Journal of Plantation Crops 5(2): 114-120. *December* 1977.

SOIL FERTILITY RESEARCH IN ARECANUT: A REVIEW*

A. R. MOHAPATRA

Central Plantation Crops Research Institute, Regional Station, Vittal 574 243, Karnataka, India.

ABSTRACT

The research carried out so far on soil fertility of arecanut is reviewed. Priority areas are discussed. Better management of plantations with the available local resources is suggested.

INTRODUCTION

In India, arecanut is grown in the high rainfall regions of Kerala, Karnataka, Tamil Nadu, Maharashtra, West Bengal, and Assam. Andamans is also considered as an ideal area for arecanut (Nambiar, 1954). The total area under this crop in India is about 160,000 hectares. Nambiar (1949) and Naidu (1962) have described the soils where arecanut is grown. Briefly, the soils are lateritic, but alluvial and red loams are also encountered. In the *maidan* areas of Karnataka, arecanut is planted in fertile clay loam soils. Saline and black soils are unsuitable for arecanut cultivation (Aiyer, 1966).

General fertility of soils

A comprehensive survey of fertility constituents of soils of arecanut growing areas has not been carried out. But some information on the native fertility status of soils is available from the Arecanut Research Stations situated in various States. The soils of Vittal farm (Karnataka) were texturally sandy clay loam, slightly acid with pH 5.4 and low in cation exchange capacity. The available P and K contents were low. They contained appreciable quantities of organic matter (Mohapatra, 1974; unpublished). The water holding capacity was 39.6–46.3%. The organic C content of NPK manurial plots was 0.40–0.58% in Hirehalli (Karnataka), 1.06–1.50% in Peechi (Kerala), 1.69–2.13% in Mohitnagar (West Bengal), and 0.38–1.06% in Kahikuchi (Assam) farms. The soils of Hirehalli were low in organic C (Kalbande, cf., Annual Report, CARS, 1969*a*). The total N content in Vittal farm soils was 0.06–0.11%. Iyenger (1955) reported the total N in soils of some arecanut gardens in Karnataka as 0.03–0.22%.

The physico-chemical properties of soil profiles from Arecanut Research Stations showed that all soils were rich in organic matter. Available P in Peechi, Mohitnagar, and Kahikuchi soils was medium, whereas, it was low at Vittal, Hirehalli, and Palode. Soils of all farms, except that at Mohitnagar, contained good quantities of available K. The pH was neutral to alkaline in soils of Hirehalli. The remaining profiles showed acid to neutral reaction. The total CaO and MgO contents of soils from Vittal and Palode were lower than those of others. The Al_2O_3 content was more than that of Fe_2O_3 in all the profiles. The soils from Hirehalli were clay loam and those from Peechi, Palode,

*Contribution No. 152. Central Plantation Crops Research Institute, Regional Station, Vittal.

Mohitnagar, and Kahikuchi were sandy loam in texture. A few profiles from Hirehalli and Kahikuchi were ill drained (Mohapatra and Devaraju, cf., Annual Report, CPCRI, 1973). Khadilkar, Bhade, and Pandya (1964) analysed some profiles from arecanut growing areas of Kolaba and Ratnagiri districts (Maharashtra). The soils from the coast and hill slopes differed widely in their chemical properties. The lateritic soils were mildly acidic, depleted in bases, and low in P and K. The total N and micronutrient contents of these soils were high. The alluvial soils from the coast were neutral, base saturated, and sufficient in organic matter. The acid soluble Mn, Cu, Zn, and Mo were also present in adequate quantities.

Organic matter and Nitrogen

Green leaf manuring is an accepted practice in arecanut gardens. John (1952) suggested wild sun-hemp (*Crotalaria striata*) as a green manure plant in arecanut gardens. Bhat (1956) stressed the usefulness of green manuring in arecanut. Krishnappa (1962) observed that *Crotalaria anagyroides* and *C. striata* gave good yields of green matter in *malnad* of Karnataka. Out of 24 species of green manure crops tested at Vittal, *Pueraria javanica* and *Calopogonium muconoides* showed the best establishment (Anonymous, Annual Report, CARS, 1958–59; 1963–64). Cover cropping was beneficial on the hill slopes of Palode farm. Incorporation of *Stylosanthes gracilis* increased organic C and N contents of soil (Kalbande, cf., Annual Report, CARS, 1969*a*). Of the several organic sources tried at Vittal, forest leaf contributed most to the organic matter status of soil, but *Glyricidia* decomposed faster than others (Kalbande, cf., Annual Report, CARS, 1969*b*; 1970). Trials at Vittal, Hirehalli, and Mohitnagar showed that P. *javanica* and *Mimosa invisa* were promising green manure and cover crops in arecanut gardens from the point of view of their green matter yield and nutrient addition capacity. A crop of *P. javanica* producing 14.35 t/ha of green matter contains 99.3 kg N, 16.5 kg P_2O_5 and 59.0 kg K_2O (Mohapatra *et al.*, cf., Annual Report, CPCRI, 1974).

Biddappa (1960) suggested composting of arecanut wastes. According to his estimate, 500 t N, 250 t P_2O_5, and 500 t K_2O could be supplied by composting 50,000 t arecanut husk. Arecanut husk was successfully composted with or without starter after spreading it in the cattle shed as bedding for one month. Urea at 1 kg/100 kg husk was added, and after eight months of decomposition, the material became ready for use (Anonymous, Annual Report, CARS, 1969–61).

Release of N from *Glyricidia*, *Mimosa*, forest leaf, compost, cattle manure, and fish manure added at 50 kg and 100 kg N/ha was studied in Vittal farm soil under laboratory conditions in the presence and absence of lime. The mineralisation of these substances was completed in four months. The NH_4-N, NO_3-N and alkaline permanganate-N forms were maximum from fish manure at 100 kg N/ha. Fish manure increased soil acidity. Lime reduced the contents of NH_4-N and available K. Forest leaf and cattle manure at 100 kg N/ha increased organic matter content of soil (Bhat and Aboobaker, cf., Annual Report, CPCRI, 1972).

Phosphorus

At Vittal, availability of P in areca soils was observed under laboratory, greenhouse, and field conditions. Addition of superphosphate at 50-200 kg P_2O_5/ha to Vittal soil increased P availability. It decreased with increase in depth and time of sampling (Kalbande, cf., Annual Report, CARS, 1970). In a field experiment, annual application of superphosphate, Suphala (20:20:0; FCI), Factamfos (20:20:0; FACT), and Thermophosphate (0:17.5:0) at 40 kg and 60 kg P_2O_5, and Ultrafos (0:33:0; FACT) at 80 kg and 120

kg P_2O_5/500 palms for three years, increased the level of Bray-1 P above 25 ppm P_2O_5 in soil (Mohapatra and Bhat, cf., Annual Report, CPCRI, 1974). Annual application of superphosphate at 160 g P_2O_5/palm in the NPK experiment at Vittal, raised the level of available P upto 51 ppm P_2O_5 in soil at 95-100 cm depth. Leaf P increased from 0.15% in control to 0.20% in the $N_3P_3K_3G_3$ treatment (Mohapatra and Bhat, cf., Annual Report, CPCRI, 1975). $CaCO_3$ above $\frac{1}{4}$-lime requirement reduced the availability of fertilizer P in soil and to maize plant (Mohapatra and Bhat, cf., Annual Report, CPCRI, 1976). Downward movement of P added at $1\frac{1}{2}$-P-fixing capacity was more in the column filled with Kidu soil high in organic matter than that with Vittal soil. Increase in available P content increased the pH of soils (Mohapatra and Bhat, cf., Annual Report, CPCRI, 1977).

Field experiments

The nutrient uptake of arecanut has been found to be 67.2-89.6 kg N, 22.4-33.6 kg P_2O_5 and 67.2-89.6 kg K_2O/ha/year (Anonymous, 1958). The amounts of nutrients removed by kernel alone by 17 arecanut cultivars estimated at Vittal were 6.4–91.2 kg N, 1.1–27.1 kg P_2O_5, and 5.3-49.3 kg K_2O/ha. VTL-17. which gave the highest yield of 26, 314 kg fresh nuts/ha, required 91.2 kg N, 27.1 kg P_2O_5, and 48.4 kg K_2O (Bhat and Mohapatra, cf., Annual Report, CPCRI, 1973).

Fertilizer trials were started in arecanut as early as in 1920 (Iyenger, 1955). He recommended manuring of healthy bearing arecanut gardens once in three years. Application of 56.0 kg N, 84.0 kg P_2O_5, and 112.0 kg K_2O raised the yield of betel nut to 875.6 kg/ha.

In the 1950's, the erstwhile Indian Central Arecanut Committee, Calicut, organized simple manurial trials in the cultivators' field. The experiment was conducted in 200 gardens, out of which 100 were located in the sub-montane region of Kerala and Karnataka, 40 in the coastal area of Kerala and Karnataka, and 60 in the plains of Karnataka, West Bengal, and Assam. The N, P, and K fertilizers were ammonium sulphate, superphosphate, and muriate of potash respectively, applied for the three years 1961-62 to 1963–64. The levels of nutrients added were N: 56.7, 113.4 kg; P_2O_5: 45.3, 90.7 kg; and K_2O: 85.0, 170.1 kg/ha. However, the treatments were different for sub-montane, coastal, and plains under each State. The yield data from Kerala, Karnataka, and West Bengal alone were statistically analysed. The treatments found economical were 56.7 kg N+45.3 kg P_2O_5+170.1 kg K_2O/ha for sub-montane, and 56.7 kg N+45.3 kg P_2O_5+85.0 kg K_2O/ha for coastal regions of Kerala and Karnataka States. In the plains of West Bengal, no response to added fertilizers was observed (Lakshmanachar, Biddappa, and Paulose, 1966).

Kalbande (1965) has described the principles underlying liming of humid soils. Krishnappa (1964) reported the benefit of liming arecanut palms in *malnad* soils. Lime increased nut yield significantly in the presence of manures and fertilizers.

A comprehensive trial to determine the manurial requirements of young areca palms has been laid out at Vittal in 1961, Hirehalli in 1962, Peechi in 1961, Mohitnagar in 1967, and Kahikuchi in 1962. The treatments consist of N at 0, 25, 50 kg; P at 0, 20, 40 kg P_2O_5; K at 0, 35, 70 kg K_2O; and green leaf at 0, 3400, 6800 kg/500 palms. At Mohitnagar, the treatments consist of N at 0, 50, 100 kg; P at 0, 20, 40 kg P_2O_5; and K at 0, 70, and 140 kg K_2O/500 palms as main treatments, and lime at 0 and 1 kg/palm as subplot treatment. At Vittal and Peechi, the existing doses were doubled in 1971 to study the responses at higher levels of nutrients.

In the same year, at Peechi, lime was included as a sub-plot treatment. N and green leaf in the original schedule increased the yield of nuts significantly over their zero levels at Vittal, Hirehalli, and Kahikuchi. Effect of K on number and weight of nuts was significant at Mohitnagar and Kahikuchi. P enhanced for the first time during 1975–76 nut yield at Vittal. At Mohitnagar, lime at 1 kg/palm showed adverse effects on all the growth and yield characters (Khader *et al.*, cf., Annual Report, CPCRI, 1977). At Vittal, analysis of soil in 1969 indicated high mobility of N in the plots (Velappan *et al.*, cf., Annual Report, CARS, 1971). Bhat (1969) advocated split application of N to minimise leaching losses. He felt that N should always be applied with P and K to get maximum benefits from fertilizer application. Ammonium sulphate as a source of N increased soil acidity at Vittal from pH 6.3 to 4.4 (Khader et al., cf., Annual Report, CPCRI, 1977).

An experiment to study the effect of continuous application of manures and fertilizers to arecanut is in progress at Vittal since 1969. The nutrients applied are 100 g N, 40 g P_2O_5, and 140 g K_2O/palm/year in the form of organics and inorganics. The treatments are organic manure alone, inorganic fertilizers alone, organic manure+inorganic fertilizers, organic manure+inorganic fertilizers+cultivation, organic manure+cultivation, and inorganic fertilizers+cultivation. Annual application of inorganic fertilizers decreased soil pH. Application of organic manures significantly increased organic C in soil to a higher degree than inorganic fertilizers (Bhat and Mohapatra, cf., Annual Report, CPCRI, 1974). At the sixth year, treatment differences were not significant for height of palms and number of nodes. The palms started bearing in 1975 and yield differences between treatments have not been statistically significant so far (Bhat and Mohapatra, cf., Annual Report, CPCRI, 1977).

Nutritional studies on yellow leaf disease of arecanut

This has been reviewed by Mohapatra, Bhat, and Harishu Kumar (1976). The distribution of the disease is more in southern Kerala and Chickmagalur district of Karnataka. The disease is largely confined to the high rainfall areas, river banks, and low lying valleys that are likely to be flooded during monsoon and having high water table during the remaining part of the year. Two extensive surveys of healthy and affected gardens of Kerala and Karnataka were carried out in 1969 and 1974. A total of 287 soil and 282 leaf samples were analysed for various constituents to understand the association of nutritional factors with the disease. The nutrient contents of leaf and soil between healthy and disease plantations were about the same each State but differed within between the States. The Kerala gardens were lower in fertility than those of Karnataka. Soils of both the States were high in organic matter, low to medium in available P and K, and contained adequate levels of exchangeable Fe, Mn, Zn, and Cu. Karnataka soils were neutral in reaction while Kerala soils were slightly acidic. However, application of lime at 4 kg and 8 kg/palm as dolomite did not have any beneficial effect on the diseased palms at Palode. The contents of N, P, K, Ca, Mg, Fe, Zn, and Cu in leaf samples from Kerala were lower than in those from Karnataka. The P content of leaf from Kerala was 0.14%, which is less than the assumed level of sufficiency of this nutrient. But application of NPK fertilizers did not improve the condition of diseased palms at Palode.

Package trials were laid out during 1965–66 in the yellow leaf disease affected arecanut gardens at Koothattukulam, Annamanada, and Punalur in Kerala, and Jayapura in Karnataka. The treatments superimposed were: (*i*) NPK (140 g ammonium sulphate+225 g superphosphate + 115 g muriate of

potash + 11 kg cattle manure/palm); (*ii*) NPK + 1 kg lime + 11 kg cattle manure/palm; (*iii*) NPK+57 g $FeSO_4.7\ H_2O$+11 kg cattle manure/palm; (*iv*) NPK + 23 g $Na_2B_4O_7.10\ H_2O$ + 11 kg cattle manure/palm; (*v*) NPK+23 g $ZnSO_4.7\ H_2O$ + 11 kg cattle manure/palm; (*vi*) NPK + 68 g $MnSO_4$ + 11 kg cattle manure/palm; (*vii*) NPK+68 g $MgSO_4.7\ H_2O$ + 11 kg cattle manure/palm; (*viii*) healthy control (receiving garden owner's usual treatment); (*ix*) NPK+68 g $MgSO_4.7\ H_2O$+68 g $MnSO_4$ + 11 kg cattle manure/palm; (*x*) NPK+ 68 g $MgSO_4.7\ H_2O$+68 g $MnSO_4$+23 g $ZnSO_4.7\ H_2O$+11 kg cattle manure/palm; (*xi*) NPK+68 g $MgSO_4.7\ H_2O$+68 g $MnSO_4$+23 g $Na_2B_4O_7.10\ H_2O$ + 11 kg cattle manure/palm; (*xii*) NPK+58 g $MgSO_4.7\ H_2O$+68 g $MnSO_4$+23 g $ZnSO_4.7\ H_2O$+23 g $Na_2B_4O_7.10\ H_2O$+11 kg cattle manure/palm; and (*xiii*) Diseased control (receiving garden owners' usual treatment).

After four years, treatments (*iv*) and (*x*) reduced foliar yellowing, and increased the yield of nut to as high as 55.34% at Jayapura. These effects were not very consistent in the remaining three centres in Kerala (Nagaraj, Mathai, and Vellaichamy, 1976).

More recently, management of arecanut garden in low lying area at Aranthodu, near Sullia (Karnataka), brought out similar informations. The *band* disease of arecanut in Maharashtra has also been ascribed to poor drainage, soil acidity, and toxic concentration of Mn (Daji, 1948; Kibe, Gokhale, and Narayana, 1957).

Miscellaneous studies

Bhat and Mohapatra (1971*a*) have observed that soil samples from arecanut basins show wide variations in pH and available nutrients. For sampling purposes, they have, therefore, suggested that three cores, taken at 30 cm, 60 cm, and 90 cm from the base of palms at a depth of 50 cm should be pooled (Bhat and Mohapatra, 1974).

Mohapatra, Bhat, and Devaraju (1972) compared three methods to determine organic C in soil and found that Graham's colorimetric procedure was superior to others.

In a study of the association between total N and organic C content of soils, the total N was found to increase significantly with a corresponding increase in contents of organic C in Vittal farm soils (Mohapatra, 1974; unpublished). Soils containing more than 0.7% organic C were significantly correlated with available N (Bhat and Mohapatra, 1971*b*).

For elemental analysis in arecanut palm, the third leaf from the spindle was found to show least variations in N, P, and K. The seventh leaf from the top was found appropriate for the estimation of Ca and Mg (Bhat and Mohapatra, cf., Annual Report, CPCRI, 1972).

Mohapatra, Bhat, and Aboobaker (1971) have found hot water to be a good extractant for the estimation of K in leaf of arecanut palm.

Mohapatra et al. (1973) estimated the cation exchange capacity of roots of arecanut seedlings from 13 cultivars. It was maximum in the root tips and also in the main root. It was higher in high yielding varieties. The morphological characters of seedlings were not related to the root CEC. CEC and P content of root showed a significant positive correlation. Leaf CEC was also positively correlated with the root CEC (Mohapatra et al., 1972).

Conclusion

The soils of arecanut gardens are slightly acid and low in general fertility. There is enough scope to step up the yield of arecanut from the present levels by judicious manuring. Since fertilizers are expensive, methods should be evolved for the better use of indigenous resources and more efficient soil management. For instance, crop

residues can be composted and returned to the garden. Cover crops or grasses can be grown in plantations to check soil erosion. The above-ground vegetative part can be used for green manuring. Fertilizers which increase acidity in soil should not be preferred for use. Acidity adversely affects physical, chemical, and biological properties of soil. Liberal application of organic matter buffers soil reaction. Measured quantities of lime can be added to soils whose pH is below 5.0 to correct acidity. Thus, a condition could be created where all the factors responsible for nutrient transformation work most optimally for giving the best yields.

The micronutrients do not have a pronounced effect on the growth and yield of arecanut. The association of nutrient elements with the yellow leaf disease of arecanut is not clearly understood but evidences are that excess moisture in the root zone predisposes the palms to the disease. The causes of other disorders like *band*, nut splitting, tender nut fall, and kernel discolouration have also to be studied more critically.

REFERENCES

AIYER, A. K. Y. N. 1966. Field Crops of India. 6th Ed. 449 pp. Bangalore Printing and Publishing Co. Ltd., Bangalore.

ANONYMOUS, 1958. Simple manurial trials on arecanut in ryots' gardens. *Arecanut J.* **9:** 17-19.

ANONYMOUS, 1958-59. *Ann. Prog. Rept., Central Arecanut Res. Stn., Vittal.* pp. 29-30.

ANONYMOUS, 1960-61. *Ann. Prog. Rept., Central Arecanut Res. Stn., Vittal.* p. 41.

ANONYMOUS, 1963-64. *Ann. Prog. Rept., Centrul Arecanut Res. Stn., Vittal.* p. 48.

ANONYMOUS, 1969a. *Ann. Rept., Central and Regional Arecanut Res. Stn., Vittal,* for 1965-66. pp. 44-45.

ANONYMOUS, 1969b. *Ann. Rept., Central and Regional Arecanut Res. Stn., Vittal,* for 1967. p. 46.

ANONYMOUS, 1970. *Ann. Rept., Central and Regional Arecanut Res. Stn., Vittal,* for 1968. pp. 41-45.

ANONYMOUS, 1971. *Ann. Rept., Central and Regional Arecanut Res. Stn., Vittal,* for 1969. pp. 36-37.

ANONYMOUS, 1972. *Ann. Rept., Central Planta tion Crops Res. Instt., Kasaragod,* for 1971. pp. 152-155, 161-165.

ANONYMOUS, 1973. *Ann. Rept., Central Plantation Crops Res. Instt., Kasaragod,* for 1972. pp. 106-110.

ANONYMOUS, 1974. *Ann. Rept., Central Plantation Crops Res. Instt., Kasaragod,* for 1973. pp. 99-102.

ANONYMOUS, 1975. *Ann. Rept., Central Plantation Crops Res. Instt., Kasaragod,* for 1974. p. 96.

ANONYMOUS, 1976. *Ann. Rept., Central Plantation Crops Res. Instt., Kasaragod,* for 1975. pp. 93-95

ANONYMOUS, 1977. *Ann. Rept., Central Plantation Crops Res. Instt., Kasaragod,* for 1976. pp. 98-102, 106, 109.

BHAT, K. S. 1956. Why not areca growers also grow green manure? *Arecanut Bull.* **6:** 196-197.

BHAT, N. T. 1969. Correlation studies of leaf tissue tests and soil analysis with areca palms (*Areca catechu* L.). M.Sc. (Ag.) Thesis, 85 pp. University of Agricultural Sciences, Bangalore.

BHAT, N. T. AND MOHAPATRA, A. R. 1971a. Standardization of soil sampling method in arecanut. Part I: Variation in fertility gradient under basin system of manuring. *Madras Agric. J.* **58:** 595-599.

BHAT, N. T. AND MOHAPATRA, A. R. 1971b. Evaluation of interrelationship between organic carbon and available nitrogen in some soils where arecanut is grown in India. *Indian J. Agric. Sci.* **41:** 663-665.

BHAT, N. T. AND MOHAPATRA, A. R. 1974. Standardization of soil sampling method in arecanut. Part II: A procedure to secure homogenous composite sample. *Andhra Agric. J.* **21:** 163-165.

BIDDAPPA, K. G. 1960. Utilization of arecanut waste. *Arecanut J.* **11:** 106-108.

DAJI, J .A. 1948. Manganese toxicity as a probable cause of the band disease of areca palm. *Curr. Sci.* **17:** 259-260.

IYENGER, B. N. 1955. Manuring of the areca palm. *Arecanut Bull.* **5:** 162-166.

JOHN, T. J. 1952. Green manure for arecanut plantation. *Monthly Bull.* **3:** 1-4.

KALBANDE, A. R. 1965. The role of liming in soil fertility. *Arecanut J.* **16:** 8-12.

KHADILKAR, V. B.., BHADE, N. N., AND PANDYA, H. G. 1964. Physico-chemical studies in the coastal and hilly soils under arecanut palm of the Bombay-Deccan. *Arecanut J.* **15:** 7-13.

KIBE, M. M., GOKHALE, G. P., AND NARAYANA, N. 1957. Band disease of the areca palm—A note on the preliminary investigations in the Bombay State. *Arecanut J.* **7:** 83-84.

KRISHNAPPA, K. T. 1962. Growing green manure and cover crops in arecanut gardens in the *malnad* tract. *Arecanut J.* **13:** 129-131.

KRISHNAPPA, K. T. 1964. Liming of arecanut gardens in the *malnads*. *Arecanut J.* **15:** 74-77.

LAKSHMANACHAR, M. S., BIDDAPPA, K. G., AND PAULOSE, T. T. 1966. Simple manurial trials on arecanuts in ryots gardens. *Agric. Situation India* **21:** 441-450.

MOHAPATRA, A. R., BHAT, N. T., AND ABOOBAKER, V. O. 1971. A rapid method for determination of tissue potassium in arecanut. *Curr. Sci.* **40:** 518-519.

MOHAPATRA, A. R., BHAT, N. T., AND DEVARAJU, C. 1972. Note on the comparison of some methods of organic carbon estimation in soils. *Indian J. Agric. Sci.* **42:** 955-957.

MOHAPATRA, A. R., PILLAI, S. S., BHAT, N. T., AND MURTHY, K. N. 1972. Evaluation of interrelationship between cation exchange capacity of leaf and root in arecanut *Areca catechu* L. *Curr. Sci.* **41:** 224-225.

MOHAPATRA, A. R., PILLAI, S. S., BHAT, N. T., AND MURTHY, K. N. 1973. Growth characters and mineral nutrient composition of arecanut seedlings as related to their cation exchange capacity. pp. 63-66. **in** *Proc. First National Symposium on Plantation Crops*. December 8-9, 1972, Trivandrum, Kerala State. Ed., N. M. Nayar, Indian Society for Plantation Crops, Kasaragod 670 124, Kerala.

MOHAPATRA, A. R., BHAT. N. T., AND HARISHU KUMAR, P. 1976. Yellow leaf disease of arecanut in soil fertility studies. *Arecanut & Spices Bull.* **8:** 27-31.

NAGARAJ, B., MATHAI, C. K., AND VELLAICHAMY, K. 1976. Yellow leaf disease of arecanut; Comprehensive Package Plan. *Arecanut & Spices Bull.* **8:** 45-47.

NAIDU, G. V. B. 1962. Arecanut in Mysore. 14-24 pp. *Information Series No.* 7, Dept. Agric., Government of Mysore.

NAMBIAR, K. K. 1949. A Survey of Arecanut Crop in Indian Union. 9 pp. Indian Central Arecanut Committee, Calicut.

NAMBIAR, K. K. 1954. Possibilities of arecanut cultivation in the Andamans. *Arecanut Bull.* **5:** 65-67.