



Balanced fertiliser application-

A critical analysis for ensuring better productivity in coconut

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Coconut, the 'Kalpa Vriksha' is bestowed with the unique quality among all the tree crops to sustain mankind with all its plant parts –providing food, fodder, fuel, medicine, nourishment, housing and so on. The tender coconut provides a refreshing drink. The raw kernel is a major part of our diet. The oil is used for cooking as well as in soap and toiletries. The oil cake is a valuable cattle feed. The husk is used in the manufacture of coir ropes, mats and matting. The trunk is used in house construction and furniture making. The leaves are used for thatching houses. The inflorescence sap is used for making neera, sugar jaggery etc. Each and every part of the crop finds its application in our daily life. So, no part is there remaining to be wasted and it is the same uniqueness of the crop that make it prone to all sort of 'nutritional vagaries'. As the productivity of the palm increase, the quantity of nutrient removed from the soil also increases. During its productive period spanning for six to seven decades, it removes a huge quantity of nutrients from the soil. The palm parts are rich source of nutrients and hence when these palm parts are removed from the coconut production system, it removes with it a major chunk of nutrients from the soil. Based on a study conducted at ICAR-CPCRI RS, Kayamkulam, it has been found that the magnitude of nutrient uptake in an apparently healthy adult palm is of the order 889 gram nitrogen 389.7 gram calcium, 1075 g potassium, 71.6 g magnesium, 229.69 g sulphur, 321.63 mg boron, 2304 mg zinc, 569 mg copper and 1784 mg manganese. On the other hand, if these palm parts are properly incorporated, it will add up to the soil quality so that a multitude of microbes can thrive upon it, sustain the above and below ground biodiversity making it possible for the

growth of wide array of crops in the cropping system. Hence all nutrients which are removed from the system through the different palm parts, needs to be replenished with adequate quantity of nutrients through the external supply of inputs, in the right proportion at the right time.

In this background, let us see the necessity of ensuring balanced nutrient management in coconut. Being the basic necessity to ensure the optimum soil reaction for ensuing the nutrient use efficiency of added nutrients, soil pH should be maintained at the optimum level. Hence the factors affecting soil reaction should be looked upon.

Soil reaction

Soil acidity is a major chemical constraint in tropical soils wherein the rainfall is of such a magnitude to leach appreciable amounts of calcium and magnesium from the surface layers of soil. Correction of soil reaction forms the foremost step towards adequate nutrient management in coconut. This implies that the pH of the soil should be in the optimum range for ensuring optimum growth and productivity. The pH range for the growth is in a wide range between 5.2 and 8.0, most ideal being between 6.0 to 6.5. Soil acidity hence needs to be managed for effecting the nutrient use efficiency of added nutrients.

Formation of soil acidity

Heavy rainfall in the tropical regions can cause the leaching down of bases such as calcium, magnesium, sodium and potassium and a resultant rise in soil acidity will occur. Humus, formed by the microbial

decomposition of organic matter in soils is capable of reacting with iron and aluminium ions and form complexes which may undergo hydrolysis to give hydrogen ions. Also, the hydrous oxides of iron and aluminium occurring as amorphous particles of colloidal dimensions undergo hydrolysis giving rise to hydrogen ions. Application of soluble fertilisers with residual acidity also can intensify the soil acidity.

Amelioration of soil acidity

For rectifying the soil acidity, the added material should contain the metallic ion which could reduce the hydrogen ion concentration in the soil solution. It also should not be too caustic to handle nor its reaction with soil shall be too rapid. The metallic cation supplied should encourage aggregation of soil colloid and should not leach out from the soil. Hence potassium and sodium compounds could not be used as ameliorant for soil acidity instead calcium and magnesium compounds are to be used for the amelioration of soil acidity. The anion associated with calcium and magnesium is also important. Hence calcium and magnesium salts of strong acids are not suitable for liming, as it may cause the release of free acids and hence will aggravate soil acidity. Calcium and magnesium salts of weak acids such as carbonates and basic compounds such as oxides or hydroxides are used.

The chemical reaction in the acidic soil while applying liming material

When lime is applied to soil, there will be rise in percentage base saturation, increase in active calcium and magnesium which will lower the hydrogen concentration in soil solution.

The important liming materials in soil include agricultural lime (CaO) which is produced by the heating of limestone (CaCO₃), dolomite (Carbonate of calcium and magnesium), and lime hydroxide.

The effectiveness of liming material is decided by the purity of limestone and its fineness. If the material is finely powdered, its reaction will be very fast and if it is coarse the reaction will be very slow.

Effect of lime material on soil and plant health

Liming can enhance the availability of phosphorus under extreme acid conditions as it precipitates out its available forms during the raising of pH. Liming can reduce the toxicity of micronutrients such as iron, manganese, copper and zinc. It can increase

the availability of boron and molybdenum. The microorganism responsible for nitrification need large amounts of active calcium and therefore liming to raise the pH values to 6 or 6.5 helps increasing the nitrification. Decomposition of organic matter other than plant residues will be rapid. Symbiotic and non symbiotic nitrogen fixation is favoured by adequate liming. The growth of leguminous plants is increased due to higher amounts of nitrogen fixed and larger amounts of organic matter and nitrogen are therefore returned to the soil. The greater nitrogen fixation by non symbiotic microbes makes possible the more rapid conversion of carbonaceous crop residues to humus in adequately limed soils. Thus, soil fertility status of limed land will be improved.

In coconut, burnt lime and dolomite are effective liming material, the neutralising value of which is 179 and 109 respectively. Liming @ 1 kg/palm/year with the help of lime or dolomite is the recommendation for coconut. The time of application of liming material is important. Approximately two weeks gap is essential between the fertiliser application and liming. If the gap is not there under aqueous alkaline condition, the volatilisation loss of nitrogen will occur and hence the applied nitrogen will be lost as ammonia to the atmosphere. Also, there will be antagonistic displacement of potassium and magnesium from the root zone by calcium in the liming material if they are applied together.

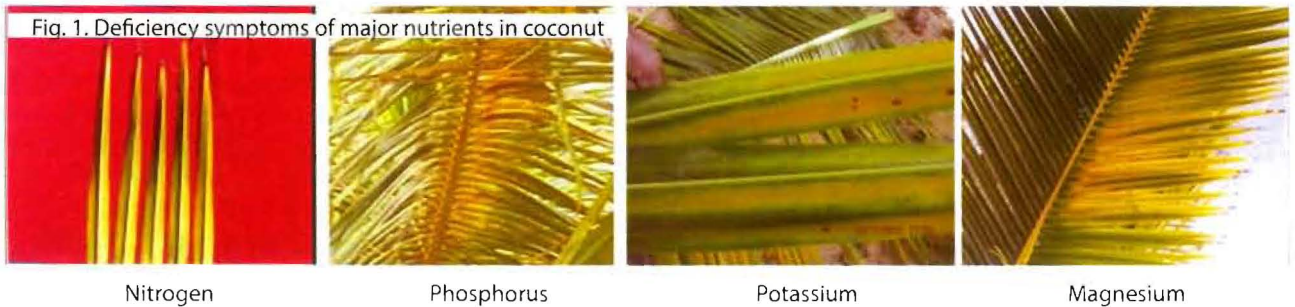
Enriching soil organic matter status in soil

Soil organic matter, forming the core of soil health management need to be maintained for sustaining the palm productivity. Organic matter can increase the nutrient exchange capacity of the soil, its buffering capacity, moisture holding capacity, and can enhance the activity of microbes so that mineralisation can occur resulting in nutrient cycling in the soil ecosystem. In coconut plantations, palm residue recycling can be effectively practiced through vermicomposting and coir pith composting.

Coconut leaf vermicomposting

The fallen leaves and coconut fronds can be converted into nutrient rich vermicompost in tanks or in pits with the help of *Eudrilus* sp. of earthworms. The well withered coconut leaves should be kept for two weeks after sprinkling with cow dung slurry @ 1/10th of the weight of the leaves. Later earthworms can be introduced @ 1 kg per tonne of the waste. Moisture content need to be maintained sufficiently and shade should be provided to prevent direct

Fig. 1. Deficiency symptoms of major nutrients in coconut



sunlight. The compost will be ready by 2.5 to 3 months. Watering need to stopped one week before the collection of the compost.

Once the composting process starts, in order to prevent rhinoceros beetle from being attracted to the tanks for egg laying, the tank can be covered with nylon nets or shade net. Clerodendron leaves and metarhizium anizoplea can be put in the tanks as it will prevent the larval transformation to adult.

Coir pith composting

Coir pith is a waste product of coir processing industry, rich in lignin and cellulose. If not composted, they are dumped at the factory premises causing serious disposal problems. However, they can be converted into value added compost using the technology developed at ICAR-CPCRI. For this, 900 kg coir pith is properly mixed with 100kg poultry manure, lime and rock phosphate each @ 5 kg and is spread evenly in an area of 4 X 2 X 1-meter dimension. Water is sprinkled regularly to maintain the moisture. The heap is covered with dry grass to prevent the moisture loss. The heap needs to be turned once in 15 days to enhance the speed of decomposition and the colour changes from reddish brown to dark brown indicating the completion of composting process.

Application of major nutrients

Providing essential nutrients in the requisite amounts after the correction of soil reaction is essential for ensuring soil and palm health as well as to sustain the palm productivity. The major nutrients required for coconut production are nitrogen, phosphorus, potassium, calcium and sulphur.

Importance of maintaining balance of major nutrients in palm

Nitrogen

Nitrogen is a constituent of plant cells and

chlorophyll. It is important for the rapid growth and development. It promotes the development of vegetative parts of the plants especially leaves and shoots. The deficiency of nitrogen is reflected in deficit leaf formation and restricted growth. But the effect of nitrogen in plant metabolism could be achieved only if phosphorus and potassium are provided. Leaf analysis is the best diagnostic method for predicting the nitrogen demand as well as possible nitrogen deficiency in the palm.

The deficiency of nitrogen predominates under dry climatic conditions when there is inhibition of nitrification, organic matter poor soils such as sandy soils as well as in waterlogged conditions. The deficiency of nitrogen is indicated as yellowing of the outer whorls of the leaves. In the leaflets, the midrib also turns yellow. Number of female flowers per inflorescence becomes lower and therein the rate of bunch production and the yield will be reduced. The annual requirement of nitrogen for adult coconut palms is 500g per palm. Soil test-based application of fertilisers, basin management with leguminous crops, application of organic manures and farmyard manure can supply requisite amounts of nitrogen to the palm.

Phosphorus

It is found in the leaves and seeds as well as in parts where vigorous cell division occurs. Application of phosphorus increase leaf production, collar girth and root density of coconut seedlings and lower the age of flowering. Under conditions of magnesium deficiency the movement of phosphorus within the plant is hampered and plant may experience the double deficiency of P and Mg according to de Silva (1973), even if the palm is supplied with available source of phosphorus.

The deficiency results in deficit root development and delayed ripening of the fruit. No characteristic visual symptom apart from slowing down of growth and shortening of fronds is observed. In young

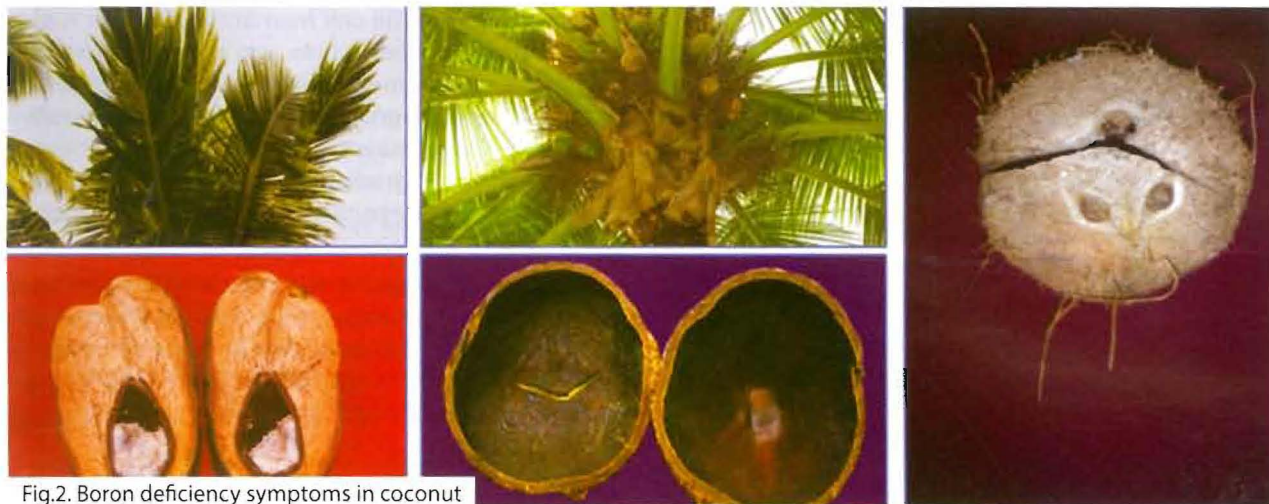


Fig.2. Boron deficiency symptoms in coconut

palms there will be stunted appearance and rosette appearance. Khan *et al* (1990) found that skipping phosphorus application for 14 years did not show any adverse effect either on yield or leaf P levels, which suggest that utilization of built up reserves in soil is the most ideal and economical way of management of coconut groves. Green manure addition could also assist in the dissolution and availability of P to palms. It was suggested based on the studies that if the available P in the 0-90cm soil is less than 10 ppm, apply the full recommended dose of 320 g P and if it is between 10 and 20 ppm, maintenance dose of 160g P₂O₅ per year is recommended. If the available P is more than 20ppm, P application can be skipped for a few years and monitored through soil analysis.

Potassium

It is the nutrient required which is removed in the highest proportion from coconut. Potassium could improve all the nut characters like weight of whole nut, weight of husked nut and copra weight per nut. It increases the production of inflorescence and thereby the number of fruits and copra per nut. Potassium increases the resistance to drought and diseases and hastens maturity and increases fruit set and the number of harvested nuts. Plants take up potassium in the form of K⁺ ion and its absorption will be hindered by the higher concentration of calcium and magnesium and sodium. There exists nutrient antagonism between, K-Mg, K-Na and K-Ca.

Under conditions of deficiency, the first visible symptom is the appearance of rusty spots on either side of the midrib, which remains green, followed by yellowing of the lamina. The yellowing is more prominent towards the tip. Later the older leaves assume an orangish tinge and the younger

leaves remain green and the rusty spots coalesce into numerous irregular brown blotches. Later the yellowing surface becomes necrotic. Overall growth of the palm is reduced and the trunk tapers and becomes slender.

Calcium

Calcium is the base nutrient ion associated with the imparting of turgidity and vigour to the leaves. It is essential for the developing tissues and cell wall development. Acidic soils contain low calcium and continuous crop removal can result in the deficiency of calcium. Calcium is an immobile element in plant and the deficiency symptoms first appear on the youngest leaves. Calcium deficiency in coconut palms are manifested as loss of vigor and turgidity in the youngest tissues, necrosis and death of the bud. Under conditions of calcium deficiency, spraying 0.5% calcium nitrate solution is recommended. Lime application @ 1 kg per palm two weeks prior to fertiliser application will supply calcium to the soil.

Magnesium

Magnesium is the central atom in the chlorophyll molecule in its porphyrin ring structure. It has a definite role in the pigment system and affects the photosynthetic capacity. It also enhances the production of female flowers and activates several enzyme systems in the plant. Magnesium deficient leaves have distinctly green leaf centres and bright lemon yellow to orange margins. Yellowing occurs principally in those parts of the leaf which are exposed to sunlight. In most of the cases, the shaded part remains green.

It is recommended to apply magnesium sulphate @ 500g per palm in areas prone to the deficiency of



Fig. 3. Soil sampling in coconut

the nutrients as well as in root (wilt) affected areas where foliar yellowing is a major issue of concern.

Owing to the antagonistic effect of NH_4^+ ions on the magnesium absorption by the palms, nitrogen fertilisation depresses the foliar magnesium levels. Also, potash fertiliser application depresses the magnesium uptake by the palm. Application of higher levels of potassium fertiliser hence has a depressive effect on the uptake of magnesium from the soil. But addition of organic manure could improve the exchange capacity of the soil and thereby nutrient balance can be achieved to a certain extent.

Sulphur

Sulphur is a component of amino acids such as cysteine, cystine and methionine. It also forms part

of sulpho lipids in the cell membrane. Sulphur is also a constituent of coenzymes and plays a key role in the redox system in the plants. Sulphur is involved in oil synthesis, copra quality as well as chlorophyll synthesis. Young leaves have low concentration of sulphur, which is gradually increased up to middle aged leaves and beyond which the concentration is decreased.

Sulphur deficiency is seen in the younger leaves and the colour changes to yellowish to orangish yellow. Nut size becomes smaller and it becomes rubbery copra on drying of the kernel. Sulphur can be supplied to soil through the sulphates of potassium and magnesium.

Micronutrients required for coconut nutrition

Boron

Boron is an inevitable micronutrient for coconut and is associated with the activity of apical meristem. It improves the water relations and transport of sugars in plants, enhances tissue respiration, nitrogen metabolism and oxidation-reduction equilibria in cells.

Deficiency of boron causes irregular leaf expansion, distorted leaves and shortened internodal length. The deficiency reduces photosynthetic capacity and stomata conductance. Apart from the foliar symptoms, there will be nut splitting longitudinally, barren nuts, cracking in the shell and button shedding.

Deficiency of boron can be corrected by the application of borax @ 160g per palm in 4 splits along with organic manure @ 20 kg per palm.

Copper

It is another important micronutrient for coconut mainly associated with enzymes involved in oxidation reactions. Copper is taken up as Cu^{2+} ions. In soils with very high organic matter content there will be chelation of copper ions within the matrix and becomes unavailable to plants, imposing deficiency symptoms. The symptoms include bending of rachis of the young leaves followed by yellowing and drying of the leaf tip, with brown and yellow margins and the middle portion remains green. Under severe deficiency, new leaves become short and there will be a diminutive and pendulous appearance to the palm.

If the soil test values of copper is less than 1 ppm, application of copper sulphate @ 25g per palm to the

soil can correct the deficiency.

Zinc

Zinc is associated with enzymes involved in the conversion of starch to sugar, formation of auxins, growth regulation and elongation. It is also associated with the plant defence mechanism.

The deficiency of zinc causes abnormal growth of young leaves which becomes rough in the surface. There will be reduced female flower production. Zinc deficiency occurs if the soil content is less than 1 ppm. The deficiency can be corrected by the application of zinc sulphate @ 100g per palm.

Chlorine

Chlorine is another important micronutrient for coconut productivity. It is taken up as chloride ions. Chlorine is associated with osmoregulation, stomatal opening and closing as well the activity of photo system II in photosynthesis. It increases the thickness of kernel and copra weight. It spurs plant development by promoting collar girth and frond production rate. It enhances the better absorption of potassium, calcium and magnesium which hastens the growth and flowering in coconut.

The deficiency symptoms of chlorine include yellowing or orange mottling in the older leaves and drying up of the outer edges and tips, reduction in number and size of the leaves.

How the balanced fertiliser application can be effected in coconut

We now have seen the importance of balanced fertiliser application in coconut. All the essential nutrients are equally important irrespective of the quantity applied in the soil. Nutrient balance in coconut can be achieved by the systematic adoption of scientific cultivation practices, considering the soil and palm health aspects in a holistic manner. Soil test-based application of nutrients can ensure the application of nutrients in the right amounts in the optimum combination so as to ensure the optimum use of resources in an environment friendly manner.

How to do soil testing in a coconut garden

Soil sample collection from the basin of coconut palms for testing is to be taken at a distance of one meter from the trunk of the palm at a depth of 30 cm, from diagonally opposite points, which are later mixed together to form a composite sample. In order to estimate the general fertility of the field, samples in this manner can be taken in between four palms.

The samples are dried in the shade and labelled properly for the laboratory estimation of major, secondary and micronutrients.

Based on the soil testing, if the soil is acidic in reaction as indicated by pH values less than 6.5, liming with agricultural lime or dolomite @ 1 kg per palm has to be applied two weeks prior to fertiliser application in coconut. However, it is necessary to ensure sufficient moisture in the soil before the application of liming material.

Fertiliser application to coconut can be done as per the following schedule. Under rainfed conditions, application of fertilisers can be done two times in a year: with the advent of South West monsoon in June July and with the advent of North East monsoon during September-October. Depending on the intensity of the rainfall, 1/3rd of the total recommended quantity can be applied in the first dose and the remaining 2/3rd can be applied as the second dose.

Table 1. Nutrient recommendation for coconut

Stage of the palm	Organic manure	Urea	Mus-sorie-phos	Muri-ate of pot-ash
	kg/palm	g/palm /year		
Kerala				
3 months after planting	5	100	160	200
1 year after planting	5	360	535	668
2 year after planting	10	720	1065	1300
3 year after planting onwards	25	1000	1600	2000
Tamil Nadu				
6 months after planting	10	-	-	-
1 year after planting	20	304	400	500
2 year after planting	30	608	800	1000
3 year after planting	40	911	1200	1500
4 year after planting	50	1215	1600	2000
Karnataka				
3 months after planting	20	109	200	225
1 year after planting	20	347	600	676
2 year after planting	20	716	1200	1350
3 year after planting onwards	50	1085	1600	2000

(Source: 1. Coconut Cultivation Practices, 2007. ICAR- Central Plantation Crops Research Institute, Kasaragod, Kerala. Eds. (Dhanapal, R., Thampian, C). Extension Publication No. 179.p.26.
2. http://www.agritech.tnau.ac.in/expert_system/coconut/coconut/coconut_mainfield.html)

3. Package of Practices Recommendations, University of Agricultural Sciences, Bangalore

Enriching soil fertility with leguminous crops

Because of the innate ability of the leguminous crops to tap atmospheric nitrogen in the root nodules, they can serve as live nitrogen suppliers to the plant. Sowing 100g cowpea seeds along with first dose of fertiliser and when one or two plants have started flowering, by 45th to 60th day of planting, they can be turned in to the field. This practice can provide 25-30kg biomass per basin along with supply of 150g nitrogen. This can enrich soil fertility. This sort of basin management with leguminous crops can also promote microbial activity favouring the nutrient mineralisation and its release for palm growth. Apart from cowpea, sun hemp, horse gram, mimosa and daincha can also be sown in the basin.

During the second dose of fertiliser application in September-October, magnesium sulphate@ 500 g per palm can be applied. This can alleviate the occurrence of magnesium deficiency symptoms and reduce the intensity of yellowing in coconut palms particularly in root (wilt) affected tracts.

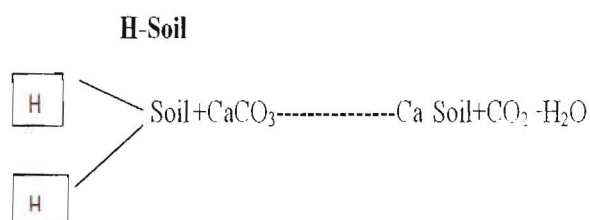
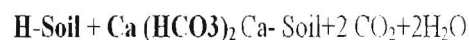
Under conditions of boron deficiency, borax@160g per palm in 4 splits can be applied along with organic manure.

Nutrient mixtures for juvenile palms and adult palms

Considering the soil nutrient status and the palm nutrient requirement, ICAR-Central Plantation Crop Research Institute, Regional Station, Kayamkulam has developed two nutrient mixtures viz., 'Kalpa Poshak' and 'Kalpa Vardhini' for juvenile and adult coconut palms, respectively. 'Kalpa Poshak' comprises the nutrients such as potassium, boron, sulphur, zinc copper whereas 'Kalpa Vardhini' contains potassium, magnesium, sulphur, boron and zinc in different concentrations. The dose recommended for 'Kalpa Poshak' is 40 g/ palm during first year after planting and 100 g/ palm for the second and third years of planting. The dose for 'Kalpa Vardhini' is 500g/palm/year. These mixtures are to be added 10 days after the normal dose of fertilizer application as per the schedule.

Irrigation

One of the critical resources in coconut production is the availability of water. Water is



the medium for absorption of plant nutrients. For all physiological process within the plant including photosynthesis water is essential. There is constant upward movement of water from soil solution through the roots of palms under transpiration pull. Sufficient water should be available in the root zone to maintain plant functions and productivity. Though the coconut growing regions in the coastal belt are endowed with high rainfall, the rainy period is confined to few months during the monsoon season. The palm experiences moisture stress and drought conditions for varying periods extending up to 5-6 months in a year which affects productivity. In the coconut growing region other than the coastal belt coconut has to be grown throughout the year by supplemental irrigation. When irrigation water is delivered through hose pipes, about 250 litres water is required to be applied every 4 days per palm. But when drip irrigation is followed, irrigation is scheduled to compensate the loss of water through evapo transpiration which amounts to 32-40 litres per day for adult palms, under Kerala conditions.

Conclusion

The perennial plantation crop of coconut is highly amenable to systematic and scientific management practices involving soil test based nutrient application, pest and disease management. In a nutshell, adoption of palm health measures systematically will ensure returns to the coconut farmer in tune with the management practices adopted. However, it requires the application of nutrients considering the availability in the soil as well as in the leaf. Correction of nutrient deficiencies as and when noticed in the soil or on the leaf should also be done periodically, for which soil and leaf analysis is inevitable. Hence balanced nutrition is an essential component for the sustainment of palm health and its productivity. ■