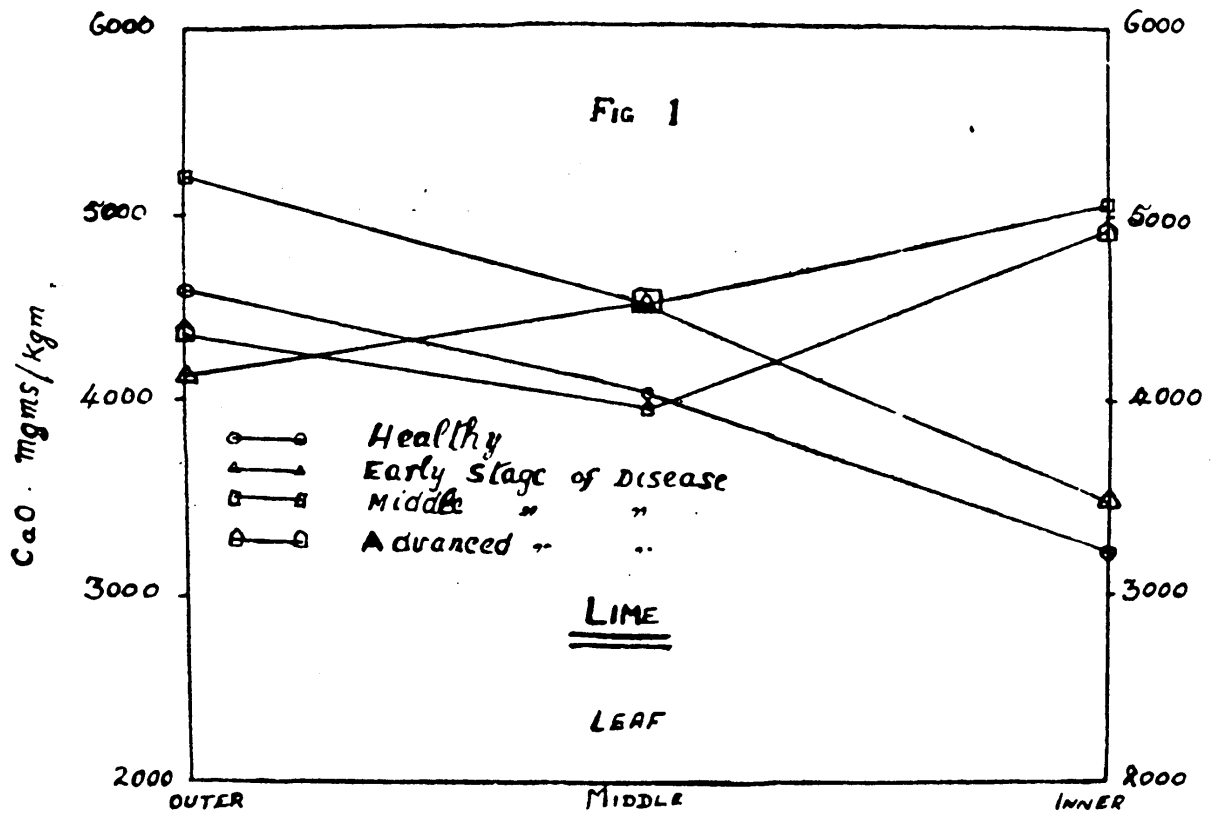
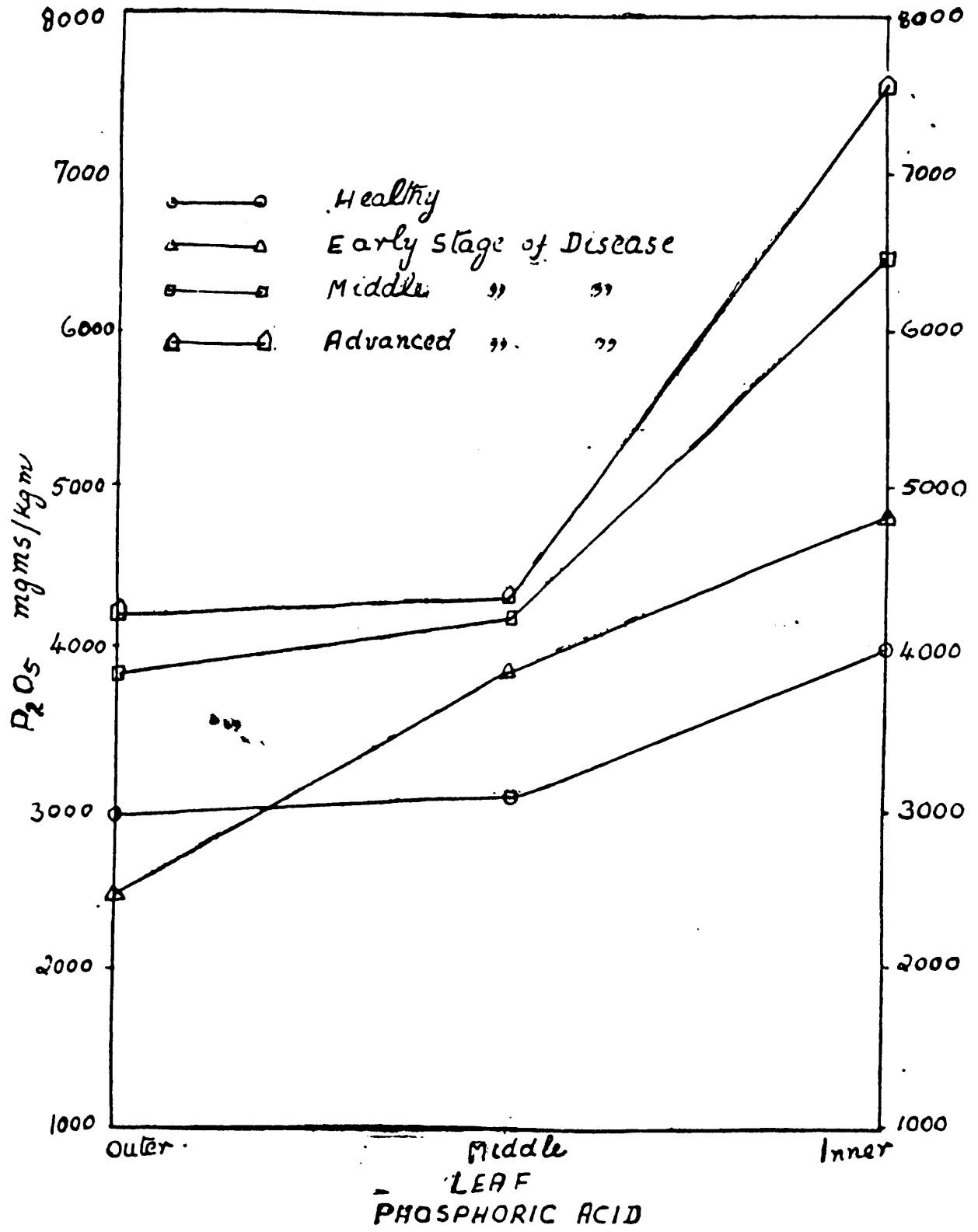
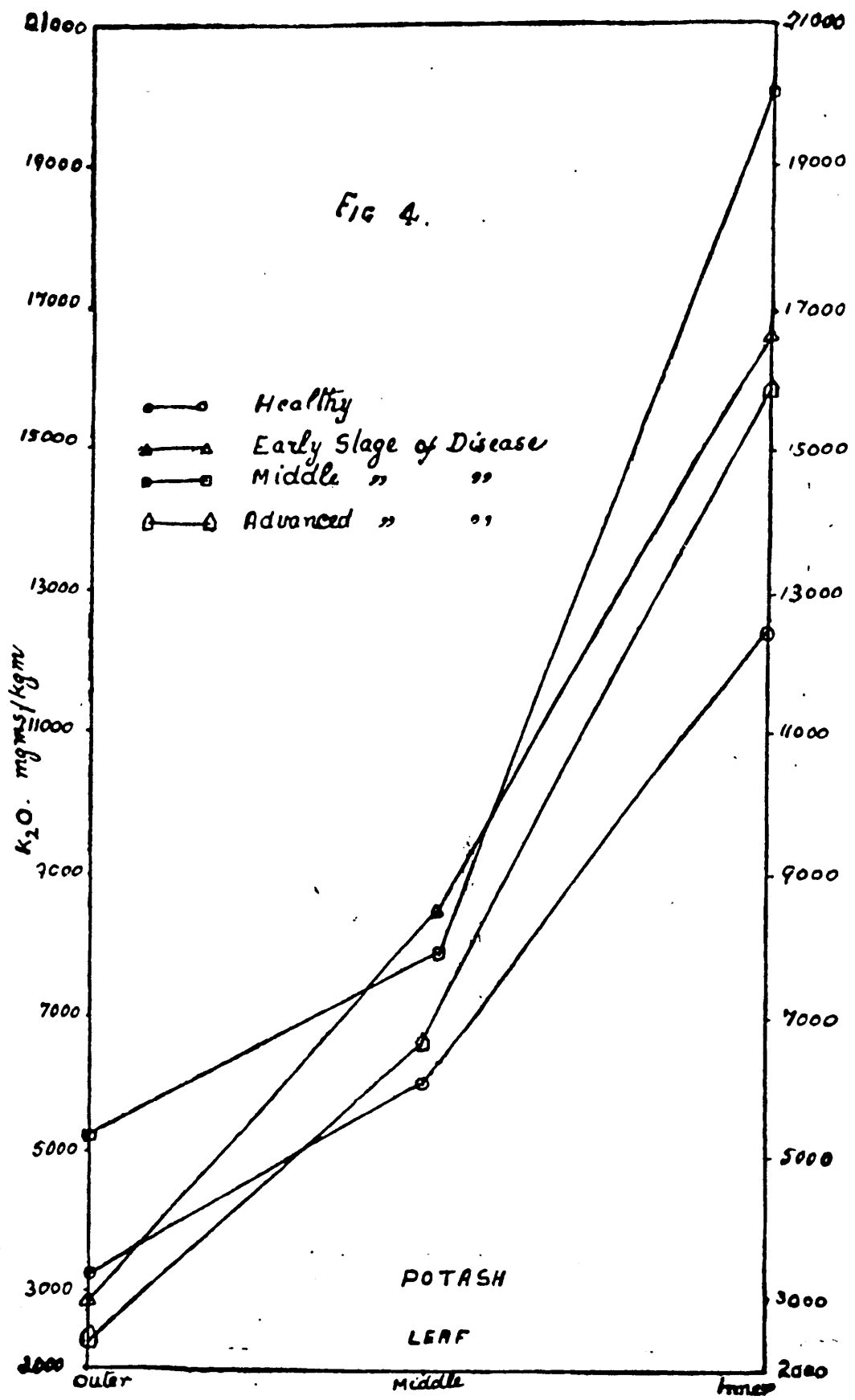


Fig. 3





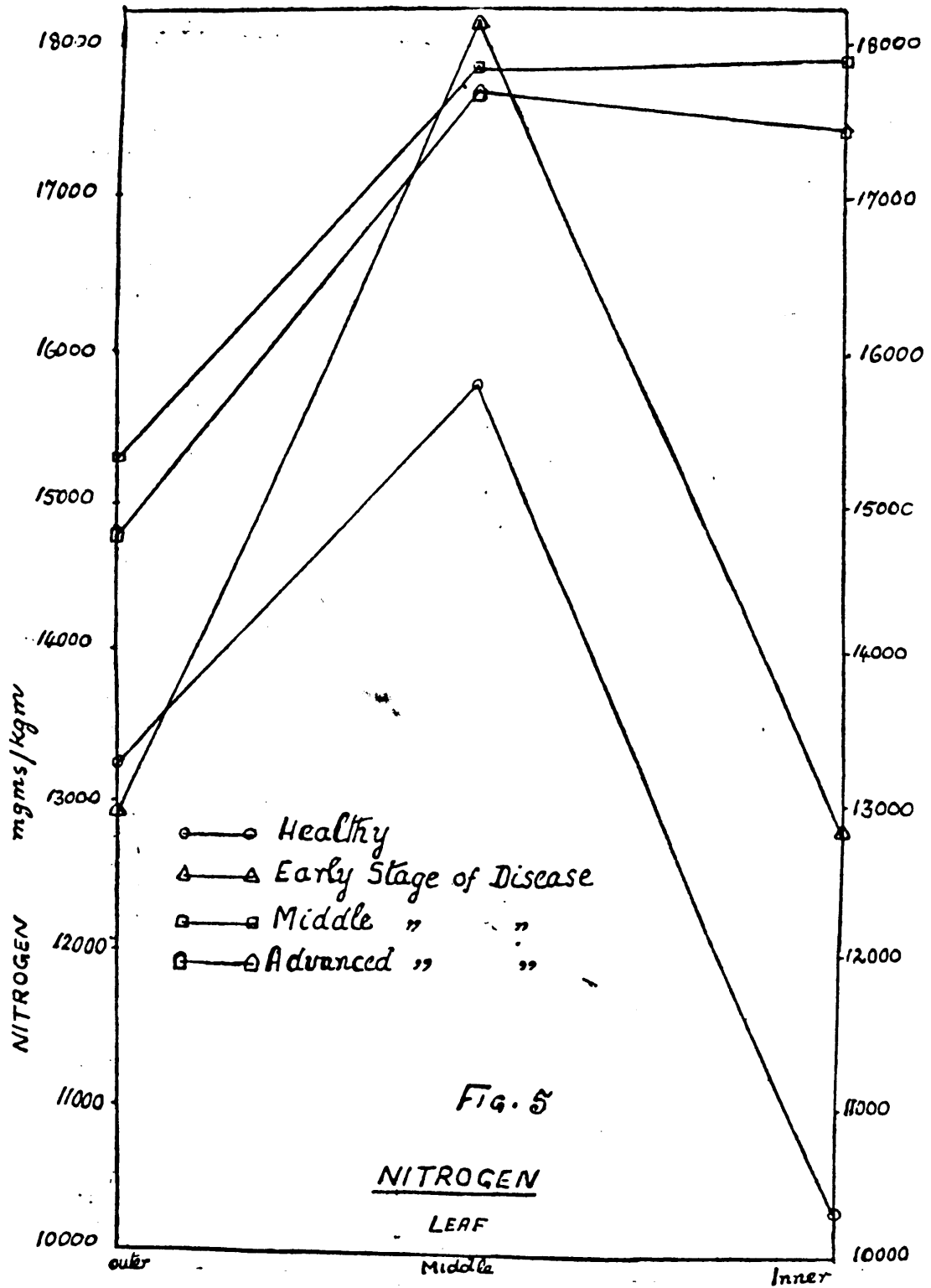


Fig. 5
NITROGEN
 LEAF

is in the soluble inorganic form, it may mean, that conversion of the nitrogen into complex organic forms has not taken place. If however, the nitrogen is in the insoluble or protein form, we could conclude, that the nitrogen has been physiologically converted into plant metabolic products. Under the former conditions there may be assumed to exist a lack of facility for optimum plant processes to occur. In the latter case unsatisfactory translocation facility may be associated with the accumulation. These aspects take us to the healthy or diseased condition of the conducting and translocating vessels, the xylem and the phloem. These again point to the importance of the different histological and plant physiological aspects of the coconut palm. It may also be seen that the use of leaf analysis methods for the determination of nutrient status requirements of the plant in health and disease, evidently presents a number of problematic features. Numerous factors, such as climate, varietal factors, soil structure, moisture capacity, agronomical practices and others influence the interpretation of data. The data cannot also be expected to give straight-forward results, as they are the sum total of several algebraic effects. Also, there can be great divergences in the range of variation from tree to tree, and from leaf to leaf, particularly since we are dealing with a perennial plant. The problem is also complicated by the greatly differing powers of soils to fix nutrients and the effects of these on nutrient availability. It may also be pointed out in this connection, that these concern more, the plant physiological view points than the application of soil chemical view points or the problems of manuring. Whether, with the plant sap, toxic substances from

the soil also find their way into the leaf tissue, and there cause the different effects, is also an important question which cannot be excluded from these considerations.

SUMMARY

1. Certain disorders causing a sort of chlorosis and necrosis of the foliage of coconut palms in Travancore-Cochin have been investigated by foliar analysis, for potassium, calcium, magnesium, phosphorous and nitrogen.

2. Statistical examination of the data of chemical analysis of the leaflets from different fronds, from healthy trees as well as trees in the different stages of the disease, showed an accumulation of the nutrient factors in the leaves from diseased trees.

3. Different aspects concerning how far possible impaired physiological processes due to disease, or inadequate translocation from the leaf to the other parts of the plant are responsible for the observed accumulation of nutrients in the diseased leaf tissue have been briefly discussed.

4. Further work from the point of view of plant physiological aspects is now in progress.

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