Maintaining Fertility on Coconut Lands*

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INTRODUCTION

Three fundamental factors govern soil fertility :—(1) nutrient availability, (ii) moisture availability and (iii) degree of aeration. Assuming that no deleterious influences such as toxic substances, or pests and disease, are present, crop production depends on the interaction of these three factors. All field operations which are aimed at maintaining or improving the fertility of soils are ultimately associated with the maintenance or improvement of one or more of these factors. However, in accordance with the theme of this symposium, I shall confine my discussions to the subject of maintining nutrient availability and fertiliser usage on coconut lands.

The paper deals with our approach to the problems of coconut manuring. It refers to the results of experiments carried out by the Coconut Research Institute of Ceylon, and the impact of these researches on fertiliser practice. Production trends in the coconut plantation industry of Ceylon are also indicated.

Plants obtain their mineral nutrients from the soil. For the successful and economic cultivation of any agricultural crop, it is therefore important to find out whether the soil has an adequate supply of the essential elements to meet the demands of that particular crop. It is also necessary to determine the optimum proportions, quantities, forms, frequency and methods of fertiliser placement according to which deficient elements should be applied to the soil.

The answers to these problems would vary according to the diverse soil and climatic conditions under which the crop is grown. Ideally, their satisfactory solution necessitates the adoption of field experimental methods depending on growth and yield data, in collaboration with laboratory studies of soils and plant materials. Unfortunately, field experimentation with a perennial such as the coconut palm involves much time, land, and money (a 3^3 factorial experiment requires about 30 acres, and a field trial must be continued for at least 7 years before any definite conclusions are drawn) so that the progress of research is inevitably slow. While the results of a single field experiment will not be of universal application (they may not even given a precise indication of the needs of an adjacent field) it is impracticable to carry out trials on all fields

*Paper read at the 1963 Sessions of the Ceylon Association for the Advancement of Science.

and soils. Cheaper and quicker laboratory tests such as the chemical analysis of soils and plant materials should therefore be developed. But soil analytical methods are largely empirical, and we have no fundamental measure which can give a precise quantitative definition of nutrient availability applicable to all soil types. The chemical composition of plant material is also by itself no more than a useful qualitative guide to what the plant needs. It will not provide quantitative information on how much fertiliser should be added to the soil to meet the demands of the plant.

The weathering of soil minerals and the decomposition of organic matter make soil nutrients available to plants. Nutrients are lost from the soil through crop removal, leaching, and erosion. When nutrient losses take place at a faster rate than the processess of natural replenishment, or when the nutrient reserves are very low (as in the case of sandy soils), then it is necessary to add fertilisers to the soil. The quanity of fertiliser to be added would depend not only on the demands of the crop, but also on the nature of the soil. For instance on sandy soils, under heavy rainfall conditions, allowance has to be made for losses of soluble fertilisers by leaching, while on acid soils rich in iron and aluminium, phosphate fixation has to be taken into account.

The quantitative relationship between crop yields and fertiliser application can only be assessed through field experimentation. Laboratory tests will hence provide reliable *quantitative* information regarding optimum fertiliser requirements only after they have been calibrated against the results of field experiments. Such tests can then be used to extend the range of applicability of results of field trials. Often requests are made by coconut planters for the chemical analysis of soils and leaf samples with the object of getting specific fertiliser recommendations for individual fields. But, only on the availability of suitably calibrated laboratory tests would it be possible to establish an advisory service for making quantitative recommendations on manurial requirements based on routine chemical analysis

Experiments hitherto carried out by the Coconut Research Institute do not provide answers to all the problems discussed above, and until the results of further experiments are known it has been the policy to make fertiliser recommendations based not only on the experimental data already available, but also on scientific hypothesis and pactical experience.

2. EXPERIMENTAL RESULTS

Estimates arrived at by different workers on the total quantities of nutrients removed from the soil by adult bearing coconut palms (1) is given in Table I. These figures show considerable variation as is to be expected from assessments made on palms grown under such different conditions. *But they all emphasise* *heavy demands of the coconut palm for potassium.* The requirements of the other macro nutrient elements are, in order of magnitude : nitrogen, magnesium phosphorous, calcium. No data is available on sulphur and the micro-elements.

Early research on the coconut palm has been confined to the three important macro-nutrients nitrogen, phosphorus and potassium. More recently, our attention has been directed to magnesium as well. The appearance of new abnormal foliar colorations has made it seem necessary to focus attention on other essential elements too. On soils which have been subject to a long period of mono-culture (extending to nearly a hundred years or even more in some areas) the appearance of new deficiency symptoms is to be expected, particularly in view of the increasing tendency to use highly refined chemical fertilisers.

(a) **Nutrient deficiences.** The main coconut growing areas of Ceylon comprising about 700,000 acres of a toal of 1.1 million acres are in the southern, western and north-western provinces and fall within the great soil group of red-yellow podzolic soils according to the classification of Ceylon soils by Moorman and Panabokke (2). The pioneer field experimental work of Salgado (3, 4, 5 (*a*), (5*b*) 6, 7, 8) has shown that coconut production in these major coconut growing areas is limited by deficiencies of nitrogen, phosphorus and potassium in the soils. More recently, it has been shown that magnesium deficiency can also be a serious limiting factor to coconut production in these areas. Manuring with inorganic fertilisers has brought about significant increases in crop production. Different soils varied in their response to manuring.

TABLE I

Quantities of plant food ingredients removed from the soil per annum

No.	(In pounds per acre)					Basis	Authority
	N	P_2O_5	K_2O	CaO	MgO		
1	18	5	38			2,000 nuts per acre per year	Pillai, 1919
2	57	26	85			From one acre per year	Jacob and Coyle ,1927
3	82	37	122			2,800 nuts per acre per year	Copeland, 1927
4	66	27	123	15.7	28.6	Soil rich in plant nutrients	Georgie and Teik, 1932
5	81	36	117			Annual removal from one acre	Eckstein et., al., 1937
6	24	12	60			Recommendation for annual addition per acre	Patel, 1938
7	81 to 126	27 to 45	108 to 144			156 mature palms per hectare	Carvalho, 1947
8	26	8	24	13.0	20.0	60 palms per acre with 25 nuts each per annum	Cooke, 1950

In the poor, heavily leached lateritic soils of the wet zone—(Edunkelle Estate, Ahangama, (3) and the Kumbaloluwa Estate, Veyangoda) the response to manuring was more marked than that obtained on the comparatively richer soils of Bandirippuwa (5*a*, 5*b*), Ratmalagara (Madampe) (6), Nattandiya (7) and Bingiriya (8), in the intermediate rainfall zone. In the wet zone soils, without manuring, the yields were of the order of about 300 lb. copra (or 600 nuts) per acre per annum. Biennial application of 0.6 lb. N, 0.6 lb. P_2O_5 and 1.0 lb. K_2O per palm, increased the yields to about 1,000 lb. copra (2,100 nuts)—over a 200 per cent. rise. At Bandirippuwa, comparative figures for no manuring were about 1400 lb. copra (3,000 nuts) and the complete NPK mixture 1,900 lb. copra, (4,000 nuts)—a 30 per cent. increase. At Ratmalagara, the experiment on young palms now in their 15th year gave in 1962, 1,254 lb. copra per acre (2,400 nuts) for unmanured plots, 2,133 lb. copra per acre (4,200 nuts) on plots treated with 4 ½ lb. of fertilizer mixture containing equal proportions of sulphate of ammonia, saphos phosphate and muriate of potash (C. R. I. General Coconut Fertiliser Mixture) and 2,782 lb. copra per acre (5,750 nuts) on plots receiving the complete NPK fertiliser mixture. This represents a yield increase of about 120 per cent. over the unmanured plots at the higher level of fertiliser application, and a 70 per cent increase at the lower level. The response to fertiliser application at Bandirippuwa has been more due to a drop in the fertility level of the control plots, rather than an increase in the absolute yields of fertilised plots. On the other hand at Ahangama and Veyangoda the plots receiving fertilisers have shown a marked increase in absolute yields. *Potassium* has proved to be the dominant requirement in the 3 × 3 × 3 NPK factorial experiment on adult palms at Bandirippuwa. The biennial application of 0.75 lb. K_2O per palm produced a significant yield response in the fifth year after the first manuring, whereas the higher dosage of 1.5 lb. K_2O responded in the third year (5*a*, 5*b*). At Ratmalagara where potash was applied at the rate of 1 and 2 lb. K_2O per palm biennially, only the higher level showed a response after thirteen years.

Soil analysis has satisfactorily explained the higher reponse obtained to potassium applications at Bandirippuwa, compared to Ratmalagara ; the Ratmalagara soils having 0.2 m.e. per cent. exchangeable K_2O as against 0.02 me per cent. K_2O in the Bandirippuwa soils (9).

The response to potassium has been reflected not only in the increased number of nuts produced, but also in better copra out-turn (i.e., less number of nuts per candy of copra). Potash showed no effect on the number of female flowers formed, but had a positive effect on the setting of nuts from female flowers (10).

The results of two experiments on young palms from the seedling stage, one on underplanted seedlings at Letchmey Estate, Nattandiya and the other on seedlings planted in a new clearing of secondary jungle at Ratmalagara, showed that potash played a relatively less important role in the early stages of vegetative growth. The effects of potassium were most pronounced at the bearing stage, as reflected in yield data. This is supported by the results obtained by Nathanael (11) who, using sand culture techniques on coconut seedlings, found that " during the first year of growth an absolute deficiency of K produces no retardation in growth or any visual symptoms ".

Under acute potash deficiency the mature fronds of adult palms exhibit characteristic visual foliar symptoms i.e., a bronzing of leaflets and marginal scorch.

Nitrogen was tested at three different levels on adult bearing palms only at Bandirippuwa but showed no significant main effects. There was however a significant N—K interaction. Potassium at the 0.75 lb. K_2O level gave highest yields when combined with 0.5 lb. N, while the increased response to the application of 1.5 lb. K_2O was maximum when nitrogen was increased to 1 lb. N. At low levels of potash, increased nitrogen dosages had a depressive effect on yields. This appeared to be due to excess nitrogen inhibiting potash uptake—as indicated by the lower concentration of potash in nut water from high nitrogen no–potash plots. It is not yet known whether the suppressive effect is due to NH_4—K ion antagonism or to the high levels of elemental N.

Nitrogen increased the production of female flowers, but had an adverse effect on the copra out-turns (10).

In the case of young palms nitrogen has had a marked effect on promoting leaf development and early flowering. In the Ratmalagara experiment on young palms, the main effect of nitrogen has continued to show a positive and significant response on yield data as well.

Nitrogen deficiency in the field experiments has not been accompanied by any visual sumptoms. Nathanael (11) has however reported that in seedlings, nitrogen deficiency causes pronounced restriction in growth of both tops and roots, and a highly significant retardation both in height and girth. Leaf number is reduced and the leaves remain webbed. Younger leaves develop a pale yellowish-green colour, the yellow becoming more prominent in the older leaves.

Phosphorus showed a significant response in the $3 \times 3 \times 3$ NPK trial at Bandirippuwa only after 27 years. The previous lack of response was apparently due to residual effects of heavy applications of bone meal on this land prior to the commencement of the experiment. On the other hand, at Ratmalagara the biennial application of 1 lb. P_2O_5 per palm has given highly significant increases of 600—800 lb. copra per acre annually in crop yields. Similarly, the experiments at Veyangoda and Ahangama showed that the increased yields obtained through applications of NPK mixture was about 100% higher than the yield increases obtained through application of N and K only.

The $3 \times 3 \times 3$ NPK trial on young palms at Ratmalagara showed that growth as measured by leaf production and age of flowering, is largely influenced by phosphate application (12).

In the Ahangama and Veyangoda experiments phosphorous showed a marked positive effect on the number of female flowers produced ; but it had no influene in the percentage setting of female flowers. Copra out-turn was also not influenced by phosphorous (13).

The incidence of fungus disease, *Helminthosporium incurvatum*, was found to be generally associated with young palms receiving high levels of nitrogen and no phosphorus (14). Similar observations were made by Nathanael (8) in his sand culture experiments. No specific symptoms of phosphate deficiency have been observed under field conditions. But Nathanael (11) has reported phosphate deficiency in seedlings to be associated with stunted growths, retarded root development and dark green leaves.

The high response to phosphorus manuring at Ratmalagara and the lack of response at Bandirippuwa could not be accounted for by the usual method, of soil analysis for assessing phosphate availability in soils : both soils showed a low order of availability (15). On the other hand, nut water analysis proved a better guide in interpreting the different response patterns in phosphate manuring (14).

Magnesium : The manuring of coconut palms has until recently been restricted to the application of nitrogen, phosphoric acid and potash. Within the last decade an intense yellowing of mature leaves has been observed in coconut palms grown on regularly manured but heavily leached lateritic soils of ths high rainfall area in the western and southern provinces. *This has been found to be due to magnesium deficiency* (16*a*, 16*b*). Soils consisting of lateritic gravels or light sands are more prone to be deficient in magnesium. Magnesium deficiency is known to be accentuated by the presence of excess acidity, and the continued use of ammonium, postassium and calcium salts. The highly leached lateritic soils and light sandy soils receiving regular doses of NPK fertiliser mixtures, containing refined chemical fertilisers such as ammonium sulphate, muriate of potash, and saphos phosphate, therefore present optimum conditions for the development of magnesium deficiency symptoms in coconut palms grown on them.

Incidence of magnesium deficiency in coconut palms has now been observed in most major coconut growing districts in Ceylon. It is widespread in the acid lateritic soils of the southern and western provinces and in the cinnamon sand soils types of the Chilaw-Negombo area. It has also been found to occur on gravelly and sandy loam soils in the Chilaw-Kurunegala and Matale districts.

Characteristic visual symptoms of magnesium deficiency in coconut palms are the yellowing of mature fronds with a green marginal effect on either side of petioles and midribs, which retain their normal colour.

Foliar spraying of affected palms with 1–2 per cent solutions of magnesium sulphate brought about complete recovery in a few months (16*b*)

Field trials with soil applications of magnesium (both as magnesium sulphate and dolomitic limestone) along with the usual NPK fertiliser mixture were begun in 1957. Affected palms receiving magnesium gave a yield of about 50 nuts per palm per annum in the period 1960–62 in contrast to a yield of 35 nuts from palms not receiving any magnesium. Complete recovery of leaf colour in the affected palms which have been treated with magnesium fertilisers annually since 1957 has not been achieved yet. Healthy green palms on the same plantation receiving only NPK fertilisers gave a yield of 70 nuts per palm per annum for the period 1960–62. Field trials have also indicated that soluble magnesium sulphate acts quicker than the insoluble dolomite in improving leaf colour.

Provided that a proper sampling technique is adopted, magnesium deficiency can be diagnosed by chiemical analysis of leaflets (17). A magnesium content of 0.25—0.3% Mg in leaflets from the 6th fully opened frond would indicate sufficiency of magnesium. If the Mg content falls below 0.2% deficiency symptoms can be expected.

Once again, standard soil analytical methods proved to be of little value in differentiating between soils sufficient and deficient in magnesium. Exchangeable magnesium in soils showed no significant correlation with the content of magnesium in coconut leaflets. But there was good correlation between leaf magnesium and magnesium concentration in 10^{-2} molar calcium chloride extracts of soils (7).

Calcium requirements of the coconut palm are small, according to the figures in Table I. However, on the acid lateritic soils and sandy soil types on which most of our coconuts are grown, the availability of calcium is poor. Fortunately, sufficient calcium enters the soil through the application of rock phosphate so that calcium deficiency is no problem. Sand culture experiments have shown that an absolute deficiency of calcium causes a retardation in growth of seedlings (11). The outstanding symptom of calcium deficiency is the marked retardation of root development, characterised by a proliferation of short roots—a symptom not shown by any of the other deficiencies (11).

Coconut palms are reputed to thrive under a wide range of soil pH. Tc what extent the liming of acid soils to near neutrality would cause beneficial effects is not known. A major field experiment on adult palms to study the effects of liming acid soils was commenced in 1960. It is premature to draw any conclusions yet.

Sulphur : There is no recorded data on the sulphur requirements of the coconu t palm. No doubt, sufficient sulphur goes into the soil through the use of ammonuim sulphate to meet any possible deficiencies. Paltridge and Santhirasegaram (18) have however reported sulphur deficiency on a cinnamon sand coconit soil on the basis of pot culture experiments using grass and legumes as indicator plants (*Paspalum commersonni* and *Phaseolus lathyroides L.*)

Micro elements : No information is available on the micro-element requirements of coconuts. But Paltridge and Santhirasegaram in their pot culture experiments on coconut soils with the legume *Medicago sativa* found that the application of boron to a cinnamon sand soil improved dry matter production (18). Similar responses to boron have been obtained on the acid lateritic soils of the wet zone low lands (19).

Chemical analysis of coconut leaflet samples from adult palms of Bandirippuwa Estate showed a boron content of about 20 ppm., whereas samples from Pannipitiya and Gonapinuwala areas (wet zone) showed a boron content of 7–12 ppm. Highly leached acid soils are known to be relatively poor in boron. Whether coconut yields on such soils are limited due to boron deficiency is a matter for future investigation.

(b) **Form of Fertiliser.** There is no evidence yet to suggest that the efficiency of fertiliser utilisation by the coconut palm is governed by the form in which it is applied.

In a simple observation trial at Bandirippuwa comparing a mixture of sulphate of ammonia, saphos phosphate and muriate of potash against a mixture of sediment poonac and ash containing equivalent amounts of N, P and K. it was found that the mixture of artificial fertilisers is at least as efficient as the other (20). Except when the locally available product is cheap there is no justification for preferring to use oraganic manures (e.g. oil cakes, fish meal), which are generally expensive. Where cattle manure is used it should be supplemented with potash and phosphate.

It is sometimes argued that organic manures improve the physical condition and moisture holding capacity of soils. But in comparison to the amount of soil involved, the quantity of organic matter added is so small that it would make little material contribution towards this end. This could be best achieved by turning into the soil bulky green manures grown on the spot.

The following points are usually considered in selecting the type of fertilisers to be used—(a) price per unit value, (b) cost of transport and handling (bulky manures though cheap may prove expenisve to transport) and (c) storage qualities. Storage quality should be judged from the tendency of the fertilisers to absorb moisture under the usual conditions of storage. Fertilisers with a high capacity for abosrbing moisture are unsuitable. For instance fertiliser mixtures containing urea were found to lose over 50% of their nitrogen through loss of solution from the deliquescent mixture after two weeks storage.

On this basis, fertiliser mixtures made up of ammonium sulphate, saphos phosphate, and muriate of potash, are generally perferred.

In the NPK experiment at Bandirippuwa, the continuous use of sulphate of ammonia alone has been observed to reduce the soil pH from 5.4 to 4.7 But where saphos phosphate had also been applied the calcium in it was apparently able to neutralise any tendency towards acidification (12).

Recently there has been considerable interest regarding the possibilites of using other sources of nitrogen such as urea and calcium ammonium nitrate which, it is enviasged, can be manufactured in Ceylon without importing any raw materials. But as already mentioned, urea in the presently avialable form is very hygroscopic and unsuitable for use in fertiliser mixtures which have to be stored. *The feasibility of manufacturing ammonium cholride in Ceylon merits serious consideration,* particulaly since cholrine is readily available as a waste by-product (with a disposal problem) of caustic soda manufacture at the Paranthan Chemicals Factory. Ammonium chloride shows relatively little hygroscopicity, stores well, but is more acidic than sulphate of ammonia. It should prove a satisfactory alternative to sulphate of ammonia in fertiliser mixtures. A field experiment to test the relative efficiency of alternative source of nitrogen on coconut palms was commenced this year.

(c) **Fertilizer recommendations.** Prior to the availability of any experimental data, fertilizer mixtures used on coconut lands were composed of about 5%, N, 10% P_2O_5 and 5% K_2O. Often, preference was given to organic sources of nitrogen and phosphrous. *Research has shown that potash is the dominant requirement of adult coconut palms, and that the cheaper inorganic fertilisers are as effective as organic fertilisers.* Accordingly the general coconut fertiliser mixtures now recommended are composed of sulphate of ammonia, saphos phosphate and muriate of potash containing about 7%N, 9% P_2O_5 and 17% K_2O.

Rates of fertilizer application are governed by economic factors. Good market prices for copra and subsidised fertilisers are conducive to liberal fertiliser applications with a view to maximising yields. In recent years an increase in the rates of fertiliser application up to 7–8 lb. per palm per annum has, therefore, been recommeded.

Field experiments on young palms have shown phosphorus and nitrogen to be the dominant requirements during their early stages of growth. The fertiliser mixture recommended for young palms until flowering consists of sulphate of ammonia, saphos phosphate and muriate of potash in the proportions 2 : 2 : 1 by weight (8.2%N, 11% P_2O_5, 10% K_2O).

Commencing with 2 lb. per seedling in the first year, the rate of application is increased each year by 1 lb. to 5 lb. in the 4th year, the annual dosage being given in two to four split doses. Seedlings planted in virgin jungle clearings in colonisation schemes have been reported to be attacked by the fungus disease *Helminthosporium incurvatum*—probably as a result of phosphate deficiency, aggravated by the high content of soil nitrogen generally associated with new clearings. Hence the incorporation of 1 lb. saphos phosphate in each planting hole is recommended. As a long term preventive measure against magnesium deficiency, ground dolomitic limestone should be applied at 3–5 lb. per adult palm and 3 lb. per young palm once in three years. Second plantations, particularly those on gravelly and light sandy soils are more likely to develop symptoms of magnesium deficiency. The inclusion of 1 lb. dolomite in all planting holes and in manurial programmes of young replantations or underplantations is therefore recommedned as a matter of routine.

Where symptoms of magnesium deficiency have appeared, in addition to the long term preventive measures it is recommended that Kieserite be applied at 3 lb. per palm per annum until the palms regain their healthy green colour.

(d) **Fertiliser consumption and nut production trends.** Investigations at the C.R.I. have clearly proved that manuring brings better crop returns. It has thus been possible to recommend general fertiliser mixtures both for adult and young palms. But owing to adverse economic conditions and the inevitable time lag of at least one year, if not more, between the application of manure and the realisation of its beneficial effects, it was only after the coconut fertiliser subsidy scheme came into operation in 1956 that the full effect of using these fertilizer mixtures came to be felt. Unlike tea and rubber, the majority of coconut lands (70%) are small holdings. Their owners have had little inclination to carry out any systematic programme of manuring under conditions of economic stress. The fertiliser subsidy scheme could not have been introduced at a more opportune time. The coconut plantations industry was already in a state of decline. It is significant that before the second World War less than 10,000 acres or 0.1.% of our total coconut acreage received fertiliser.

During the late 1940's and early 1950's when copra fetched high prices, this figure increased to about 150,000 acres and the tonnage of fertilisers used increased to 15,000 . Since the fertiliser subsidy scheme was introduced, the annual fertiliser consumption has risen to 45,000 tons in 1962, covering an acreage of about 325,000 or 30% of the total coconut acreage. Of these only about 125,000 acres are small holdings.

The effects of increased fertiliser usage is reflected in the production trends. During the period 1932—1947, the estimated annual nut production was static at about 1,800 millions (17). From 1948 onwards, the annual nut production has shown a steadily increasing trend giving the record yield of 2,800 million nuts in 1961 and nealry 3,000 million in 1962. The average annual production for the period 1958–61 was 2,500 million nuts.

It is estimated that a greater part of the increased production has been utilised for internal consumption on account of population growth. Prior to 1950 about 55% of the total production was exported. In the last few years the exports have amounted to about 45% of the total production. If our export earnings from coconut are to be at least maintained at the present level it is necessary that there should be a coniderable increase in the coconut acreage receiving fertilisers. Intense propaganda drives on the need to use fertilisers and economic relief such as long-term loans for purchase of fertilisers are essential for this purpose.

REFERENCES

1. Menon, K. P. V., and Pandalai, K. M. (1951) " The Coconut Palm " a Monograph—p. 161.

2. Moorman, F. R., Panabokke, C. R. (1961) *Tropical Agriculturist*, Vol. 117. p. 5.

3. Annual Report of the Coconut Research Scheme for 1949—p. 16—17 (Government Publication Bureau, Colombo).

4. Annual Report of tho Coconut Research Scheme for 1948—p. 10—11.

5a. Salgado, M. L. M. (1947) *Tropical Agriculturist* 103 p. 113—120.

5b. Annual Report of the Coconut Research Scheme for 1949, p. 10—14.

6. Annual Report of the Coconut Research Scheme for 1949, p. 14—15.

7. Annual Report of the Coconut Research Institute for 1954, p. 15—17.

8. Annual Report of the Coconut Research Institute for 1957, p. 16—17.

9. Annual Report of the Coconut Research Scheme for 1949, p. 10.

10. Annual Report of the Coconut Research Scheme for 1944, p. 10.

11. NATHANEAL, W. R. N. (1961) " Coconut Nutrition and Fertilizer requirements—the plant approach "—*Ceylon Coconut Quarterly* Vol : 12 No. 3/4.

12. Annual Report of the Coconut Research Institute for 1955, p. 17.

14. Annual Report of the Coconut Research Institute for 1953, p. 15.

15. Annual Report of the Coconut Research Institute for 1953, p. 20—22.

16a. Annual Report of the Coconut Research Institute for 1960, p. 18

16b. NETHSINGHE, D. A. (1961) *Ceylon Coconut Planters' Reviev*, Vol. 2 No. 1/2 p. 3—6.

17. Annual Report of the Coconut Research Institute for 1963 (in print).

18. PALTRIDGE, T. B. and SANTHIRASEGARAM, K. (1957) " Studies on the Nutrient status of some coconut soils "—C. R. I., Bulletin No. 12.

19. Sathirasegaram, K. (Private communication).

20. Annual Report of the Coconut Research Institue for 1955, p. 21

21. FERNANDO, J. K. T. (1962)—*Ceylon Coconut Planters' Review* pp. 25—28 Vol. 3