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Nutrition of Coconut

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1. INTRODUCTION

Coconut is essentially a tree crop of humid tropics and is versatile in its adaptability to a wide range of soil and climatic conditions. It is grown in heterogenous conditions of soil ranging from littoral sand to heavy clay in situations from poorly drained low marshy soils to well drained uplands and hill slopes, and in strongly acid to highly calcareous coral soils. The natural habitat of coconut is the coastal belt of tropics where it is flourishing in a sea washed littoral sand with constant motion of underground current of water in a saline atmosphere. The best soil for coconut cultivation is a rich alluvium or loam having optimum water retention capacity and good drainage. However, the coconut is being cultivated in the interior parts of country where the pedo-ecological condition is not exactly suited to coconut cultivation.

2. SOILS

Major soils on which extensive cultivation of coconut is undertaken are laterite, lateritic, red sandy loam, sandy, alluviums, coral, peaty and black soils. Some major characteristics of major coconut growing soils of Kerala have been summarised in Table 1.

2.1 Laterite and Lateritic Soil

These groups of soils are extensively cultivated for coconut and are found in humid tropical zones in the western and eastern belt of India. These are highly weathered soils, moderately deep to deep, loamy to clayey in texture, well drained and predominantly acidic in nature with a pH range of 4.5-6.8. They are deficient in essential plant nutrients, such as K, Mg, Ca, B and Zn. These soils, in general, possess a dominant kaolinitic clay mineralogy and are found in Kerala, coastal and south interior Karnataka, coastal Maharashtra, Andhra Pradesh, Tamil Nadu, Orissa, West Bengal and north-eastern parts of India. These soils cannot sustain coconut productivity for a longer time without proper fertilizer application.

2.2 Coastal Sandy Soils

These soils are found on the coastal belt of the western and eastern coast of

Table 1 : General physico-chemical properties of the soils

Soil group	Mechanical composition (%)			pH (1:2.5 soil) water	Organic Carbon(%)	CEC (me/100 g)
	Clay	Silt	Sand			
Laterite	16.8 (9.6-39.2)	10.5 (2.2-20.0)	64.4 (49.2-86.8)	5.72 (4.0-6.8)	0.55 (0.06-1.8)	5.1 (1-14.4)
Alluvial	17.9 (9.2-31.6)	6.9 (1.0-18.0)	75.1 (50.4-89.2)	5.79 (4.2-7.1)	0.69 (0.03-1.81)	4.4 (0.7-11.3)
Reclaimed marshy*	15.0 (9.0-26.4)	3.9 (0.0-13.6)	78.7 (64.0-91.0)	4.76 (3.7-6.5)	0.68 (0.23-2.91)	4.1 (0.6-24.3)
Coastal sandy	6.8 (3.6-10.8	0.8 (0.0-7.8)	92.4 (87.2-95.4)	6.67 (5.2-8.3)	0.13 (0.00-0.46)	0.5 (0.4-5.4)
Sandy loam	17.0 (8.8-30.2)	3.8 (0.6-14.0)	79.4 (69.4-90.2)	5.81 (4.8-8.6)	0.31 (0.06-1.44)	3.7 (1.0-11.7)

Source : N. Gopalakrishna Pilai, 1975.
Figures in Parantheses denote ranges.
*This includes pokkali, kappadu, kari soils and kayal reclamations. Generally, these soils are acid saline or acid sulphate and coconuts are grown on raised beds.

the country. As the name implies, these are skeletal soils with over 95 per cent as sand fraction with very little amount of silt and clay. The soil pH varies from 5.2 to 8.3 with very poor organic matter content. Both total and available nutrient status is very low. The cation exchange capacity and exchangeable bases are also low. The CEC varies from 0.4 to 5.4 m.e./100 g. The base saturation is high due to presence of salts inundated from sea water. Due to constant motion of underground water current in saline soil atmosphere, these soils support coconut growth. Most of the palms that grow in these soils suffer due to drought. Drooping of leaves, severe yellowing, button shedding and matting of roots affect productivity of palms. In southern Kerala, the soils are poor in bases and application of magnesium sulphate is recommended as an insurance against magnesium deficiency problems.

2.3 Alluvial Soils

The alluviums cultivated to coconut are a highly heterogenous group of soils that occur in Tamil Nadu, Andhra Pradesh, West Bengal, Assam and, to a certain extent, in Kerala. These soils are fertile, very deep and loamy clayey in texture generally non-calcarious and freely drained. The cation exchange capacity ranges from 15.0 to 42.6 m.e./100 g. The exchangeable bases and base saturation are also very high. The alluviums of Kerala are light textured with a CEC varying from 0.7 to 11.3 m.e./100 g. The mineralogy is often mixed with predominantly illite type of clay mineral. These are the best group of soils for coconut where high productivity can be expected. However, the alluvial soils adjoining coastal areas are frequently inundated by sea water during high tides rendering them saline. Such soils invariably warrent special soil management treatments like leaching of excess of salt to make it suitable for successful coconut culture.

2.4 Red Sandy Loam Soils

These soils are found in between coastal sandy tracts and laterite soils in Kerala and parts of Karnataka. They are loamy in texture, porous, well drained, deep and are formed by the process of colluviation. They do not show much variation in the profile characteristics and offer excellent physical conditions for the growth of coconut. They are medium in fertility and the cation exchange capacity on an average is 3.8 m.e./100 g. The base saturation seldom exceeds 35 per cent. These soils respond well to manuring and palms experience moisture stress conditions in these soils.

2.5 Coralline Soils

These soils are found in the Lakshadweep, and Andaman and Nicobar islands in India. These are greyish brown on the surface, the colour attributed mainly by the organic matter. The profile is sandy throughout, structureless and mainly comprises fine bits of coral which is rich in $CaCO_3$ to the extent of 96 per cent. The soil has an alkaline pH ranging from 7.9 to 8.7, highly permeable, poor in water and nutrient retention capacity with hard limestone pan which is impermeable to water. The clay content is less than 2 per cent and rest of the mechanical fraction is entirely made of coral. These soils, in general, are poor in availabe nutrients. Lime induced micronutrient deficiencies are common in such soils. Cation exchange capacity of these soils vary from 1.4 to 5.0 m.e./100 g which closely follows the organic matter content. In spite of the soil and nutrient constraints, excellent coconut groves are found in these soils.

2.6 Acid Sulphate Soils

The acid sulphate soils are mostly found in southern Kerala in the districts of Kottayam, Alleppey and Ernakulam. These soils are of marine origin, very deep, dark greyish black in colour and rich in undecomposed organic matter. They are locally known as *pokkali, kaippadu* and *kari* soils. The soil is loamy containing fairly good amount of silt and clay and organic colloids. These are drained and porous soils containing higher amount of aluminium, sulphur, iron and manganese and are extremely acidic with a pH of 2.5 which seldom goes beyond 4.5. due to the frequent inundation with brackish sea water. The soils are sometimes saline. The soil is very fertile with reference to plant nutrients. However, the low productivity of these soils is attributed to low pH, excess aluminium and sulphur. Often the sulphide injury and aluminium toxicity has been encountered.

2.7 Black Soils

These soils are found in semi-arid regions of India, particuarly in the central part of southern peninsula in the states of Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Bihar and Madhya Pradesh. Successful coconut grooves are raised wherever irrigation facilities are available. The soils are alkaline and rich in $CaCO_3$. The CEC and base saturation are very high. It contains high amount of exchangeable bases, such as potassium, calcium, magnesium and sodium. The soil is very fertile but for its poor physical properties.

3. SOIL FERTILITY AND ITS MANAGEMENT

An important factor determining suitability for good growth and yield of coconut is tied up with high fertility status of the soils. According to Pandalai (1953), atleast six principal soil factors govern the coconut productivity, viz., depth of soil, soil moisture, soil nutrient availability, soil air, temperature and injurious toxic products, of which moisture and nutrient supply regulate the productivity to the extent of 80 per cent. The depth of the soil is very important physical criterion to promote sustained productivity of coconut for more than 40-50 years. The minimum depth of the soil is little more than one metre and is considered essential. If the depth of the soil is shallow, the coconut palm show quick decline in vegetative growth and reproductivity after about 15-20 years depending upon the depth of the soil.

3.1 Soil pH

Coconut adapts itself to a wide range of soil acidity. The optimum pH at which the coconut grows well is in the range of 5.0 to 6.5. Coconut palms thrive well up to a pH range of 8.5. In extremely acidic soils, free acidity and aluminium dominates the exchange sites, and such soils may need to be ameliorated with organic or inorganic amendments. The acid sulphate soils having low pH and excess aluminium should be amended with suitable chemical amendments preferably magnesium silicate. In general, the soil acidity can be corrected by liming and alkalinity by using gypsum according to lime/gypsum requirement.

3.2 Electrical Conductivity

Coconut is a semi-halophyte which can tolerate fairly high amount of salts in the soil. Coconuts are found to grow without suffering any permanent physiological injury even in situations where their roots had come into contact with high salt concentration (Sankaranarayanan *et al.*, 1958) and are known to withstand fairly high salt concentration of 10,000 ppm (Krishnamoorthy and Premanathan, 1968). In majority of the soils, salt content is not considered as a serious problem. However, coastal saline soils, black soils in the semi-arid tracts, *Pokkali* soils and low lying alluvial soils in the coastal belt do contain moderately high amount of salts that might pose problem to coconut growth and production. In such cases, suitable ameliorative measures need to be undertaken either through leaching of excess of salts or use of chemical amendments, such as application of gypsum, sulphur and acid forming chemical fertiliizers. In the case of heavy soils, where drainage is a serious problem, suitable soil management practices must be adopted right from planting of coconut. In these soils, the planting pits must be filled with a mixture of 1:1 ratio of soil and sand along with 1-2 kg of gypsum and sufficient amount of organic materials. The successive earthing of pits should also be done with mixture of sand and soil up to 3 to 4 years. This process ensures not only proper drainage in the root zone of coconut but also facilitates the removal of excess salts through drainage water. In the case of low lying areas, the planting of coconut has to be undertaken on the raised mounds to avoid the direct contact of coconut roots with salinity during the initial stages of growth.

3.3 Soil Organic Matter

Soil organic matter is a product of its environment. The type of vegetation, the nature of soil organisms and the climate determine the kind and amount of organic matter in soil. Manciot *et al.* (1979a) suggested a threshold value of 1.0 per cent organic carbon for coconut soils. Improving organic matter status of soils has beneficial effect on soil physical and chemical environment, helped in establishing coconut groves in coastal sandy soils (Nambiar *et al.*, 1983). Farmers, in general, resort to extensive annual application of green leaf manure consisting of forest leaves to coconut gardens. Growing leguminous green manures crops in the fertilizer application basins has been shown to enrich the soil with adequate organic matter in the coconut basin (Thomas and Shantharam, 1984). Growing green manure crops in the interspaces of coconut and incorporating these manures into the basins of coconut is also a feasible preposition to improve the nutrient status in the coconut root zone. Intercropping cocoa with coconut can contribute to substantial addition of organic matter and nutrient recycling through litter fall and prunings (Anon., 1988).

3.4 Soil Nitrogen

The nitrogen supply in the soil is directly correlated with soil organic fraction which varies with soil types. Generally, the total nitrogen status of soils is medium to poor. In low rainfall areas and in areas with uneven distribution of rainfall, nitrification time and root activity is reduced and weed growth further adds to the problem in coconut plantations. The loss of nitrogen through various processes, especially through leaching in high rainfall areas, poses problems of nitrogen management in coconut plantations.

The studies conducted at CPCRI, Kasaragod (1986-90) has indicated that there is a good scope for the use of slow release nitrogen sources such as N:P tablets and urea formaldehyde, etc., compared to urea. The second approach in nitrogen management is through organic farming (Thomas and Shantharam, 1984). Cocoa and an array of other identified inter and mixed crops have been found to enrich the soil through their litter fall and root activity. Further, cultivation of green manures in the coconut manuring circles to a radius of 1.8-2.0 m around the bole, and in the interspaces and their incorporation would add substantial amount of nitrogen to the soils.

3.5 Soil Phosphorus

The soil P content varies with different soils depending upon parent materials nature of weathering under different climatic conditions. The available soil P status of laterite, lateritic, red and red sandy loam soils is medium. The phosphorus applied is reverted to insoluble forms by the high sesquioxide contents of red soils and as Ca-P in black and alluvial soils. In case of swampy and *Kari* soils, the major fraction of phosphate is held in the organic form.

The mobility and diffusion of P in the soil is very slow, and in the fertilization programme of coconut, it was observed that the applied P tend to accumulate in the surface horizons of the soils. Hameed Khan *et al.* (1985) indicated a slight migration of P to the subsoil horizons when continuous P fertilization at the rate of 320 g P_2O_5/ palm/year was made for 5 years. Thus, the loss of P through leaching is almost nil. However, in sloping lands, erosion of top soil which is unabated in laterite soil areas may remove considerable quantities of phosphates accumulated in the top soil.

Since applied P is not invariably lost and a high build up occurs in the coconut basins, there is scope to skip or cut down P fertilization to coconut. Monitoring soil and foliar P levels, and yield of palms, Hameed Khan *et al.* (1992) have suggested that P application to coconut can be profitably withheld for several years based on soil tests without any deleterious effect on yield and nutrition of palms.

The general management of soil P in coconut plantations is not a serious problem both in acidic and alkaline soils due to minimum loss and very low amount of P utilised by coconut.

3.6 Soil Potassium

The potassium content in differen coconut growing soils of India varies with soils and can be linked to the nature of parent material. In general, almost all acid soils that support coconut production, contain relatively low amount of potassium, and black and alluvial soils contain high amount of potassium.

In Kerala, the available potassium status varies from 13 ppm for coastal sandy soils to about 95 ppm in laterite soils (Pillai, 1975). Since potassium is one of the most important element in the coconut nutrition, any damage done due to inadequate supply of K would be difficult to correct in the latter stages of crop growth. Hence, it is important that the adequate supply of K must be ensured right from field planting of coconut itself.

The management of soil potassium is not very difficult as in the case of nitrogen. Regular potassic fertilization combined with possible organic recycling would build up soil potash levels.

3.7 Soil Sodium

Almost all laterite, lateritic and coastal sandy soils are poor in available sodium due to profuse leaching. The soils formed under semi-arid conditions such as black and red soils contain considerable amount of soil sodium. The soils near sea coast are rich in sodium due to constant current of motion of sea water underground as well as continuous salt spray from the sea. In brackish water and marshy soil ecocystem, where the soil is frequently inundated with sea water, the soil may contain high concentration of Na. Since cococnut is a semi-halophytic plant, it can tolerate fairly high amounts of Na concentration in the soil solution.

Pillai (1975) observed exchangeable Na contents to vary from 37 to 151 ppm in chief coconut growing soils of Kerala. Sodium chloride is used as a soil ameliorant to enhances the softening and weathering of laterite faster for easy penetration of roots.

3.8 Secondary Nutrients

Among secondary nutrients, Mg and S are important as far as growth and productivity of coconut is concerned. Both Mg and S are almost deficient in most of the coconut growing soils in humid tropics. This is true in India also. The laterite and lateritic soils in the states of Kerala, Karnataka, Maharashtra, Andhra Pradesh, Tamil Nadu and north-eastern part of India where extensive coconut plantations are located is deficient in Mg and S. However, the availability of these two nutrients in alluvial, black and swampy soils is comparatively high. Both Mg and sulphate are highly mobile and lost from the soil due to leaching. In acid sulphate soils of Kerala, sulphur concentration is very high and even reaches toxic level.

All the soil groups of Kerala cultivated to coconut are deficient in magnesium. The mean values for 733 soils studied by Pillai (1975) for the soil groups varied from 1.11 to 1.08 m.e./100 g in 0-50 and 50-100 cm depth respectively. The sandy soils were very poor with mean values varying from 0.21 to 0.28 m.e./100 g. Magnesium deficiency is also caused by imbalance of nutrients such as high K/Mg or Ca/Mg ratios in soil. Continuous application of chemical fertilizers to coconut in red sandy loam soil over a period of 10-15 years depletes the Mg concentration rapidly (Hameed Khan *et al.*, 1986) and is reflected in Mg and Mg/cationic ratios both in soil and plant (Ashraf, 1990), Cecil (1987), while studying the Mg application along with NPK, did not find soil build up of Mg in the loamy sand soils of southern Kerala. In this context, application of $MgSO_4$ at the rate of 500 g/palm have been recommended to coconut growing soils. This practice also supplies S along with Mg to coconut. Due to shift in the fertilizer use, viz., urea in place of ammonium sulphate and rock phosphate in lieu of superphosphate, it may lead to sulphur deficiency problems especially in soil poor in organic matter.

The available Ca content of most of the coconut growing soils is sufficient to meet the coconut demand. Although Ca is one of the essential secondary nutrients, its specific importance in coconut nutrition has not been much realised. The management of soil calcium is not a serious constraint because it is being supplied incidently through phosphatic fertilizers.

The availability of soil Ca in black, alluvial and coralline soils is high and do not warrant any lime application. Although, lime application is desirable in acid soils to correct soil acidity and to suppress Al activity, it has not been found beneficial on the productivity of coconut.

3.9 Micronutrients

Among micronutrients, copper, chlorine, boron, zinc, iron, manganese and molybdenum are important for coconut productivity. Acid lateritie and lateritic soils are deficient in Zn, B and Cu while Fe and Mn are high and even reach toxic levels. In case of black soil, availability of micronutrients barring Fe and Mn is high, whereas alluvial soils contain optimum amount of all the micronutrients required for coconut growth and productivity. Acid sulphate soils of Kerala tend to contain all the micronutrients in excess quantities while in coraline and coastal sandy soils, several micronutrients except chlorine are deficient.

The management of micronutrient supply to the soil should be judiciously planned. Any excess supply of micronutrients should be avoided to eliminate chronic problems of toxicity. The micronutrient application must be attempted only after studying soil and plant analysis results for these elements. Soils located near coastal belt receive chlorine through salt spray of sea water. In semi-arid tracts, Cl content of soil is very high to meet the requirements of coconut. Not much work has been done in India on the importance of chlorine in coconut nutrition though much information is available from IRHO work in West Africa and from the Philippines. It is evident from published literature that in soils rich in K, increased yields obtained by KCl application is attributed to chlorine. In addition to the above micronutrients, requirement of iodine also needs attention as it is essential for the biosynthesis of oil. Probably, this is the reason why the application of common salt gives indirect beneficial effect on the growth and productivity of coconut as common salt carries adequate iodine as an impurity. Much more work on this line is needed.

4. NUTRITIONAL REQUIREMENT OF COCONUT AND ITS MANAGEMENT

Coconut is a perennial crop that exports nutrients to the above ground parts continuously from a limited volume of soil throughout its existence. It is, therefore, essential that a nutritionally rich environment is provided in the feeding zone (root zone) of coconut to realise adequate yields. Many attempts have been made earlier to estimate the quantity of nutrient exhausted/exported from soil by the growing palms. Nevertheless, the work of Pillai and Davis (1963), and Ourier and Ochs (1978) provide a realistic estimate of differential nutrient need of the palms (Table 2). There is no uniformity in soil type, variety of palms, age, climate, soil factors and management conditions of palms compared so that a general comparison can be made. However, the data provides information

Table 2 : Annual nutrient removal by coconut palm

Country	Basis	Nutrient removal (kg/ha)						
		N	P	K	Ca	Mg	Cl	S
India*	173 palms/ha 40 nuts/palm West Coast Tall	56 (1.0:0:21:1.25)†	11.9	70	33.9	12.5	—	—
Ivory Coast**	6-7 tonnes copra/ha (PB 121 hybrid)	174 (1.0:0.114:1.43)†	20	249	70.0	39.0	249	30

*Pillai and Davis (1963).
**Ouvrier and Ochs (1978).
†Ratio of N:P:K.

on the extent of nutrient exhausted by coconut palms. It is evident that, for coconut palms, nutrients of importance can be arranged as potassium, nitrogen, phosphorus, calcium and magnesium (Table 3). IRHO workers have also outlined the importance of chlorine in such a list.

Table 3 : Nutrient uptake by a West Coast Tall palm

Nutrients (g)				
K	N	Ca	Mg	P
406	321	196	72	69

4.1 NPK Requirement of Seedlings in Nursery

In about eight to nine weeks after a mature nut is sown, the embryo develops and a spongy haustorium or apple is formed which is the reservoir of food for the growing embryo. The spongy tissue is fairly constant in chemical composition during its development and contains around 85 per cent water, 10-11 per cent alcohol soluble material and only 4-5 per cent cellulose structural constitutents (Child, 1974). The haustorium initially absorbs food material from the coconut water and latter on from the kernel and supply it to the young plant. About 18 to 20 weeks after sowing, the shoot appears through the husk and nut is said to have been germinated. Foale (1968) reported that nutrient contribution by endosperm to the growing seedling decreased from fourth month after germination suggesting that the young seedlings are actually in short supply of nutrients for a major part of their one year growth in the nursery when seed bed is not adequately supplied with nutrients. Though food reserves were adequate as far as carbon compounds and nitrogen were concerned (Harries, 1970), potassium uptake was more and the experiments indicated the advisability of adding potash. Heavy organic and inorganic fertilization can be recommended to the nursery and, in India, it was suggested that application of fertilizers to the nursery in December, February and April to supply 40 kg N, 20 kg P_2O_5 and 40 kg K_2O/ha can be resorted to under west coast conditions to produce vigorous seedlings (Nelliat, 1973).

4.2 NPK Requirement of Young Palms in Pre-bearing Age

Health of palm at the prebearing age is very important for faster and vigorous growth, reducing prebearing period (Smith, 1969) and in attaining optimum productivity and sustainability of yields. Young palms adequately supplied with potassic fertilizers fruited at the fifth year after planting while it took 8 years for unmanured palms to come to bearing. Fremond and Ouvrier (1971) found that the damage caused by potassium deficiency in the early stages was not fully repaired by latter dressings with potassium. Although, later application of potassic fertilizers enabled re-establishment of good physiological functioning, palms which suffered from potassium deficiency during the pre-bearing stage remained on an average 15 per cent less productive than those that never suffered.

Table 4 : Effect of different levels of fertilizer application on plant (14th leaf) nutrient status of three coconut genotypes

Genotype	Fertilizer Level	Plant nutrient (%)					
		N	P	K	Mg	Ca	Na
WCT	M_0	1.4	0.11	0.7	0.23	0.23	0.25
	M_1	1.7	0.11	1.0	0.17	0.33	0.13
	M_2	1.7	0.11	1.1	0.15	0.27	0.13
COD × WCT (D × T)	M_0	1.4	0.11	0.6	0.22	0.26	0.24
	M_1	1.6	0.11	1.0	0.13	0.26	0.11
	M_2	1.7	0.11	1.1	0.11	0.27	0.10
WCT × COD (T × D)	M_0	1.4	0.10	0.6	0.26	0.25	0.27
	M_1	1.6	0.11	1.1	0.16	0.26	0.14
	M_2	1.6	0.11	1.1	0.15	0.30	0.11
LSD at 5% Fertilizers	—	0.9	0.12	—	0.03	0.03	—

M_0 = Control; M1 = 500 g N : 500 g P_2O_5 : 1000 g K_2O.
M_2 = 1000 gN : 1000 g P_2O_5 : 2000 g K_2O.
H = Hameed Khan *et al.*, 1986.

A series of trials conducted in India had also indicated the beneficial effect of NPK fertilizers at the pre-bearing age. Application of NPK at the rate of 340 g N, 230 g P_2O_5 and 450 g K_2O per adult palm per year induced flowering one year ahead at Veppankulam (Tamil Nadu) than no-fertilizer plots. When the dosage was doubled, pre-bearing period was further reduced by four months (Anon., 1971). In the West Coast of India, Nelliat and Muliyar (1971) observed that among 54 palms that flowered by sixth year, none was from the plots that did not receive fertilizers. On the coastal sandy soils, flowering was enhanced when organic matter like coir dust, forest leaves, coconut sheddings and farm yard manure were blended with NPK, and applied to young seedlings (Nambiar *et al.*, 1983). The importance of mauring young palms viz., West Coast Tall, Dwarf × Tall and Tall × Dwarf hybrids, was much reflected in their growth performance in inducing good vegetative growth and precocity in flowering (Anon., 1974, 1976). A series of countrywide fertilizer experiments conducted under the All India Co-ordinated Project on Palms also highlight the importance of manuring young palms. It is imperative that in an intelligent fertilizer application programme, importance of fertilizing young palms with adult palm dosage should be resorted to well in advance before they come to flowering (Hameed Khan *et al.*, 1990). Fertilizer dose recommended for adult palm should be given to young palms from third year onwards. Once the seedlings are planted in the main field, about one-tenth of the adult dosage may be applied after three months, one-third after two years of growth, two-thirds after three years and full dosage after fourth year onwards.

4.3 NPK Requirement of Adult Bearing Palms

Experiences throughout the world under varying soil conditions indicated the importance of balanced fertilization to coconut in realising satisfactory and significantly increased yields.

Menon and Pandalai (1958) reviewing the work done in India on various aspects of fertilizer application to coconut palm reported that :

a) There is a general response to N and K while response to P was seen only under certain conditions.

b) Responsse to manuring was dependent to a large extent on the availability of nutrients in the soil.

c) A minimum of three years are required to obtain the full response of fertilization in coconut.

d) Nitrogen had beneficial effect on female flower production, potassium had little effect, while phosphorus had a depressive effect.

e) Nitrogen had an adverse effect on copra content while potassium had a very beneficial effect, but phosphorus had no effect on copra weight.

f) Oil and protein contents of copra were not influenced by the different nutrients.

g) Experimental evidence was too mearge to express any conclusive opinion regarding the alleged superiority of organic form of fertilizers over inorganic forms.

Application of 340 g N, 340 g P_2O_5 and 680 K_2O/palm/year influenced 35 per cent increase in nut production and 44 per cent increase in copra out-turn in the cultivators gardens where the palms were hitherto unmanured. When response to fertilizer application was not observed, significant increase was obtained when potassium level was revised to 900 g K_2O/palm/year. Further enhancing N, P_2O_5 and K_2O to 900, 1135 and 1135 g respectively resulted in additional increases in yield (John and Jacob, 1959).

Ressponse to N application was obtained in terms of yield from third year onwards and for phosphorus from ninth year onwards at Kasaragod. For palms yielding less than 60 nuts annually, optimum nitrogen dose ranged between 400 and 650 g/palm/year and that of potash between 890 and 1210 g/palm/year. Nitrogen adversely affected all the nut characters studied, viz., weight of whole nut, weight of husked nut, volume of husked nut and copra weight per nut (Muliyar and Nelliat, 1971). These characters were highly improved by potassic manuring while phosphorus had negligible effect. Although, N application increased the yield by 16.9 per cent, copra yield was increased by only 6 per cent. With potassium, increase in nut production was 12 per cent while that of copra yield was 22 per cent.

The back water areas of Kerala are highly saline and present a different physical and nutritional environment for coconut. Addition of 230 g N, 340 g P_2O_5 and 450 g K_2O/palm/year would suffice for satisfactory growth and yield of coconut (Thomas, 1968).

General requirement of fertilizer elements for palms yielding an average of 50 nuts/palm/year would be 500 g N, 320 g P_2O_5 and 1200 g K_2O/palm/year. Higher dose of 1000 g N, 500 g P_2O_5 and 2000 g K_2O/palm/year can be recommended for palms with larger yield potential (Nelliat, 1973). However, copra quality and antagonism of K with Mg has to be monitored with plant analysis for maintaining optimum nutrient balance in the palm whenever higher doses of N and K are given. The reader is advised to study the review on mineral nutrition and fertilization of coconut around the world (Manciot *et al.*, 1979 and 1980) for an excellent treatment of the subject.

4.4 Calcium Requirement of Coconut Palm

Calcium requirements of coconut palm are moderate and, in fact, coconut is a lime loving plant (Fremond *et al.*, 1966). Calcium deficiency in coconut palms has not been observed in India. Even in acidic soils of India and Sri Lanka where coconut is cultivated extensively, palms seldom suffer due to calcium requirement. Calcium application had no influence on Ca content in leaves and on yield (Manciot *et al.*, 1979). However, some instance of increase in yield due to calcium application has been reported from Malaya and Trinidad.

4.5 Magnesium Requirement of Coconut palm

Magnesium is observed to be one of the limiting nutrient elements in the nutrition of seedlings and young palms, especially when the soil supply is low. Specific instance of absolute Mg deficiency conditions in the soil were reported in West Africa (Brunin, 1969), Sri Lanka (De Silva, 1966) and India (Pandalai *et al.*, 1958; Verghese, 1966; Cecil, 1969). Balanced application of N, K and Mg is needed from the time of planting, especially on poor soils. Prolonged use of higher rates of potassic fertilizers, has been reported to depress magnesium content in plant and induce Mg deficiency (Manciot *et al.*, 1979; Hameed Khan *et al.*, 1986). Magnesium deficiency is more prominently expressed when neglected gardens are brought under intensive manuring to increase yield. Under such situations, magnesium deficiency is caused due to luxury consumption of potassium and its antagonism towards uptake of magnesium. Deificiency of magnesium in well fertilized palms where foliar symptoms are not expressed has also been reported in (Table 4) (Hameed Khan *et al.*, 1986).

Application of magnesium containing fertilizers corrected Mg deficiency very well, raised Mg levels of leaf, improved growth and increased the production provided that K supply was adequate. When potassium levels were adequate in the system and plants were deficient in magnesium, application of magnesium could enhance yield to as much as 40 per cent. However, effect of magnesium was seen only on number of nuts per palm and it had no effect on copra content.

4.6 Sulphur Requirement of Coconut Palm

Sulphur deficiency causes severe chlorosis, poor yields and poor copra often described as rubbery kernel. Specific deficiency of sulphur was reported from Papua and New Guinea and Madagascar in many widely scattered areas. In India, sulphur deficiency did not seem to be an immediate problem for coconuts in West Coast of India. However, it is desirable to include any one of the sulphur containing fertilizers in fertilizer schedule. Southern (1969) recommended use of 900 g sulphur/tree once in two years for conditions existing in Papua and New Guinea. Fertilization in the form of sulphur as sulphate quickly restores the copra to normal and brings the oil content back to 60 per cent few months after the first application.

4.7 Sodium Requirement of Coconut Palm

The addition of common salt (NaCl) has been an age old practice, very popular among coconut growers in Kerala (India), Java and Coloumbia. The coconut grows in soils rich in Na although there is no direct relationship between the sodium content of soil and that of plant. In laterite soils, addition of common salts in pits and planging seedlings was known to soften the laterite bed and helped early penetration of the tender roots. Beneficial effect of NaCl on increased female flower production, number of nuts and copra content per nut has been reported (Fremond, 1964). Performance of palms in terms of yield was at par with palms receiving full dose of K_2O and 50 per cent K_2O substituted with Na_2O (Prema *et al.*, 1987) in laterite soil region of northern Kerala. There is a growing interest among cultivators and scientists on the róle of sodium in substitution of functions of potassium. Preliminary studies indicate that sodium, to a certain extent, substitute the role of potassium when potassium supplies are inadequate.

4.8 Chlorine Requirement of Coconut Palm

The importance of chlorine in oil palm and coconut is now accepted by most research workers. Ollagnier and Ochs (1971), and Von Uexkull (1972), interpreting experimental results at Ivory Coast and Philippines respectively, brought to light that Cl levels significantly influenced yields. They even suggested to rank chlorine as an essential major nutrient for coconut and oil palm. The high requirement of chlorine by coconut was proved latter by Ouverier and Ochs (1978) for hybrid coconut PB 121, the exhaust of chlorine was equal to that of K (Table 2). The importance of chlorine was realised to such an extent that it was recommended to be ranked as the second most important element, next to K, for coconut. Chlorine improved vegetative growth, nutritional status and yield of coconut. The effect of chlorine is manifest more on the thickness of kernal. In certain experiments in the Philippines, 55.5 per cent increased nut production, 74.3 per cent increased copra weight per nut and 80.3 per cent increased copra/tree was attributed to chlorine (Margate *et al.*, 1979).

Thus, there is reason to believe that applying common salt (NaCl) to coconut and its influence in increasing the yield and nutrition of palms can be attributed to the anionic component, viz., chlorine of the sodium chloride. This beneficial effect was more pronounced in palms grown under neglect as most often obtained under farmers conditions.

5. MICRONUTRIENT REQUIREMENT OF COCONUT

5.1 Boron

Boron deficiency causes malformation of leaves which are quite characteristic. The prominent symptom noticed is the appearance of hook leaf, shortening of fronds and crowding of emergent leaves around the apex which gives a chocked appearance. In some cases, the petiole of new leaf becomes very thick and forms a tubular structure enclosing the entire space at the apex. Recently, wide spread boron deficiency has been reported in parts of Assam, West Bengal and Kerala. In Boron deficient soils, preventive action of boron applied from planting was very effective. IRHO experiences (Manciot *et al.*, 1980) indicate that there were 40 per cent anomilies in the control plots against 0.2 per cent in those getting borated manuring as a preventive measure (Table 5). However, on adult palm, application of boron was not found to influence production of copra/tree though increase in absorption of boron was recorded.

Table 5 : Effect of boron on production

Year	Foliar boron levels (per cent)		Production (copra/tree)	
	Without B application	With B application	Without B application	With B application
1963	7.0	10.3	5.7	6.7
1964	6.2	9.3	12.4	12.8
1965	7.1	10.7	11.6	11.6
1966	6.0	8.7	12.9	13.3
1967	7.2	11.6	7.3	7.5
1968	6.6	10.8	11.9	12.1

In Assam and West Bengal where boron deficiency was noted on young palms, healthy palms had higher boron content (6.9-7.9 ppm) compared to diseased palms which recorded 4.7 to 6.3 ppm boron. Ca/B ratio was also found to be lower in healthy palms (Baranwal *et al.*, 1989). They recommended soil application of borax at the rate of 50 g per palm just after appearance of symptoms. Two applications of the same dose at an interval of 3-4 months was necessary in advanced cases for curing the disorder.

5.2 Zinc

Most acid, laterite and lateritic soils which are cultivated, to a large extent, to coconut are deficient in zinc especially in root (wilt) disease affected areas (Pillai *et al.*, 1975). However, zinc deficiencies and typical symptoms are very rarely seen. Ollagnier and Ochcs (1980) report that P and Mg applications increase Zn levels significantly whereas N or K applications lower them.

5.3 Iron and Manganese

Iron and manganese deficiency is rare in India in the major coconut growing tracts. However, coral soils of Lakshadweep and Andaman and Nicobar islands may pose problems of Fe and Mn deficiency. Closer observations in coralline tracts may reveal the influence of calcareous nature of the soil in blocking the uptake of Fe, Mn, Zn and Cu. Compared to soil application, injection of a solution of ferrous sulphate and manganese sulphate in the trunk of adult palms was found to give better results (Pomier, 1969).

5.4 Copper

Copper deficiency is not commonly found in coconut. Application of coppor in the form of chelates raises the Cu level, but has no influence on growth or yield. Peaty and of acid sulphate soil of Kuttanad area in Kerala may pose problems of Cu deficiency.

6. NUTRIENT INTERACTIONS

The presence of adequate amount of nutrients *per se* in both soil and tissue is not important as far as biomass production and productivity of coconut is concerned. Most of the cations and anions, which are nutrients, are involved in different magnitude of interactions among themselves either in synergestic or antagonistic manner. Thus, the productivity of coconut ultimately depends upon the extent of optimum ratio of different nutrients in coconut palm (Menon and Pandalai, 1958). As expected, the critical level of K is operated when nitrogen level in the tissue was at sufficient level. Further, Smith (1969) suggested N:K ratio of 2.25 when N level was less than 1.8 per cent. However, Ollagnier and Ochs (1973) in their studies of N-K interaction in tropical crops concluded the absence of any possible interaction due to sufficiency level of nitrogen. Fremond (1964) reported that P did not show much beneficial effect in increasing either the yield of nuts or copra content but, in the presence of K, P was found to have beneficial effects. Manciot *et al.* (1979a, b) found that deficiency of Mg influences the translocation of phosphorus resulting in a situation where coconut experiences deficiency of P and Mg or both. Silvà (1978) also reported a similar phenomenon.

Kamaladevi *et al.* (1973) and Hameed Khan *et al.* (1986) observed a strong negative interaction between Mg and K. Often, Mg level in the tissue decreased consequent upon high fertilization. Coomons (1977) and Manciot *et al.* (1979) oberved that foliar contents of Ca, Mg and Na are depressed by high K levels, the effect was much pronounced on Mg levels in the palm. Wahid *et al.* (1974) demonstrated the antagonistic effect of combined level of Na, Ca and Mg on K in the palms when judged through foliar analysis.

The calcium contents are appreciably increased by nitrogenous or phosphatic fertilizers. Potassium manuring tends rather to depress it (Manciot *et al.*, 1979b).

7. FERTILIZER PRACTICES

It has been established throughout the coconut growing nations that fertilizer application is the best practice to increase the yield. Necessity of fertilizer application as means of increasing the yield of coconut is determined by soil analysis and foliar diagnosis. More often, there is more than one deficiency and their correction requires application of several mineral elements.

The inevitable time lager between commencement of any improved practice and the realization of its benefits has led many coconut growers to think whether manuring and cultivation are really necessary and will, in fact, be paying.

Efficiency of utilization of applied fertilizers was governed by two factors, viz., extent of root surface available for absorption and concentrations of nutrients in the soil solution. Studies in Jamaica showed better response from broadcast application in wide circles than using the same quantity close to the bole, whereas De Silva (1967) recommended fertilizer application in the entire area around the palm up to a distance of 150 cm from the bole for maximum efficiency. Nethsinghe (1964, 1966, 1983) concluded that for maximum efficiency in the uptake of nutrients by bearing palms, fertilizers should be applied around the palms in the entire area up to a distance of 150 cm from the bole. Placement in full circles was 40 per cent more effective than placement in semi-circle. However, studies in India on loamy sand (Dwivedi *et al.*, 1981) indicated that the quickest recovery of ^{32}P in palms was detected after 7 days of placement when applied through hole method, 8 days of application by trench method and strip methods, and after 11 days in basin method (Table 6). Though quickest recovery of radio-active ^{32}P was noted when applied through hole method, the average highest accumulation of activity (CPM/g, dry matter) among all the methods of soil placement techniques was recorded in trench method where roots are exposed. Nevertheless, for obtaining higher efficiency, fertilizer application in circular basins 20 to 30 cm deep and 150 to 180 cm radius around the base of the palm is recommended by Central Plantation Crops Research Institute, Kasaragod in Kerala. For better utilization of nutrients by the palm annual dose of fertilizers should be applied in two or more splits (Table 7; Nelliat, 1973).

Under average management conditions, a minimum of 340 g N, 170 g P_2O_5 and 680 g K_2O may be applied per palm in two split doses as indicated above. As a normal practice, organic manures are applied (50 kg green leaf or compost) followed by inorganics and the manuring basins are covered with the excavated soil. However, organic manure component is not compulsory and depends upon the availability of the resource. In southern Kerala, especially in Kollam and Alapuzha districts, the soils are poor in exchangeable bases and application of magnesium sulphate at the rate of 3 kg per palm per year is recommended along with the other ferilizers. Liming is not normally recommended as a regular practice. However, in addition to recommended levels of fertilizers, 1.0 kg of dolomite or 1.0 kg lime plus 0.5 kg magnesium sulphate per palm per year may be applied in acidic soils.

8. SOIL ANALYSIS

Though soil analysis is successfully employed for fertilizer recommendation for annual crops, its usefulness for plantation crops like coconut has been limited.

Table 6 : Absorption and accumulation of ^{32}P in coconut palms through different methods of radio activity application

Methods of application	Plant parts	P activity (CPM/g dry matter) after different period of sampling											
		3rd h	4th h	8th h	12th h	18th h	24th h	6th day	7th day	8th day	11th day	18th day	30th day
Plant injection technique													
Growing	FFOL	Nil	Nil	Nil	Nil	180	822	520	ND	ND	380	260	190
root tips	Roots	Nil	Nil	Nil	Nil	180	367	98	ND	ND	380	260	70
Stem	FFOL	Nil	Nil	260	320	910	1215	928	ND	ND	640	481	313
injection	Roots	Nil	Nil	100	210	412	560	410	ND	ND	310	270	150
Cut end	FFOL	Nil	350	580	1410	1501	1680	931	ND	ND	410	380	280
of roots	Roots	Nil	126	216	312	501	740	411	ND	ND	260	210	130
Soil placement technique													
Hole	FFOL	ND	ND	ND	ND	ND	ND	Nil	200	310	530	400	104
method	Roots	ND	ND	ND	ND	ND	ND	Nil	120	160	250	300	85
Strip	FFOL	ND	ND	ND	ND	ND	ND	Nil	Nil	240	570	610	130
method	Roots	ND	ND	ND	ND	ND	ND	Nil	Nil	120	181	280	60
French	FFOL	ND	ND	ND	ND	ND	ND	Nil	Nil	280	940	880	180
method	Roots	ND	ND	ND	ND	ND	ND	Nil	Nil	180	360	325	100
Basin	FFOL	ND	ND	ND	ND	ND	ND	Nil	Nil	Nil	88	100	50
method	Roots	ND	ND	ND	ND	ND	ND	Nil	Nil	Nil	34	64	30

FFOL: First fully opened leaf.; ND: determined.
CD at 5%- Plant injection techniques 294; Soil placement techniques 60.1.

Table 7 : Dose of fertilizer recommended for different age group of palms (g/tree)

Age group	May-June			Sept.-October		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
First year	Planting May-June			50	40	135
Second year	50	40	135	110	80	270
Third year	110	80	270	220	160	540
Fourth year onwards	170	120	400	330	200	800

Source: Coconut Package of Practices, Central Plantation Crops Research Institute, Kasaragod, Kerala.

Conventional soil analysis is difficult to interpret when large mass of soil is explored for nutrients by the coconut roots. Very often, the reflect of soil nutrient content is not indicated by analysis of leaves. Coconut thrives well in multivarious locations in differing soil types. Moreover, nutrient absorption capacity by palm is inadequately understood and often excellent growth is seen in littoral sandy soils and marginal lands. The soil analysis in such areas does not provide much indication to the nutritional status of the palms.

However, based on long term observations, 70-80 ppm mineralizable nitrogen in the main fertilizing zone (coconut basin area of 1.8 m radius around the bole) is found to be adequate for optimum nutrition with reference to nitrogen (Hameed Khan *et al.*, 1986). Manciot *et al.* (1979), and Longanathan and Balakrishnamoorthy (1980) observed that an Olsen's P value of 25 and 17 ppm respectively as threshold value for phosphorus. Hameed Khan *et al.* (1986) indicated 10 ppm Bray-I P level in the soil can sustain sufficient level of P in palms. Based on long term observations, Hameed Khan *et al.* (1992) indicated that, for soil test values (STV) of less than 10 ppm, the recommended dose for adult palm, viz., 320 g P_2O_5 may be applied and for STV of 10-20 ppm, 160 g P_2O_5/palm/ year would suffice. However, if the STV is more than 20 ppm, phosphorus application can be skipped. Potassium is the most important nutrient in coconut nutrition and almost all soil groups in Kerala are found to be deficit in potassium. Critical level of soil available K was observed to be between 50 and 65 ppm. Manciot *et al.* (1987) have suggested a threshold level of 0.15 to 0.20 m.e./100g exchangeable K with an exchangeable Mg/ K ratio of 2.5 when the total exchangeable cations is 1.0 m.e./100 g. Though exact requirement of nutrients cannot be indicated for coconut, soil testing can suggest whether optimum nutrition can be made available for palm from nutritional status of soil.

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