

Nutrition of Oil Palm

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1. INTRODUCTION

Oil palm, a relatively new crop to the Indian agriculture under new environments, is emerging as an important perennial oil yielding crop under irrigation in the states of Andhra Pradesh, Assam, Karnataka, Kerala, Goa, Gujarat, Maharashtra, Orissa, Tamil Nadu, Tripura and West Bengal. Being a new crop, it requires proven scientific management practices suiting to the soil, environmental and ecological conditions prevailing in these areas. As for any other crop, oil palm requires rational manuring for maximum production and stabilized yields. Among the major tropical plantation crops, oil palm removes greater amounts of nutrients from the soil (Turner and Gillbanks, 1988) which is given in Table 1.

Table 1 : Nutrients removed by various plantation crops

Crop	Yield	Nutrients (kg/ha)				
		N	P	K	Mg	Ca
Oil Palm	25 t fruit bunches	93.5	11.0	92.7	19.3	20.3
Coconut	2400 kg Copra	40.8	6.8	99.8	7.0	3.5
Cocoa	1125 kg dried beans	25.5	5.0	50.0	6.3	3.2
Coffee	1125 kg coffee	40.0	7.3	50.3	—	—
Tea	1350 kg dried tea leaves	62.5	4.5	28.3	3.0	5.5
Rubber	1928 kg dry rubber	19.1	3.8	15.5	2.6	—

Source : Turner and Gillbanks (1988).

The data illustrates that oil palm nutrition is of extreme significance. Though not much work has been reported from India on nutrition of oil palm, the research findings carried out at the Central Plantation Crops Research Institute (CPCRI) Research Centre, Palode along with most relevant information from elsewhere are consolidated in this chapter.

2. OIL PALM GROWING SOILS IN INDIA

The suitability of a soil for oil palm cultivation is influenced by the physical, chemical and biological properties of the soil. Appropriate management of these soil

properties and availability of water play a major role in determining oil palm yield. The major chemical properties that have a direct impact on oil palm production are : (i) soil fertility and mineral nutrient status and (ii) soil acidity and alkalinity. The degree of availability of a nutrient for oil palm is conditioned by the amount of nutrient, moisture and organic matter present and the pH of the soil. A range of soil nutrient content and fertility exists in the oil palm growing soils of India, based on which nutrient availability classification can be constructed. An example of the major criteria used in determining soil suitability for oil palm as given by Ng (1968) is given in Table 2 and 2a.

Table 2 : Criteria for assessing suitability of soils for oil palm

Properties	Grade		
	Favourable	Marginal	Unfavourable
Terrain (slope)	<12°	12-20°	>20°
Effective depth in relation to impenetrable sub-soil layer or permanent water table	>75 cm	40-75cm	<40cm
Texture	Loam or heavier	Sandy loam	Loamy sand or sand
Structure and consistency	Strongly developed, friable to moderately firm	Moderately developed and firm	Weak or massive and extremely firm
Laterite	Nil	Fragmental 15-30 cm thick	Fragmental > 30 cm thick or massive
pH	4.0-6.0	3.2-4.0	<3.2
Peat layer (thickness)	0-0.6m	0.6-1.5m	>1.5m
Permeability	Moderate	Rapid or slow	Very rapid or very slow

Table 2a : Soil classification based on the above criteria of suitability

Classification	Criteria
Highly suitable	Soils possessing all scheduled properties within favourable grade.
Moderately suitable	Soils possessing not more than two properties in marginal grade.
Marginal	Three or more properties under marginal grade plus one property in unfavourable grade.
Unsuitable	Two or more properties under unfavourable grade.

Source : Ng (1968).

Under irrigated conditions, it is envisaged to grow oil palm in different types of soils.

2.1 Soil Types

In Andhra Pradesh it is envisaged to grow oil palm mainly in the coastal districts—Godavari East and West, Guntur, Nellore, Prakasam, Srikakulam, Vizag, Vijayanagaram

and part of Khammam Districts. The soil in these regions are mainly red sandy soils, red earths, red loamy (shallow to deep), red soils with clay base, deltaic alluvial and coastal soils. The pH of these soils range from 6.5 to 9.0. The soils are low to medium in organic carbon, deficient in available P and medium to high in available K.

Soils of Assam have five major groups, viz., alluvial soils, such as recent riverine alluvial soils, old riverine alluvial soils and old mountain valley alluvial soils, non-laterized red soils with mixed red and black soils, ferruginous red soils, ferruginous gravelly soils and laterite red soils. Alluvial and red loam soils have 1.5 per cent organic carbon, medium to high N, low P_2O_5 and medium K_2O and pH range of 4.8-6.8. These soils are ideal for oil palm cultivation.

Soils of Goa and Maharashtra are mostly lateritic with low to medium N, P and high K. Deficiency of Ca, Mg and trace elements like B and Mo are commonly noticed. In Maharashtra, the South Konkan coastal zone has laterites or lateritic soils with PH 4.7 to 6, and coastal saline and alluvial soils with pH 5.6 to 8.2.

In Gujarat, black soils and alluvial soils followed by saline alkali soils are predominant in the area identified for growing oil palm in the State. Isolated pockets of coastal alluvium and laterites also occur in this region. In the case of black soil, one has to be careful in preventing the deep cracks during summer and water logging during rainy season by providing adequate drainage facilities and adopting agronomic practices. Similarly, the saline, alkali soils also require ameliorative measures and appropriate management to overcome the problem.

In Karnataka, the soils are red or brown sandy loams and black clayey with pH ranging between 6.5 and 9 in the Thungabhadra Project, black cotton soils having a PH of 7.8 to 9.5 in Upper Krishna, or red sandy loam with a pH of 7.0 to 8.3 in the Bhadra project area. In the Cauvery basin, red sandy loam or river alluvium which are rich in humus are common. Ameliorative measures are to be taken in soils having high pH values whenever oil palm cultivation is envisaged in the State. However, areas with high pH need to be eliminated while selecting the land for oil palm.

In Kerala and Andamans, the soils are laterites, lateritic types or red gravelly loams. Because of heavy rainfall and consequent leaching of nutrients from these soils, they are either low or medium for its nutrient content especially nitrogen and potassium which emphasise the need for an efficient nutrient management programme. The crop has also been introduced in acid sulphate soils of Kuttanad area in Kerala having pH values as low as 3.5 to 4.5 where again the crop is found to thrive well. Oil palm is grown on raised bunds in this region.

Soils of Orissa are red and yellow, red loamy, river alluvium, coastal alluvium and brown forest soils. Most of the soils are acidic except coastal saline soils.

In Tamil Nadu, soil is mostly alluvium in Tanjavure district. However, laterite or gravelly laterite are also found in certain regions. It is river alluvium, red sandy or

red soils which are common in Tiruchirapally district. Alkaline and water logged pockets are found near the sea coast. The deep soils seen on plain lands of the state are very ideal for oil palm cultivation.

In Tripura, most of the soils are acidic with pH values ranging from 4.8 to 5.8. These soils are often found deficient in nitrogen, phosphorus, potassium and calcium. Soils of Tripura are categorized as forest and hill soils, alluvial soils and red soils. Texture of soils vary from loamy sand to sand and are deep. Similar soil and climatic conditions suited for oil palm also occur in other North-Eastern states.

In West Bengal, soil is sandy loam in Jalpaiguri and sandy loam to loam in Cooch Bihar, which are mostly alluvial deposition of different rivers. Sandy loam soils and alluvial soils are also found in Darjeeling district. A majority of these soils are acidic though saline pockets are also found to occur.

2.2 Soil Nutrient Status

To assess the immediate fertilizer requirement of the crop, top soil analysis gives more or less the same indications as that of leaf analysis. Percentage saturation of potassium and exchangeable magnesium in oil palm soils gives indication on existence of deficiency or adequacy of these cations. A soil with a pH of 4-5 with more than 1 per cent carbon, more than 1 per cent mineral nitrogen, more than 300 ppm total P and 20 meq/100g exchangeable K is more suited for oil palm. It is interesting to note that soil in most of the countries where oil palm is grown are acidic with values ranging from 4-6. However, in India, it is observed that the crop could establish very well even in soils with high pH up to 8.5 as in Karnataka and Andhra Pradesh. Oil palm requires higher nutrient concentrations in soil than for other crops.

3. FUNCTIONS OF NUTRIENTS

The effects of major and secondary nutrients on growth and yield of oil palm has been reported from most of the oil palm growing countries including India (Nair and Sreedharan, 1982). It is important to note that fertilizer application to oil palm gives resultant response in yield only during subsequent years indicating the importance of continuous supply of nutrients to the crop. It has become increasingly clear that not only must the levels of individual nutrients be adequate within the palm, but also that the relative concentrations of these elements are important, i.e., the various nutrient components must be present in a particular ratio giving a balanced nutrient status.

Most of the biochemical reactions in the crop are catalyzed by enzymes which are proteins in which nitrogen is a constituent. Whenever chlorophyll synthesis is inhibited due to lack of nitrogen, chlorosis of leaves occurred and yellowing becomes deeper in more deficient palms. Phosphorus is a constituent of nucleic acid and phospholipids are important for the metabolic activities of the palm. An adequate presence of phosphorus

is necessary for the efficient use and action of nitrogen. Potassium is important for the regulation of transpiration, water use efficiency and drought resistance of the crop especially due to the specific role of K on the opening of stomata. Magnesium is an essential component of the chlorophyll molecule. A particular function of magnesium on oil palm is its association with phosphorus in the formation of phospholipids in oil. Thus, magnesium is required in the fatty acid synthesis.

Ollagnier *et al.*, (1971) and Ollagnier (1973) reported the essentiality of chlorine nutrition for oil palm and coconut though no specific deficiency symptoms were reported. Chlorine nutrition is important for the water economy (von Uexkull-1990), and pest and disease resistance. Optimum Cl concentration in frond 17 range between 0.45 and 0.6 per cent.

Vegetative dry matter (VDM) of oil palm increased with N, P and K but not with Mg. N increased the rate of leaf production and, therefore, rapid growth and fruiting, more number of bunches and the bunch weight. Phosphorus also increased number of bunches, bunch weight, female flowers and sex ratio. Potassium increased leaf area, female inflorescences, number of bunches and bunch weight in oil palm. An early bearing was also noted due to K application. Crop growth rate (CGR) has also improved with N, P and K application showing NK interactions. Nitrogen enhanced the net assimilation rate (NAR) and both N and K increased the leaf area index (LAI) of the crop. Wherever LAI is less than 5, palms respond to nitrogen application. The role and functions of all major nutrients in increasing oil palm bunch yield had been reported by many workers from all the oil palm growing countries of the world.

4 NUTRIENT DEFICIENCY SYMPTOMS

Visual signs or foliar diagnosis are helpful in correcting nutrient deficiencies in oil palm. Small trunk diameter, short fronds and small bunches are produced when phosphorus is limiting. Deficiency symptoms were observed for the nutrients, viz., potassium, magnesium and boron in isolated pockets in Kerala and were corrected by supply of the particular nutrient.

In potassium deficient palms, pale yellow leaf spots were initially developed on older leaves, which later turned to orange or bright orange in colour. Though the main K deficiency symptom noted is confluent orange spotting, symptoms such as midcrown yellowing and orange blotches on pinnae are also observed. In severe deficiency as the time advanced, the leaves became brown and dried up. These symptoms were observed in the estates of Oil Palm India Ltd., Bharathipuram in plots where fertilizers were applied in much lesser quantity than that is being recommended. The deficiencies were rectified by application of recommended annual doses of 1200 gK₂O as KCl to the palm.

In the case of magnesium deficiency, orange yellow patches of discolouration occurred in areas between veins on either sides of the midrib, leaflets which are exposed

to sunlight showed yellowing or orange yellow discoloration. In advanced stages, dark necrotic spots and scorching from the tip were observed and the leaflets dried up. On adult palms, these symptoms are most striking with bright orange yellow colour which is designated as 'orange frond'. Magnesium deficiency symptoms were observed in isolated pockets in Palode. Experimental trials conducted at Palode has established that Mg deficiency could be corrected by soil application of $MgSO_4$ at 2000g/palm/year applied in two equal splits continuously for two years and at 1000g/palm/year in two subsequent years. Magnesium application is recommended wherever deficiency symptoms are noticed. Mg application should be carried out before the application of KCl to correct severe deficiency. Usually deficiency symptoms occurred where leaf levels are below 0.2 per cent (Fig. 1).

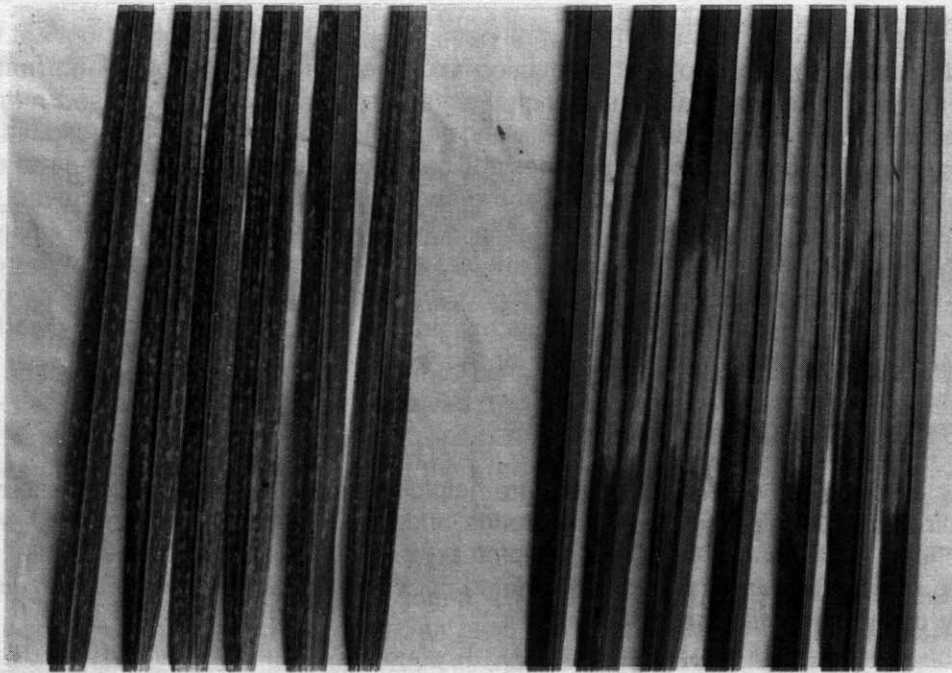


Fig. 1 : Orange spotting—K deficiency symptoms on oil palm leaflets (on left) orange yellow discoloration—Mg deficiency symptoms on leaflets exposed to light (on right).

In boron deficient palms, the emerging leaf showed lack of expansion. These leaves are usually wrinkled, dark green and brittle. The development of pinnae is incomplete forming a tuft of bristles at their tip with stunted growth. Emergence of deformed leaves are also noted. Boron deficiency caused abnormalities like 'Hook leaf' with single or double hooks appeared on the pinnae, little leaf, fishbone leaf and blind leaf symptoms. Application of borax at 180 g/adult palm could rectify the boron deficiency symptoms (Fig. 2).

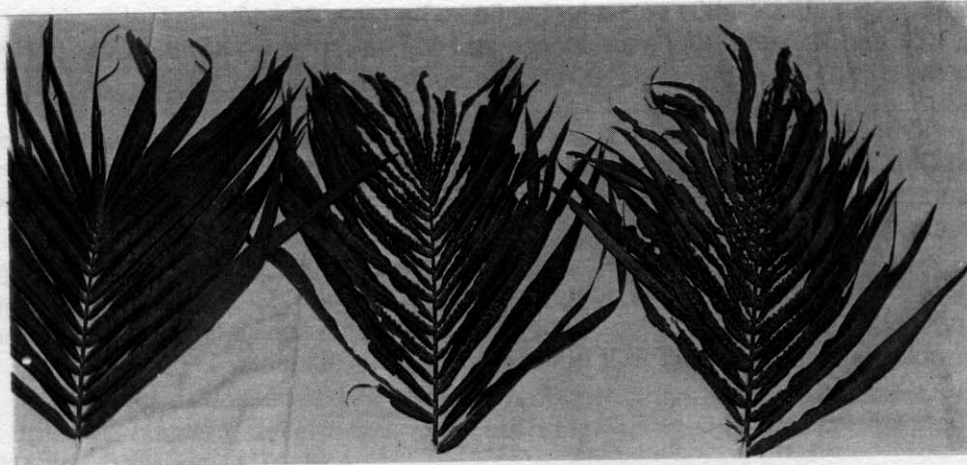


Fig. 2 : Wrinkled leaf tips—Boron deficiency symptom on adult palms.

5. UPTAKE AND EXHAUSTION OF NUTRIENTS

The vegetative matter that is harvested or removed from a single oil palm in an year varied with age, environment and growth rate of the crop. However, around 60-250 kg fresh fruit bunches (ffb), about 150 kg leaves and 20 kg of male flowers are removed indicating the substantial requirement of nutrients by oil palm. It is estimated that oil palms with a yield of 10t ffb removes 29.4 kg N, 4.4 kg P and 37.1 kg K which means a single palm yielding 100 kg ffb removes 294 g N, 44 g P and 371 g K through bunches alone. In addition, the crop require nutrients for vegetative growth and also to substitute the losses through leaching, fixation and volatilisation. These requirements which are to be met from the soil and shortage of any element can cause inadequate or unbalanced nutrition leading to low production.

The annual N, P, K, Ca and Mg nutrient requirement of palms (kg per hectare) of different ages as estimated by Tan (1977) are 39.8, 6.1, 55.4, 12.9, and 7.4 (0-3 years), and 191-267, 32-42, 287-387, 85-114 and 48-67 (3-9 years) respectively. The total N, P, K and Mg uptake (kg/ha) from 1 ha (148 palms) were 191, 27, 265 and 59 in Malaysia where the yield is 24 t ffb/ha (Ng and Thamboo, 1967) and 149, 21, 107, and 56 in Nigeria where the yield is 9.7 t ffb/ha (Tinker, 1976).

6. ROLE AND SOURCE OF ORGANIC MANURES

Organic matter (OM) being the key factor to retain nutrients in its available form determines the fertilizer use efficiency for prolonged period. Lack of OM also adversely affect the soil water relationship.

The two major organic sources of manure for oil palm plantations are the cut fronds and the empty fruit bunches. (EFB). Cut fronds yielding 10 tonnes of dry matter

per hectare, a nutrient value equivalent to 58 kg/ha urea, 30 kg/ha rock phosphate, 120 kg/ha KCl and 70 kg/ha Kieserite. Hence, cut fronds are to be spread over the inter-row for recycling of nutrients as an organic source.

Empty fruit bunches (EFB) are good organic source of nutrients, especially potassium. EFB can be applied in the inter-row as mulch. Bunch ash is an important source of potassium. This is used as a potassium rich fertilizers and has an average nutrient content of 40 per cent K_2O , 3-4 per cent P_2O_5 , 5-6 per cent MgO and 4-5 per cent CaO . It is used for amelioration in many areas. Tropical soils of India, wherein oil palm is grown, have variable contents of organic matter. Organic matter content in soils under oil palm cultivation may be improved through the application of animal manure, fresh mulch materials, empty fruit bunches or factory effluents.

7. ROLE OF INORGANIC FERTILIZERS

7.1 Leaf Nutrient Content and Crop Nutrition

In a tree crop like oil palm, leaf sampling and analysing is carried out both for greater sensitivity and convenience as compared to the soil analysis. Selection of leaf to be sampled is usually restricted to the leaf 1, 9, 17 or 25 which are on the same spiral.

Most appropriate among these is the one in which the nutrient levels are best comparable with yield. Depending on the sensitivity and reliability of leaf tissue analysis, leaf 17 is recommended for routine sampling as standard errors were the least for most of the nutrients like N, P, K and Ca in this leaf. For palms below 3 years of age, leaf samples are collected from 9th frond. Two or three pairs of healthy undamaged leaflets from the central portion are taken for analysis. Sampling has to be done between 7 and 11 am to avoid diurnal variations. Greater accuracy can be obtained by taking at least one composite sample from 25 trees within an area of 25 hectares.

Correlation of NPK content in the leaf and yield were reported by Nair and Sreedharan (1982). Seasonal variations in nutrient content were also observed by them. N and P were lower during the dry season and increased during the rainy season. The relationship between N and P showed that critical level of P changed with N content. Critical nitrogen level also changed with the age of the palm. Water deficits during the previous months must be used for interpreting foliar analysis as any restraint on transpiration can limit K uptake by the crop. Leaf levels are also influenced by nutrient interactions such as N-P and Mg-K.

7.2 Critical Levels and their Importance

A convex curve for yield-concentration relationship with a strong response in the zone of lowest concentration has been found true for oil palm.

Critical levels of nutrients as suggested by Ochs and Olivin (1971), IRHO are as given in Table 3.

Table 3 : Critical nutrient concentraion in oil palm leaves

Leaf No.	N	P	K	Ca	Mg	Cl	S
17	2.50	0.15	1.00	0.60	0.24	0.55	0.22
9	2.75	0.16	1.25	—	0.24	—	—

Optimum levels of micronutrient elements are not precise. The published figures that are most commonly found ranges in frond 17 (in ppm) but do not necessarily indicate either optimal or deficiency levels : boron-18, 10-29, 10-12; zinc-15, 15-20; copper 5, 5-8; manganese-150-200; 200-400; iron-80; and molybdenum-1, 0.5-1.

However, a consolidated data on ranges of leaf nutrient concentrations associated with optimum nutrition, deficiency and excess as given by von Uexkull and Fairhurst (1991) are furnished in Table 4.

Table 4 : Nutrient concentration of oil palm leaves (deficiency, optimum and excess levels %)

		Deficiency	Optimum	Excess
Young palms (below 6 years)	N	< 2.5	2.6 - 2.9	> 3.1
	P	< 0.15	0.16 - 0.19	> 0.25
	K	< 1.0	1.1 - 1.30	> 1.8
	Mg	< 0.20	0.30 - 0.45	> 0.7
	Ca	< 0.30	0.50 - 0.70	> 1.0
	S	< 0.20	0.25 - 0.40	> 0.6
	Cl	< 0.25	0.50 - 0.70	> 1.0
	B(ppm)	< 8	15 - 15	> 35
	Cu(ppm)	< 3	5 - 7	> 15
	Zn(ppm)	< 10	15 - 20	> 50
Old palms (over 6 years)	N	< 2.3	2.4 - 2.8	> 3.0
	P	<0.14	0.15 - 0.18	> 0.25
	K	< 0.75	0.90 - 1.2	>1.60
	Mg	< 0.20	0.25 - 0.40	> 0.70
	Ca	< 0.25	0.50 - 0.75	> 1.00
	S	< 0.20	0.25 - 0.35	> 0.60
	Cl	< 0.25	0.50 - 0.70	> 1.00
	B(ppm)	< 8	15 - 25	> 40
	Cu(ppm)	< 3	5 - 8	> 15
	Zn(ppm)	< 10	12 - 18	> 80

Source : von Uexkull and Fairhurst (1991), IPI Bulletin 12.

Teoh and Chew (1988) classified the nutrient status based on the K status of rachis as high (> 1.6%), adequate (1.31 - 1.6%), marginal (1.01-1.3%) and low (< 1.01%).

Due to the perennial nature of the crop and considering the time taken from primordia initiation to harvest, one should consider the changes in leaf levels in the preceding two years and should not rely on a single year's analysis results. Fertilizers applied during this period are to be considered in interpreting the leaf nutrient results. Leaf nutrient concentrations showed wide variations in the estates of Oil Palm India Ltd. in Kerala both due to soil variations and differences in fertilizer management techniques adopted in different years. Leaf nutrient status is also influenced by age of the palm and seasonal factors as rainfall and vegetative growth of the palm which are to be considered for interpretation of the tissue analysis results. Any reduction in leaf nutrient content is usually interpreted as at least partly due to the fall in available soil reserves of that particular element which are to be supplied from external sources.

8. FERTILIZER MANAGEMENT

8.1 Nutrient Requirements, Forms, Frequency and Methods of Supply

Fertilizer requirement of oil palm vary with the type planting material, stages of growth, climate, spacing and ground cover. Fertilizer application depending on the stages of growth of the palms such as :

- a) Nursery stage (up to 18 months),
- b) Early growing stage (from field planting upto the end of 3 years)
- c) Early yielding stage (end of 3 years to end of 9th year), and
- d) Mature stage (10th year onwards).

Fertilizer management in oil palm involves the choice of suitable fertilizers, fertilizer rates, time and frequency of application to suit the pH of the soil, age, and requirements of the palm. The area of fertilizer application is based on the extent of spread of absorbent roots as well as the system of irrigation. The application method and periodicity should be based on the absorbent power of the soils which is generally poor in tropical soils in which oil palm is grown. Nutrients should be supplied at such concentrations so that more of the applied nutrients are retained and less is lost in leaching.

8.2 Choice of Form of Fertilizers

Oil palm is grown in India over a wide range of pH from 3.5 to 8.5 as found in acid sulphate soils of Kuttanad region of Kerala to alkaline soils of Andhra Pradesh and Karnataka. Acid soils are mostly found in high rainfall-regions of Andamans, Assam, Kerala, Goa, Maharashtra and the north-eastern states of Tripura and Mizoram. In other states, oil palm is mostly grown in near neutral or slightly high pH soils.

Among different forms of nitrogenous fertilizers used, urea is most commonly recommended as source of nitrogen in acidic soils. Ammonium sulphate is better used in alkaline soils. Ammonium sulphate is applied at the rate ranging from 1.5 to 8 kg/palm per year and the higher rates are usually given for a lower density of 112-118 palms per hectare.

As far as phosphatic fertilizers are concerned, most often the less soluble form of phosphorus is recommended as they have been found to be taken up by the palms effectively in diverse situations. In the early growing stage up to three years of age, water soluble forms of phosphorus is applied and for older palms rock phosphate is recommended. Rock phosphate is the major source of phosphorus recommended for oil palm grown in acid soils. In other soils also, rock phosphate may offer economy, but it must be verified that there is adequate uptake in such soils. Diammonium phosphate can also be used as source of N and P.

Of the different forms of potassium, chloride form is more economical as well as ideal for oil palm due to its chlorine requirement. Hence, muriate of potash, i.e., potassium chloride is applied to oil palm to suit all conditions.

8.3 Fertilizer Recommendations

8.3.1 Nursery Manuring

In the absence of research results of any fertilizer trials on nursery seedlings conducted in India, the recommendation by Hartley (1977), which is found to ensure vigorous growth and supply of healthy seedlings, is being followed in India as detailed in Table 5.

Table 5 : Fertilizer recommendation for oil palm nursery

State of seedling	Recommendation
3 Months stage	<i>Liquid form</i>
4 Months stage	Application of urea at weekly interval—Apply 7 gm in 5 litres of water per 100 seedlings
<i>5 Months onwards</i>	<i>Solid form</i>
Make a mixture containing Ammonium Sulphate, Superphosphate, Muriate of Potash and Magnesium Sulphate in 1 : 1 : 1 : 2 proportion and apply every month from 5th month onwards at the rate as given below :	
5 months stage	10 g mixture/seedling
6. months stage	15 g mixture/seedling
7. months stage	20 g mixture/seedling
8. months stage	25 g mixture/seedling
9. months stage	30 g mixture/seedling
10. months stage	35 g mixture/seedling

Care must be taken to apply fertilizers 10-12 cm away from the base of the seedling to avoid scorching.

8.3.2 Fertilizer Recommendation in the Field

At the time of transplanting, super phosphate is applied at 200g per pit. First dose of nitrogen and potassium application can be given three to four months after planting in the main field at 100-120g each of N and K₂O per seedling.

The recommended dose for an adult palm is 1200gN + 600g P₂O₅ + 1200g K₂O per palm per year (CPCRI, 1986) for West Coast conditions based on a fertilizer experiment conducted by CPCRI in the estates of Oil Palm India Ltd. (OPIL) at Bharathipuram in Kerala. Studies conducted by Nair and Sreedharan (1982) has shown that higher levels of application of nitrogen increased the foliar P and K which would have also increased the yield. Neither CaO nor MgO applied at 500g/palm showed any significant effect on yield. During the first year of planting in the main field, 1/3 of the adult dose; during second year-2/3 of adult dose; and from the third year, full dose are being recommended. Fertilizers are applied in two equal splits in April/May and September/October, i.e., towards the beginning and end of rainy season as far as the West Coast is concerned.

In most soils, the spread of feeding roots of oil palm is confined to that area covered by leaf spread during its early growth period. Up to five years, it is better to apply the fertilizer on a circular area corresponding to that subtended by the spread of fronds around individual palms. For adult palms, fertilizers are applied to a circular area within a radius of 2m around the base of individual palms. Under rainfed conditions of West Coast with this level of fertilizer application, on average yield of 15t ffb/ha is obtained and with assured water supply during the summer months, the yield went up to 22t ffb/ha (4t oil/ha) at Palode in Kerala (Varghese and Nampoothiri, 1986). Thus, adequate fertilizer application with assured supply of water improved the mineral nutrition of the palms with a corresponding yield improvement. Details on the material cost, application charges and the share of fertilizer input cost to the total cost showed that fertilizer management in oil palm account for the major share of 50 per cent of the cultivation expenses (Varghese and Nampoothiri, 1988). Fertilizers are applied evenly over the weeded circle by broadcasting and should be applied at times of assured water supply.

8.4 Fertilizers for Intercropping Systems

There is ample scope for raising intercrops in oil palm plantations during the initial 3-4 years. Growing cereal crops, oilseed crops, pulses, vegetables, cash crops, spices, fruit crops like banana and pineapple and tobacco are practised in India. Since oil palm removes large quantity of nutrients, both oil palm and the intercrops are to be adequately and separately manured with their doses when multiple cropping systems are resorted to.

9. NUTRIENT INTERACTIONS

Studies conducted with various nutrients in oil palm revealed that full expression of one nutrient was obtained only when other nutrients were supplied in adequate

quantities. Nutrient balance is important in oil palm production. The major nutrient interactions of significance to oil palm are that of N and P and K, K and Mg, and K and B. In phosphorus deficient soils, response to N and K are obtained only when phosphorus deficiency is corrected (Ollagnier and Ochs, 1981). When K is limiting, increased N levels decrease oil to bunch ratio and the ratio is enhanced with adequate N and K nutrition (Foster *et al.*, 1988). Chan (1981) also reported the lack of response to K on yield and vegetative dry matter without nitrogen fertilizer and good response with nitrogen fertilizers. Chan and Rajaratham (1971) noted a negative effect due to magnesium levels in the absence of potassium and a positive effect with the presence of potassium on yield of oil palm. Due to the K-Mg antagonism, application of heavy doses of potassium can lead to nutrient imbalance in oil palm. Imbalances in nutrient content affects the growth and yield of oil palm. White stripe is a symptom reported to be due to excess of nitrogen with low K and B status. Such interactions of nutrients on yield warrants the need to use nutrient proportions or nutrient ratios in both soil and plant as a guide for drawing fertilizer programmes for oil palm.

10. AGROTECHNIQUES FOR BETTER NUTRIENT EFFICIENCY

10.1 Cover Cropping and Management Practices

In areas where oil palm is cultivated on slopes as in parts of Kerala, contour bunding, terrace cutting and platform cutting around the palm are essential to ensure better efficiency of applied nutrients. Soil conservation measures and maintenance of soil moisture and soil organic matter are to be carried out for promoting growth and yield of oil palm. Cover cropping with *Pueraria phaseoloides*, *Calapogonium muconoides*, *Centrosema pubescens* and *Mucuna sp.* can increase the nutrient cycling fraction through atmospheric nitrogen fixation by these legumes and also through addition of leaf litter and by way of maintenance of good soil physical conditions. Nitrogen nutrition can be increased through establishment of cover crops which can contribute up to 300kg N/ha (Han and Chew, 1982). The cover crops are to be supplied with phosphatic fertilizers initially for its proper establishment. On gentle slopes, cover cropping are to be practised. On steep slopes, platforms or terraces are to be constructed.

Supply of nutrients with reference to its quantity and time are to be adjusted giving due consideration to the soil and environmental conditions without adversely affecting the prevailing ecological conditions. Frequency of application should ensure a continuous supply and should minimise the losses. On occasions of heavy nutrient removal through harvest of a bumper crop due to better moisture supply or better pollination, are to be compensated by additional supply of nutrients during such periods.

10.2 Preventing Nutrient Losses

Losses of nutrients due to soil erosion, leaching, volatilization and fixation are to be prevented or minimised through proper agronomic measures. Proper establishment of cover crops, contour planting and forming platforms and terraces, spreading cut fronds

on contour lines, mulching with empty fruit bunches, timely fertilizer application and avoiding heavy rainfall periods are some agronomic means to prevent soil and nutrient erosion losses. Leaching losses of N, K and Mg can be reduced by spreading fertilizers evenly over rooted area through split application, application of organic matter such as leaf fronds and empty fruit bunches, and by increasing pH of acid soils by liming to improve CEC. Volatilization losses of nitrogen has to be minimised by application of urea only with assured rainfall, by covering with soil and through split applications. Losses due to phosphorous fixation can be prevented through single application in bands or only at the outer rim of weeded circles through application of organic matter such as empty fruit bunches and proper lime application.

11. CONCLUSION

Oil palm nutrient management should ensure adequate and continuous supply of both macro and micro nutrients throughout the growth period of oil palm for getting constant higher bunch yields. Fertilizer being the single high cost input for oil palm cultivation, its optimum application under different agroclimatic conditions in India are to be based on results obtained from field experiments, soil analysis and foliar diagnosis. Quantity and proportions of nutrients supplied should coincide with the crop requirements and is also determined by the age and productivity of the plantation. Frequency and method of application are to be site specific and should be based on soil moisture retention characteristics and climatic conditions especially the prevailing rainfall pattern of a locality. Nutrient losses are to be minimised by adopting suitable agronomic measures. In problem soils such as the alkaline soils of Andhra Pradesh and Karnataka and the acid sulphate soils of Kuttanad regions of Kerala ameliorative measures are to be adopted to improve efficiency of applied nutrients.

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