Indian Cocon. J. 3, 1950.

INVESTIGATIONS ON DISEASES OF THE COCONUT PALM IN TRAVANCORE - COCHIN STATE.

STUDIES ON SOIL CONDITIONS IN RELATION TO DISEASE INCIDENCE

By K. P. V. MENON, H. SANKARA-SUBRAMONY AND K. M. PANDALAI

INTRODUCTION

FROM the point of view of soil types the arable portion with respect to coconuts in the Travancore-Cochin State can be broadly divided lengthwise into three main tracts of almost equal width *viz.*, the western coastal tract of loose sandy soil bordering the Arabian sea, the middle tract embracing the plains essentially typical of the sandy loam and the alluvial silty soils of the river basins and thirdly the eastern upland laterite region bordering the foot of the Western Ghats. The coconut palm appears to be a very hardy and adaptable type of perennial and apparently thrives pretty well in all the three soil types. This probably, accounts for the coconut industry being the mainstay of the people inhabiting this part of the sub-continent. By about the beginning of this century, a set of disease conditions of the coconut palms in the State loosely termed "coconut palm disease" but actually consisting of different diseases like "bud rot" "leaf blight", "leaf rot" etc. had assumed such severe magnitude that the Government had to take active steps in going thoroughly into the matter. As a result it was found that the disease had been in actual existence for at least the past seventy-five years and that one or more of these diseases may infect the same palm simultaneously and also that the condition was definitely an infectious one (E. J. Butler 1905). Since then this disease has been steadily on the increase and at present about the whole of Central Travancore consisting of about twelve taluks and the southern portion of the Cochin District may be said to be diseased areas.

The same or similar coconut palm diseases have been encountered in

K. P. V. MENON, B. Sc., Ph. D., D. I. C. is Jt. Director & Coconut Pathologist, K. M. PANDALAI, M. Sc., Ph. D., A. R. I. C., Soil Chemist and H. SANKARA SUBRAMONY B. Sc., Jr. Research Assistant at the Central Coconut Research Station, Kayamkulam.

other coconut growing countries like the Philippines, Jamaica, New Guinea, Bahamas etc. and has attracted the attention and study, notably by Bain (F. M. Bain 1940), Briton Jones (H. R. Briton Jones 1940), Dwyer (R. E. P. Dwyer, 1937, 1938), Martyn (E. B. Martyn 1945, 1948) Leach (R. Leach, 1946) and several others. Although the behaviour of affected palms is suggestive of an infectious disease the view has been held by workers like Leach that the nutrient status of the soil appears to be the primary factor affecting the incidence of the disease. There seems to be the possibility that some deficiency or even a toxicity may occur in the soil throughout the affected areas and he concludes that, if the disease is infectious, it would appear to be either soil-borne or else soil conditions greatly affect the palm's power of resistance. It has also been noticed that the more laxuriantly the palms grow and the better yielding capacity they have, the more susceptible they appear to be to the disease. This fact that palms are definitely more susceptible when they are vigorously and actively growing suggests some significant impairment of normal physiological functions. Dwyer is of the view that diseases which may be associated with soil deficiency, soil exhaustion or impoverished soil conditions were proving to be a very serious menace in New Guinea. The opinion is held by Park (M. Park 1932) that the Ceylon root disease is caused by physical or physiological drought. Bain tried to correlate soil factors with the bronze wilt disease of Trinidad. He collected and examined various soil samples from wilt and wilt-free areas and concluded, from these results, that physical conditions and allied water relationship of the soils are very important factors associated with the disease.

The incidence, symptoms and cause of the diseases in Travancore-Cochin, the physiology of the causal fungi etc. have been described by Menon (1937 - 1949) in the various annual reports on the scheme of research, "Investigations of the Coconut Palm Diseases in S. India" submitted by him to the Indian Council of Agricultural Research and recently by Menon and Nair (Menon K. P. V. and Nair U. K. 1948-1949). They have pointed out in these the importance of soil conditions as a factor intimately associated with the incidence of the disease. It may be seen from the foregoing that the part played by soil factors in relation to disease incidence has been emphasised by most workers who have been investigating the coconut diseases in different parts of the world. They all feel that the nutrient status of the soils is of greater consequence with regard to the incidence of the disease than to the effect of soil conditions on the

development of any virulent parasite in the soil.

On account of the significance attached to the soil conditions, it was decided to study these in relation to the incidence of the disease and an account of the preliminary work done is presented in this paper. The important characteristics of the soils are its physical and chemical composition. Soil samples were collected from diseased and healthy coconut areas for a preliminary survey. The soils were classified as loose sandy soils, sandy loams, red loams, alluvial silts and clayey soils, reclaimed *kari* soils and the upland laterite soils. It is very interesting to note that coconuts appear to thrive well in all these soils, healthy and diseased conditions being often met with in trees growing in all these different soil types. Results of chemical and mechanical analysis of the soils, studies on soil profiles, determinations of base exchange properties etc. have been included and items of work which have to be pursued to throw light on the cause and prevention of the diseases briefly discussed in what follows.

EXPERIMENTAL

Soil samples were collected from representative soil types from both healthy and diseased areas and subjected to chemical and mechanical analysis and other determinations by the well known analytical methods described by Wright (C. H. Wright 1939), Piper (C. S. Piper 1944) and by the A. O. A. C. methods (A. O. A. C. 1935) wherever suitable. In table I is given representative analytical figures for the chemical analysis of typical soil samples representing a 3-foot layer.

Table I

Showing the results of chemical analysis of typical soil samples from diseased areas.

	Western sandy region.		Middle alluvial type.		Eastern laterite type.	
	No. 1	No. 2	No. 1	No. 2	No. 1	No. 2
Moisture per cent	0.30	0.31	6.34	5.86	3.22	4.50
Loss on ignition per cent	0.88	0.98	9.10	7.89	3.40	12.71
Nitrogen per cent	0.032	0.071	0.071	0.082	0.109	0.141
P_2O_5 per cent	0.053	Trace	0.140	0.190	0.084	0.193
K_2O per cent	Trace	Trace	0.114	0.158	0.016	0.195
CaO per cent	0.102	Trace	0.029	0.041	Trace	0.184
MgO percent	0.081	Trace	0.150	0.067	0.066	0.54
Fe_2O_3 per cent	0.53	0.45	8.06	9.40	3.07	10.35
PH. ...	6.7	6.5	6.6	6.6	4.5	5.9

In this table as well as in the succeeding one the figures given are typical and chosen from the results tabulated after examination of over five hundred soil samples from diseased areas. These figures indicate the wide adaptability of the palms to different soil types. A fairly deep rooting tree with no root hairs, the effective absorption of the nutrients depends on an easily available supply of soil moisture. A soil with a hard layer within the root zone is undesirable to the palm since this in the rainy season causes water logging and consequent lack of facility for adequate root aeration. During the drought periods such physical properties of the soil as are responsible for regulating the soil moisture, drainage conditions and availability of nutrients are important factors in coconut cultivation. The results of table I also point to the fact the soils from the diseased areas are very much deficient in the essential plant nutrient factors such as nitrogen, phosphoric acid and potash, particularly the potash content when it is to be remembered that from an acre of land coconut cultivation removes 81 lb. of nitrogen, 36 lb. of phosphoric acid (as P_2O_5) and 117 lb. of potash every year according to Eckstein (O. Eckstein et-al 1937) and 57 lb. of nitrogen, 26 lb. P_2O_5 and 85 lb. of potash according to Jacob (A. Jacob et-al 1926). Potash is one of the most important soil ingredients needed for good coconut growth and consequently its presence in an available form is an index of good soil fertility with respect to the coconut palm growth and this indirectly appears to be tied up intimately with the disease resistance capacity of the palms. This condition applies to a wide range of soils from diseased areas studied.

In table II is given the values for the total and available potash and phosphoric acid content of a few representative soil samples from diseased areas.

Table II

Showing the total and available potash and phosphoric acid contents in per cent in soils from highly diseased areas.

Soil type	Locality	Potash		Phosphoric acid	
		Total	Available	Total	available
Laterite	Pandalam	0.216	Nil	0.125	Trace
	Ranni	0.071	Trace	0.147	0.009
	Yeroor	0.042	0.0004	Trace	Nil
Alluvial	Mepral	0.174	Trace	0.109	Trace
	Kaippattur	0.306	Trace	0.055	Trace
	Aranmula	0.296	Trace	0.127	0.008
	Konni	0.273	Trace	0.194	0.005
Sandy	Kumbalangy	Trace	Trace	0.036	Trace
	Vithala	0.024	Trace	Trace	Nil
	Peringalipuram	Trace	Nil	0.031	0.006
	Karthikapally	0.087	0.019	Trace	Nil

The results show that the status of most of the soils with respect to these important plant food factors is an exceedingly impoverished one, compared to the normal requirements of the trees for satisfactory growth and nut production. This is all the more important and the need for replenishment is so evident for profitable cultivation of the coconut specially because the strain of providing plant food for the promotion of the fruit and development of the tree is continual, the coconut palm being one which is fruiting throughout the year (H. C. Sampson, 1923). Coconuts have been grown on these soils for a considerable number of years and the extent to which these fertiliser ingredients have been removed from the soil year by year without adequate replenishment amounts to several thousand tons. The low availability of a food factor such as potash besides affecting the metabolic activities and sustenance level of trees, has also other undesirable repercussions on other soil factors such as for example the base exchange properties and consequently on the release of other plant nutrient ingredients in adequate quantities from the soil. Further Wallace (T. Wallace 1928) has shown that potash deficiency has a greater influence on the root development of perennial plants than on annuals. It has also been demonstrated that the relationship between "potash deficiency" and "parasitism" is specially pronounced in the perennial plants. Again potash deficiency exerts an unfavourable influence on the water utilisation of the plant. This is due to this element causing both impairment of water absorption through the roots and increased loss of water through transpiration which decreases the ability of the palm to withstand drought.

The base exchange capacity, the amount of total exchangeable bases, the percentage base saturation of the soils have been in some cases determined and these results are given in table III. (*Vide* page 86)

The soil samples were collected from experimental plots in the Central Coconut Research Station. A brief description of the soil profile is also given. The area is a highly diseased one and is also representative of a soil type in which the coconut palms thrive well in many parts of the State. The soil is of a loose sandy loam type and the horizons have been demarcated from point of view of difference in the colour and tilth of the soils. The results show that the values for the total exchangeable bases and the base exchange capacity are very low showing their low capacity for retaining the exchangeable bases. This shows that the soils have become very much impoverished in the major plant nutrient factors.

Table III

Showing the base exchange properties of the soils from diseased areas.

Description		P. H.	Total exchangeable bases Mgm. eqts.	Exchangeable Ca. Mgm. eqts.	Exchangeable Mg. Mgm. eqts.	Exchangeable K. Mgm. eqts.	Base exchange capacity Mgm. eqts.	Exchangeable H. Mgm. eqts.	Percentage base saturation
White	0–9"	6.5	2.4	Trace	1.12	Trace	3.25	0.85	73.8
sandy	9"–27"	6.0	1.96	,,	0.80	,,	3.25	1.29	60.3
soil	27"–45"	5.0	1.90	,,	0.64	,,	2.6	0.70	73.3
Greyish	0–8"	5.5	1.1	,,	Trace	,,	4.55	3.45	24.2
brown	8"–17"	5.5	1.06	,,	,,	,,	3.25	2.79	32.6
Brown	17"–72"	6.0	1.25	,,	,,	,,	3.9	2.65	32.1
Grey	0–15"	5.5	0.63	,,	,,	,,	3.9	3.27	16.2
sand	15"–48"	5.0	0.50	,,	,,	,,	3.8	3.5	7.9
Brown sand	48"–72"	5.0	0.78	,,	0.30	,,	5.85	5.07	13.3
Grey	0–21"	6.5	0.54	,,	Trace	,,	1.96	1.42	27.6
sand	21"–37"	6.5	0.16	,,	,,	,,	4.9	4.74	3.3
Brown	37"–53"	6.0	0.16	,,	,,	,,	7.35	7.19	2.2
sand	53"–60"	7.0	0.48	,,	,,	,,	1.47	0.99	32.7

Since it is known that both the clay and humic fractions of a soil contribute to its exchange capacity and since weight for weight the organic exchange complex possesses an exchange capacity several times that of the inorganic fraction, it was decided to carry out the mechanical analysis of a few soil samples as well as the analysis of the clay fractions and some of these results are presented in the tables 4 and 5 respectively. (*Vide* page 87)

Table IV

Showing the results of mechanical analysis of typical soil samples from diseased areas.

Locality	Gravel	Coarse sand	Fine sand	Silt	Clay	Soluble portion	Total
Kayamkulam	0.60	75.35	17.05	1.00	5.5	0.88	100.38
Changanacherry	10.38	59.75	20.2	5.0	3.0	1.8	100.13
Chathurthyakari	10.05	61.6	20.2	2.0	2.0	3.38	99.23
Nettur	Nil	82.1	11.65	1.5	5.0	0.55	100.8
Keerikkad	3.34	76.76	12.60	3.0	1.0	3.28	99.98
Kadayathur	37.65	56.45	2.30	1.0	2.0	0.71	100.11

These results reveal that the silt and clay contents of the soils especially of the coastal tracts which constitute the chief coconut belts of the west coast are very low being below 6 per cent only, the percentage of inert sand fraction being rather very high. Most of the soluble manures are, therefore, leached out of the soils quickly during the heavy monsoons that usually obtain here. The retentivity of the soils for moisture being thus very low, these soils remain very infertile and the palms unproductive and often diseased, even in regions where occasional manuring is practised. Attempts are now being made to render the soil more retentive by the growth in them of green manures like *Crotalaria striata* and by the application of bulky organic manures, as well as by the addition of clay to these soils. The results of these attempts will be reported later.

Table V.

Showing the composition of the clay fraction of soils from diseased areas.

Source of soil	SiO_2	Al_2O_3	Fe_2O_3	$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Al_2O_3\ Fe_2O_3}$
Sandy soil from Kayamkulam	53.6	35.0	6.8	1.53	1.29
Sandy loam from Chirayinkizh	48.6	39.2	8.0	1.24	1.03
Reclaimed clay from Ochanthuruthu	46.6	35.1	10.6	1.33	1.02

(Please turn to page 99)

(*Continued from page 87*).

From table V it may be seen that the Silica sesqui oxide ratio is slightly higher than should be expected and this in turn has important significance in orienting several properties of the soils rendering optimum plant growth. The soil samples from most of the diseased areas showed a definitely acidic reaction – the pH value being mostly below seven indicating high lime requirements. (Russel 1937). It is interesting to note in this connection that Leach has (loc-cit) reported the nature of soils in diseased areas in Jamaica to be alkaline. Some of the results have been represented graphically in figures 1 to 4 (*vide* pages 102–105) and all of this show the striking contrast between the soils examined from healthy and diseased areas.

DISCUSSION

From the results presented in this paper it may be seen that there appears to be a set of soil conditions under which plant nutrients become unavailable to the palm in the optimum ratios due to their inadequate release in the assimilable form, giving rise to unbalanced nutrition and resulting in the derangement of the normal physiological processes of the palms. A state of impaired resistance to disease attack in the palms results and this provides predisposing conditions for the disease incidence. Among these soil conditions appear to be those inherent in the soil such as a poor water holding capacity, high porosity, conditions caused by excessive acidity in the soils, drought, water-logging and inadequate drainage. There is also a general depletion of the soils caused by excessive and repeated cropping without adequate replenishment coupled with unsatisfactory cultural operations. Deficiency of any particular food factor may be of an absolute or a relative kind. It may arise directly from an acute shortage of the particular element in the soil or from a relative shortage induced or accentuated by an excess of some other element. Thus a deficiency of potassium may arise from an excess of nitrogen or phosphorus. Again deficiencies of the trace elements, iron and manganese are largely determined by the pH of the nutrient medium; these two elements being less readily utilised by plants at high pH values. Boron deficiency is found to be induced by liming and so on. A discussion on deficiency of food factor in relation to disease incidence just touches on the subject as it has long been known that there must be proper balance between the manurial constituents present both in the soils and in the plant, the absorption of nutrients by the palms depending on a set of physiological factors occurring inside the plant and on a set of environmental factors occurring outside the body of the plant. As may be expected the potash over nitrogen ratio (Potash/

Nitrogen) is of the utmost importance in the nutrition of the plant. This emphasises the need for using balanced and complete fertilisers. A number of other aspects also are involved and it can only be said that water and nutrients normally required by the palms not being met under unfavourable conditions of soil and climate leads to pathological symptoms.

In general many of the diseased areas are subject to inundation by the monsoon rains. The consequent water logged condition of the soil precludes all possible facilities for good soil aeration and this brings about a condition of infertility to the soils. It is interesting to note in this connection that there appears to be much significance in the current belief about the disease making itself significantly manifest soon after the great floods of 1882. Most of the coconut palms growing on the banks of the rivers in Central Travancore are generally found to be in a severely affected condition. The fact that apparently quite healthy trees are noticed in highly diseased areas is very intriguing and throws doubt on the validity of the conclusion that soil deficiency is primarily responsible for the disease incidence. This happens in all the different soil types. It has now to be ascertained as to what extent the nutritional deficiencies caused by adverse soil conditions as well as the depletion suffered by the soils are responsible for the appearance of the disease symptoms or for creating predisposing conditions for facultative saprophytes in the soil to assume parasitic roles. Seedlings have to be grown in synthetic sand culture media under controlled conditions and the response of the seedlings to growth in media successively deficient in the major plant nutritional constituents have to be noted. Similar controlled experiments have to be made also with regard to the mechanical composition of the soils. Inoculation experiments conducted on seedlings growing under these different soil conditions might afford valuable evidence with regard to the soil conditions favouring disease incidence.

There may also be quite probably a deficiency of the trace element nutrients in the soil. Diagnostic tests with trace elements as well as controlled agronomical trials are being made in detail at present and the data on all these aspects collected. The chemical and physiological changes that occur at various stages of the growth of the palms are also being investigated in relation to the disease incidence. Indeed the growth of diseased and healthy palms has to be carefully studied throughout the year for the elucidation of the cause of the disease and to discover the methods of cure. These and allied aspects particularly whether the diseases are the results of nutritionl factors alone or respiratory factors alone or whether they are the result of parasitic attack by specific micro-organisms are being investigated in detail in this Research Station.

SUMMARY

1. The coconut palm appears to thrive fairly well in all the three main soil types found in the Travancore-Cochin State.

2. Disease appears in trees growing in all these soil types and the disease symptoms are uniformly the

same irrespective of the locality and nature of the soil type.

3. Compared to healthy areas the results of analysis of soil samples from diseased areas show a highly depleted condition in the major plant food factors particularly in the content of available potash.

4. The soils from diseased areas have a very low clay content and consequently a very low water holding capacity.

5. The base exchange properties of the soils from diseased areas, the composition of the clay fraction etc. reveal that the soils are of a very poor type from point of view of fertility.

6. Various factors which appear to be individually or collectively responsible for the disease incidence are discussed and future lines of work briefly indicated.

7. Additional evidence has been presented with regard to the importance of soil conditions in relation to disease incidence.

Our thanks are due to the Indian Council of Agricultural Research, the Indian Central Coconut Committee and the Government of Travancore for financing these investigations. Thanks are also due to Messrs. V. Sadasivan M. Sc., and K. M. Nair, M. Sc., who have collaborated in this work.

REFERENCES

1. A. O. A. C. "Methods of Analysis" 4th Edition 1935.

2. Bain F. M. Bull. No. 22 Dept. of Sci & Agri. Jamaica 1940.

3. Briton Jones H. R. "The Disease of the Coconut Palm" London 1940.
Trop. Agriculture. 5 suppl. 1928
6 suppl. 1929.

4. Butler E. J. Bull No. 9. Agr. Res. Int. Pusa. 1908.

5. Dwyer R. E. P. New Guinea Agric. Gazette 3 P 28. 1937.
5 P 31. 1939.
6 P 1. 1940.

6. Eckstein O, Burno O and Turrentine J. W.
"Potash Deficiency Symptoms" 2nd Edn. Birlin. 1937.

7. Jacob A and Coyle V. a German booklet. 1926.

8. Leach R. Trop. Agriculture, 23 P 50, 1946.

9. Martyn E.B. Trop. Agriculture, 22 P 51; P 69, 1945.

10. Menon K. P. V. "Annual Reports on the Scheme of Investigations on coconut palm diseases in S. India", 1937 to 1949 and U. K. Nair.
The Indian Coconut Journal
April 1948.
Ibid 2 P 5 – 1948
Ibid 3 P 5 – 1949

11. Park M. Tropical Agriculturist, Ceylon 78 P 11, 1932.

12. Piper C. S. "Soil and Plant Analysis" Adelaide; 1944.

13. Russel E. J. "Soil conditions and Plant Growth" London P 535, 1937.

14. Sampson H. C. "The Coconut Palm", London P 201, 1923.

15. Wallace T. Jour Pomology and Hort Sec. 6 and 7, 1928.

16. Wright C. H. "Soil Analysis" London 1939.

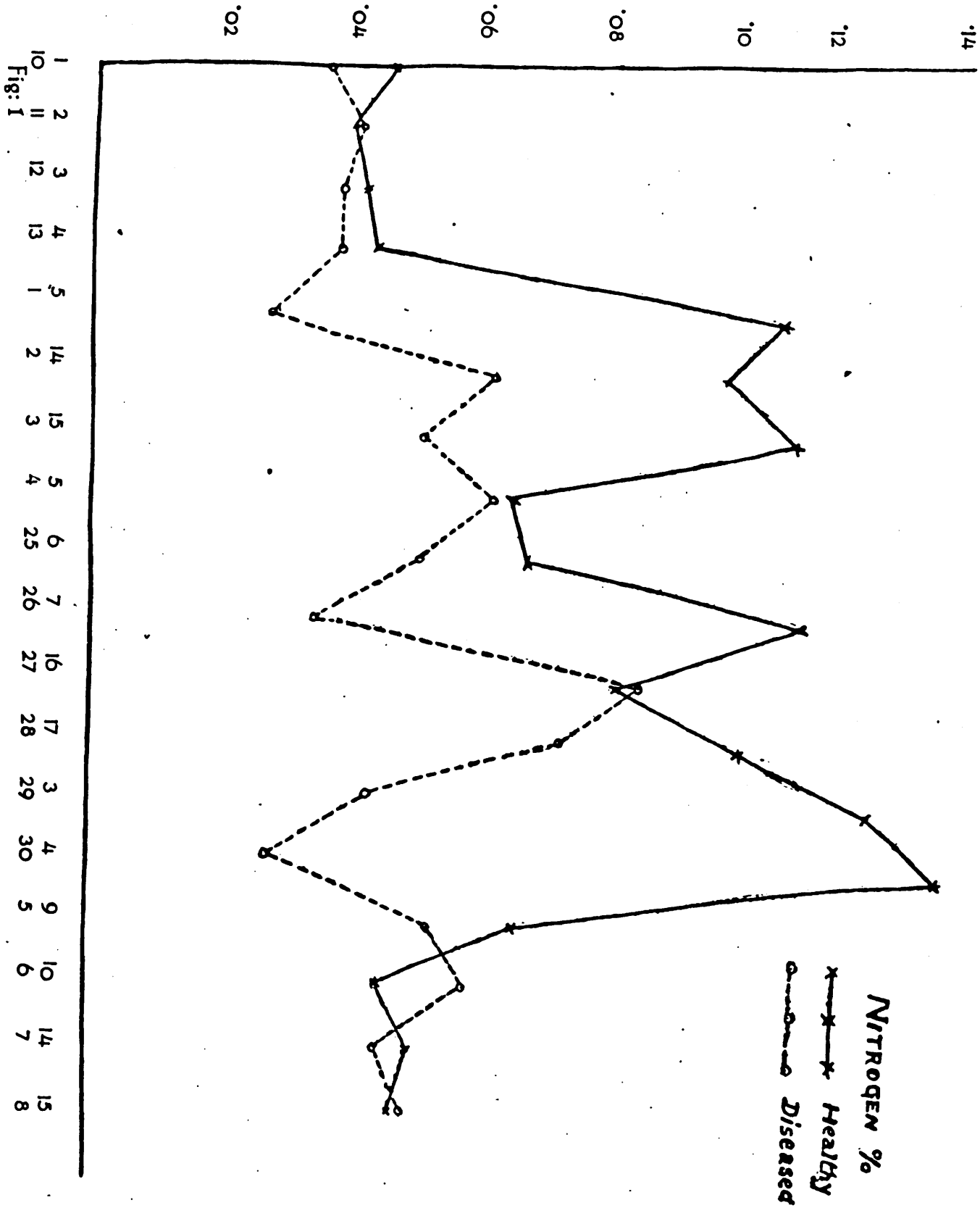

.02
.04
.06
.08
.10
.12
.14
1 10
2 11
3 12
4 13
5 1
6 25
7 26
16 27
17 28
3 29
4 30
9 5
10 6
14 7
15 8
Nitrogen %
Healthy
Diseased

Fig: 1

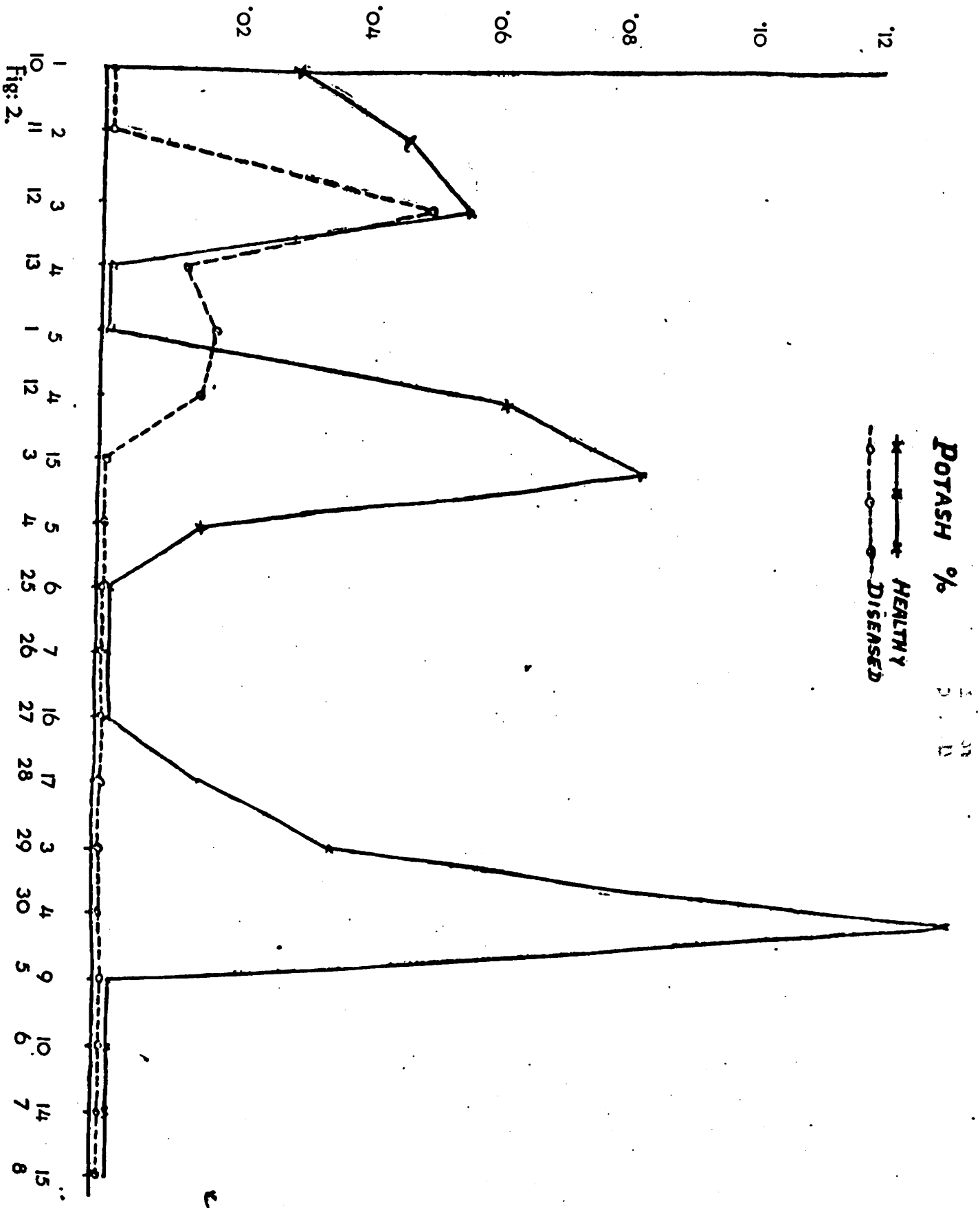

.02
.04
.06
.08
.10
.12
POTASH %
HEALTHY
DISEASED
1 10
2 11
3 12
4 13
5 1
4 12
15 3
5 4
6 25
7 26
16 27
17 28
3 29
4 30
9 5
10 6
14 7
15 8

Fig. 2.

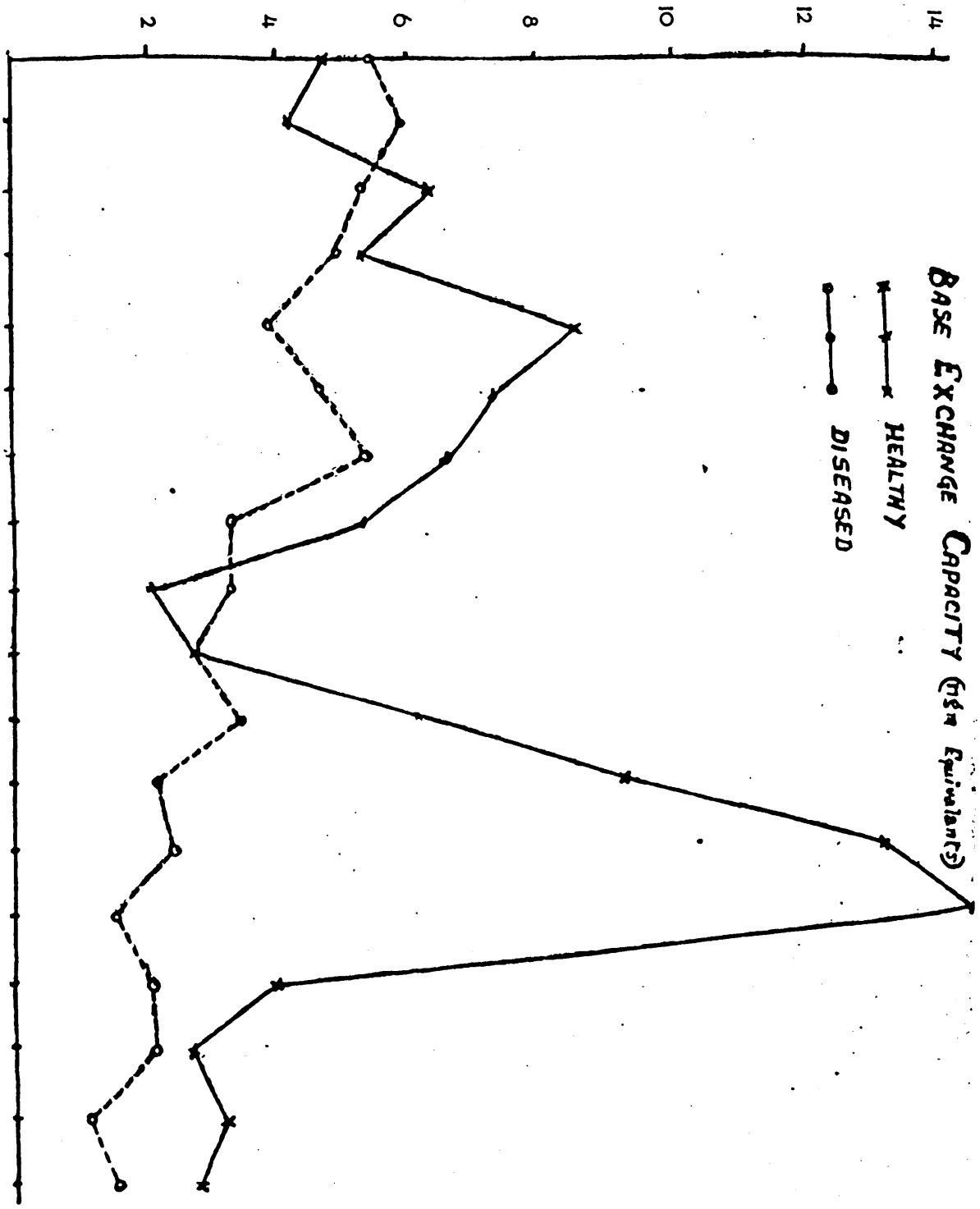
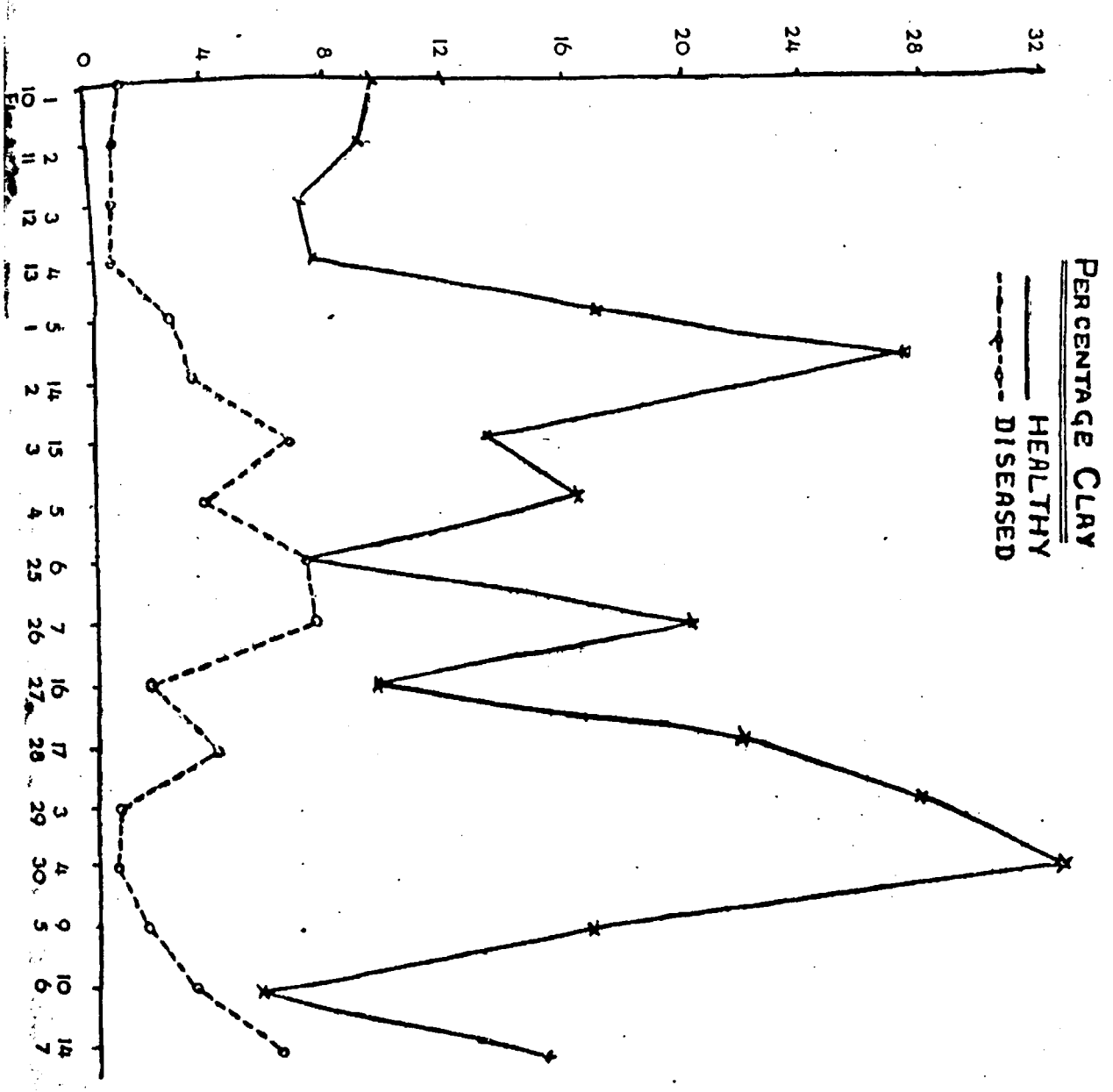

BASE EXCHANGE CAPACITY (Milli Equivalents)
HEALTHY
DISEASED
2
4
6
8
10
12
14
1 10
2 11
3 12
4 13
5 1
6 2
7 3
8 4
9 5
10 6
11 7
12 8
13 9
14 10
15 11
16 12
17 13
18 14
19 15
20 16
21 17
22 18
23 19
24 20
25 21
26 22
27 23
28 24
29 25
30 26
31 27
1 28
2 29
3 30
4 31
5 1
6 2
7 3
8 4

Fig: 3.


PERCENTAGE CLAY
HEALTHY
DISEASED
0
4
8
12
16
20
24
28
32