Nutrient Management in Cashew

भा.कृ.अनु.प. – काजू अनुसंधान निदेशालय

ICAR-Directorate of Cashew Research

Darbe (P.O.), Puttur - 574 202, Dakshina Kannada, Karnataka

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PREFACE

Cashew (*Anacardium occidentale* L.), a crop native to Brazil was introduced to India in the 16th century by Portuguese travellers. In the initial period it was grown only for the purpose of soil conservation and afforestation. Later, farmers also started growing it in the lands which are not suitable for other high value crops – say hillocks with undulating terrain in west coast areas. Over a period of time its commercial importance was discovered and it gained the status of export oriented commercial crop. Although India leads in production of cashewnuts, Indian productivity is far below the upcoming producer countries. The country requires increased production of raw cashewnuts to meet the increasing demands from both domestic and international markets. Of the several factors associated with low productivity, poor soil fertility is a major factor limiting production. Recent studies have revealed wide spread deficiency of macro and micro nutrients like boron and zinc. Addressing the poor soil fertility and soil constraints such as acidity is also important with respect to preventing soil degradation, due to the fact that cashew is mainly cultivated along the hillocks.

ICAR-Directorate of Cashew Research and co-ordinating centres of AICRP on cashew have developed many useful technologies and recommendations for addressing nutrient management issues in cashew. This bulletin covers the various aspects of nutrient management in cashew, right from soil sampling methods, liming, management of major nutrients, and management of micronutrients. A separate section on prominent nutrient deficiency symptoms has been included for early identification of nutrient deficiency, by observing symptoms on leaves in the field. The importance of manuring and various alternatives to manure application also discussed. The ways to minimise money spent on fertiliser, by going for composting of recyclable cashew biomass is another aspect covered in this bulletin.

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TECHNICAL BULLETIN ON NUTRIENT MANAGEMENT IN CASHEW

1. Introduction

Soil is one of the important natural resource on earth's surface and is made up of minerals, organic matter, air and water. Soils support the life on earth either directly or indirectly. Apart from the major role of feeding the living organisms, soils also help in recycling water, nutrients and air. Plants derive most of their nutrient requirement from soil. Of the 17 essential elements required by plants to complete their life cycle, 14 are to be obtained from soil. Soils rich in nutrients are regarded as fertile soil. Crops and plants continuously absorb nutrients to meet their growing demands. Under natural conditions, the nutrients are returned back to soil through decaying roots and natural cycling. These natural processes take long time. With present day intensive agriculture, continuous nutrient removal through harvest of crop produce and cultivation on commercial scale depletes soil of its inherent nutrients and lead to decreased productivity and increased soil degradation. Replacing the removed nutrients is the key to attain increased yield and sustainability. This can be achieved by balanced manuring and fertilizer application as per the requirement of the crop being cultivated. There is much limited attention being paid to the nutrient management in cashew. Nutrient management is the process of managing the type of nutrient, time and method of application to improve soil fertility and crop productivity, while reducing nutrient losses. This bulletin addresses various issues in nutrient management in cashew. The bulletin highlight the importance of fertilizer management in cashew for increasing the production to meet growing demands, from ever decreasing cultivated land, while preserving the fertility levels of the land for future generations.

2. About cashew

Cashew (*Anacardium occidentale* L), is native to Brazil and was introduced to India by Portugese travelers as a soil binding crop, to control soil erosion in coastal areas during 16th century. Sooner its commercial importance and adaptability to adverse soil and environmental conditions were recognized and its cultivation on commercial scale occurred along the east and west coast of India. Export of cashew kernels and cashewnut shell liquid bring foreign exchange to the country. In India, cashew is cultivated on a wide range of soil types such as sandy to sandy loam, laterite soil, loam and red latosols. Due its drought hardiness, cashew is widely cultivated in degraded hillocks and slopy lands, where profitable production of other crops are not possible. Majority of cashew growing soils are low in soil fertility in terms of nitrogen, base

status, cation exchange capacity and micronutrients such as zinc and boron. Due to heavy precipitation in the coastal areas where cashew is grown, the basic cations are washed out causing increased soil acidity. The high soil acidity in turn decreases the nutrient uptake by the plant, making some of the nutrients unavailable for cashew.

Fig. 1. Cashew grown on hillocks

2.1. Cashew growing areas in India

The major cashew growing states in the west coast are Maharashtra, Goa, Karnataka and Kerala. Along the east coast, the major cashew growing states are Tamil Nadu, Andhra Pradesh, Odisha and West Bengal. The non-traditional areas of cashew cultivation are Bastar region of Chhattisgarh and Kolar (Plains) regions of Karnataka, Gujarat, Jharkhand and in NEH region. The major districts in different states of India cultivating cashew are given in Table 1.

Table 1. Cashew growing districts in different states of India

State	Cashew growing districts
Kerala	Palakkad, Malappuram, Kozhikode, Kannur, Kasaragod
Karnataka	Kolar, Shivamoga, Belgaum, Uttara Kannada, Dakshina Kannada, Udupi, Kodagu, Gadag, Bidar, Chikmagalur, Tumkur, Hassan

Goa	Entire state
Tamil Nadu	Ariyalur, Cuddalore, Pudukkottai, Villupuram, Theni, Thirunelveli, Sivagangai
Andhra Pradesh	Sreekakulam, Vizianagaram, Vishakhapatanam, East Godavari, West Godavari, Guntur
Odisha	Baleshwar, Cuttack, Dhenkanal, Ganjam, Kandhamal, Kendujhar, Koraput, Mayurbhanj, Puri, Sambalpur, Sundargarh, Angul, Khordha, Nayagarh, Malkangiri, Nawarangpur
Maharashtra	Thane, Raigad, Ratnagiri, Sindhudurg, Kolhapur, Nasik
Chhattisgarh	Bastar, Dantewada, Raigarh, Narayanpur
West Bengal	Burdwan, Birbhum, Bankura, Puruliya, Midnapore (W), Midnapore (E)
Jharkhand	East Singhbhum, West Singhbhum, Saraikela
Meghalaya	East Garo Hills, West Garo Hills, South Garo Hills
Tripura	South Tripura
Assam	Dhubri
Gujarat	Navsari, Valsad, Dong

As per the latest statistics (2017-18) Odisha occupy the largest area under cashew (1.94 lakh ha), followed by Maharashtra (1.91 lakh ha), Andhra Pradesh (1.87 lakh ha), Tamil Nadu (1.42 lakh ha), Karnataka (1.29 lakh ha), and Kerala (0.92 lakh ha). Whereas the production of cashew nut follows the order Maharashtra (2.69 lakh tonnes)> Andhra Pradesh (1.16 lakh tonnes) > Odisha (0.99 lakh tonnes) > Karnataka (0.89 lakh tonnes) > Kerala (0.88 lakh tonnes) (Table 2).

Table 2. Area, production and productivity of cashew during 2017-18 in different states of India (DCCD, 2018)

State	Area (000 ha)	Production (000mt)	Productivity (kg/ha)
Kerala	92.81	88.18	962
Karnataka	129.07	89.45	672
Goa	58.25	34.26	561

Maharashtra	191.45	269.44	1378
Tamilnadu	142.28	71.03	478
Andhra Pradesh	186.78	116.92	600
Odisha	193.99	98.59	513
West Bengal	11.36	12.96	1140
Chattisgarh	13.70	9.83	681
Jharkhand	14.83	6.13	393
Tripura	4.25	3.45	812
Meghalaya	8.58	6.12	686
Assam	1.05	1.13	1028
Gujarat	7.25	6.50	900
Pondichery	5.00	2.16	432
Manipur	0.90	0.32	360
Nagaland	0.50	0.54	1080

2.2. Climatic features of cashew growing areas in India

The total rainfall of cashew growing regions varies much. It can grow in regions receiving rainfall as low as 300 mm (Gujarat) to >3500 mm (Maharashtra and Kerala). However, the rainfall range of 600 to 1500 mm was shown to be good for increased yield. Regions receiving few light rains during January to March further benefit to realise increased yield. The average minimum temperature in cashew growing areas ranges from 10 to 22°C and average maximum temperature from 32 to 40.1°C.

2.3. Cashew in Karnataka

Karnataka accounts for 12.28% cashew area in India and 10.92% of Indian production of cashew nuts. The productivity in Karnataka during the year 2017-18 was 672 kg/ha, below the Indian average of 753 kg/ha and it is far below the average productivity in Maharashtra (1378 kg/ha), West Bengal (1140 kg/ha), Nagaland (1080 kg/ha), Assam (1028 kg/ha) and Kerala (962 kg/ha). The area under cashew is being slowly and gradually increasing in Karnataka, and there is a general shift to cashew from other plantation crops such as rubber and mango; due to low labour requirement and drought hardiness and recent increase in price of raw cashew nuts. However, the increase is not substantial.

3. Soil characteristics of cashew growing areas in India

The soil survey studies conducted at predominant cashew growing areas revealed depletion of soil nutrients due to non replenishment of nutrient removal by the trees. Organic carbon rated as low in 2.7% samples in Puttur, Karnataka, in 20.0% samples in Vengurla, Maharastra, 81.4% samples in Bhubaneswar and 92.9% samples in Bapatla. Available nitrogen was recorded as low in 94.3% samples in Puttur, 37.1% samples in Vengurla, 94.3% samples in Bhubaneswar and 75.7% samples in Bapatla. Cashew orchards in Pilicode, Kerala were found to be high in organic carbon and available nitrogen. The percent samples rated as low in available potassium was 65.7% in Puttur, 41.4% in Vengurla, 58.6% in Bhubaneswar, 22.9% in Bapatla and 17.1% in Pilicode. The soils were deficient in available phosphorus. The soils were also deficient in calcium and magnesium. The micronutrients such as iron and manganese were sufficient. However the soils were generally deficient in zinc (22.9 to 57.14% samples in different regions) and boron (8.57 to 32.9% samples in different regions). These results indicate growing nutrient deficiencies in soils under cashew cultivation along west coast and east coast. Under such situation, soil test based nutrient management can not only improve the growth and productivity of cashew, but also arrest soil degradation.

4. Nutrient requirement of cashew

Considerable amount of nutrients is removed annually by the cashew tree. The amount of nutrients removed by a cashew tree (30 year old) is reported as 2.8 kg N, 0.75 kg P_2O_5 and 1.265 kg K_2O. The unfertilised 6 year old orchards showed a net negative N, P and K balance of 113, 38 and 92 kg ha^{-1} is reported. Soil fertility and nutrient supply is one of the important factor deciding yield and quality of the produce. At field and orchard level, the nutrition aspect is not properly taken care of, causing continuous nutrient mining and deterioration of soil health, apart from yield decline.

5. Assessing nutrient deficiency in cashew

Continuous uptake of nutrients from soil by cashew leads to depletion of nutrients in soil. Unlike living organisms, the nutrient depletion from soil cannot be judged by visual examination. The nutrient status of soil is assessed by drawing a representative soil sample followed by testing in the laboratory. These days some soil test kits are also available for testing the soil at field conditions. However, the results from field test kits tend to be less accurate than laboratory tests, since they are based on visual colour observations. Other method of assessing soil fertility is by testing the nutrient status in index leaves of cashew. Yet another method is looking for the deficiency symptoms on leaves of cashew tree.

5.1. Soil testing and interpretation

Soil testing is the most efficient method for assessing the soil fertility levels. It is used for suggesting fertiliser recommendation to cashew, predicting response of cashew to applied nutrients and to assess the soil problems such as acidity, salinity and sodicity.

5.1.1. Soil sampling

Soil sampling is to be carriedout with proper planning. Since soil testing is done on a small fraction of soil, it is important to make sure that the soil collected is of representative to the area being sampled. Sampling for soil testing is to be undertaken to assess the suitability of land for cashew before establishing the plantation. Periodic assessment of soil fertility also required for judicious fertiliser application, by sampling in existing plantations.

5.1.1.1. Selection of sampling unit

On reaching the site, conduct a visual survey by walking in the field and by observing variation with respect to slope, colour, texture, cropping pattern and management practices. If all these aspects are similar, one field can be considered as one sample unit. Separate samples are required for areas differing in each of these characteristics. However, in any case, one sample is required for every 1 to 2 hectares. Areas such as recently fertilised plots, bunds, channels, near wells and compost pits etc. are to be avoided while sampling. To increase the accuracy, large areas may be subdivided into more number of smaller units based on the availability of resources.

5.1.1.2. Depth and time of soil sampling for cashew

For cashew, the soil samples should preferably be collected from different depths. The standard depths of soil sampling in cashew are 0-30, 30-60 and 60-90 cm. The sample should be taken half way between trunk and fertiliser application zone. It is better to take 4 samples from all four different directions and make a composite sample. For new plantations soil samples to be drawn before establishment and for existing plantations soil samples are to be taken before fertiliser application and after cessation of heavy rains.

5.1.1.3. How to sample

By traversing the area, decide the number of units to be sampled. For each uniform area, 10-15 sub-samples are to be collected, by traversing the field in a zigzag manner. These sub-samples can be mixed to make one composite sample per unit. While mixing care should be taken to mix the respective depths. Before taking samples, remove the

debris and litter on the soil surface. The soil sampling can be performed using an auger which permits easy sampling from different depths, compared to the use of the spade. If the auger is not available, a GI pipe can be used for sampling purpose.

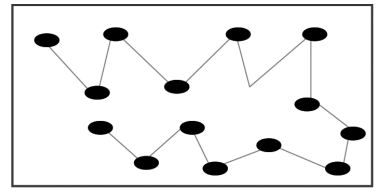

Fig. 2. Zigzag/crisscross pattern for soil sampling

If the landowner is interested in only surface soil sample analysis, a V-shaped cut is made in soil, and soil samples are drawn in a thin slice (1.5-2.5 cm) from top to bottom to the depth range desired (0-30 or 0-15 cm). Subsamples are drawn from all the sites marked to make a composite sample.

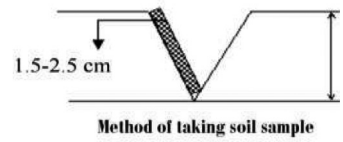

Fig. 3. Procedure for surface soil sampling

5.1.1.4. Mixing, quartering and storage

The mixing of subsamples to make composite samples can be done by quartering method to reduce sample size to about 500 g. For this, thoroughly mix all the subsamples, spread on a paper or cloth, remove large stones and pieces of roots, make four quarters and discard the opposite quarters. This process can be continued till getting a suitable quantity.

Fig. 4. Quartering for reducing sample volume while mixing the composite samples

Transfer soil to a clean polythene or cloth bag. Place label indicating the name of the farmer, depth of sampling, field identification mark, date of sampling both inside

and outside the sample bag. Send these samples immediately to nearby soil testing laboratory, along with sample information, parameters to be tested and analysis fees if any. If samples are to be sent later, make sure to dry samples under shade by spreading on paper, for 2-3 days.

5.1.2. Soil testing and soil health card

In the laboratory, soil samples are subjected to various analyses. The parameters tested are soil pH (as a measure of soil acidity/alkalinity), electrical conductivity (to know salinity status of soil), organic carbon, major nutrients such as available nitrogen, available phosphorus and available potassium, secondary nutrients such as calcium, magnesium, and sulphur, and micronutrients such as iron, manganese, zinc, copper, boron and molybdenum. If the soil pH is less than 5.5, it is better to test for lime requirement. The soil test laboratories provide the results in the form of report or soil health cards (Fig. 5). The soil health cards contain the information such as nutrient content in soil and its rating. It may also contain the rate of fertiliser to be applied and application methods or guidelines for getting the fertiliser recommendations.

Department of Agriculture & Cooperation
Ministry of Agriculture & Farmers Welfare
Government of India

ICAR- Directorate of Cashew Research, Puttur, Karnataka

Soil Health Card No.: DCR/

Validity :

Name	
Address	
Mobile Number	
Latitude	
Longitude	
Sample date	

Healthy Soils for a Healthy Life

World Soil Day

For application guidelines please see overleaf

Name of Laboratory	Soil Science Laboratory, ICAR-DCR, Puttur			
SOIL TEST RESULTS				
Sl. No.	Parameter	Test value	Unit	Rating
1	pH			
2	EC		dS/m	
3	Organic carbon (OC)		%	
4	Available N		kg/ha	
5	Available Phosphorus (P_2O_5)		kg/ha	
6	Available Potassium (K_2O)		kg/ha	
7	Iron (Fe)		ppm	
8	Manganese (Mn)		ppm	
9	Zinc (ppm)		ppm	
10	Copper (Cu)		ppm	
11	Boron (B)		ppm	
12	Molybdenum (Mo)		ppm	

For exact quantity of fertilizer to use for cashew, please use Fertilizer calculator available at:
1. www.cashew.icar.gov.in
2. Download the App from Google play store

Fig. 5. A sample soil health card

5.1.3. Interpretation of soil test data

Based on the results of soil analysis, the soil is classified as low, medium and high with respect to major nutrients. The soils are classified as sufficient and deficient with respect to micronutrients. The recommended fertiliser doses are further adjusted based on soil fertility levels. In case of low soil test rating, 30% more of the recommended dose of that nutrient is to be given. Similarly, for high soil rating 30% less of recommended dose of the nutrient be given. For medium soil test rating the recommended dose as such is applied. The general soil test rating criteria is given below in Table 3 and 4.

Table 3. Soil test rating criteria for major nutrients

Parameters	Low	Medium	High
Organic carbon (%)	0.5	0.51-0.75	>0.75
Available N (kg/ha)	280	281-560	>560
Available P (kg/ha)	9	9-22	>22
Available P_2O_5 (kg/ha)	20	20-50	>50
Amm-acetate K (kg/ha)	120	120-280	>280
Available K_2O (kg/ha)	140	140-340	>340

Table 4. Soil test rating criteria for micro nutrients

Element	Critical level	
	Extractant used	Value (mg kg^{-1})
Zinc	DTPA	0.6 (0.4 to 1.2)
Iron	DTPA	2.5 - 4.5
Manganese	DTPA	2.0
Copper	DTPA	0.2
Boron	Hot water	0.5
Molybdenum	Ammonium Oxalate	0.2

5.2. Nutrient deficiency symptoms in cashew

When the cashew plants are unable to take up nutrients from soil due to its deficiency in soil or other reasons, the plant develop symptoms which are more or less characteristics

to the element and these deficiency symptoms can serve as quick guide to assess the nutrient status in soil. The general nutrient deficiency symptoms in cashew and remedial measures are given in Table 5.

Table 5. Nutrient deficiency symptoms in cashew and remedial measures

Nitrogen	Nutrient deficiency symptoms in cashew
Deficiency symptoms ✦ Stunted growth ✦ Deficiency in older leaves ✦ Old leaves turn light green to yellow **Management** ✦ Follow the nitrogen application as per recommendation for the region based on soil test ✦ Apply FYM @10-15 kg/tree ✦ Undertake foliar application of urea (3% urea) at weekly intervals till the symptoms disappear.	
Phosphorus	
Deficiency symptoms ✦ Dark green, bluish green colour on leaves due to the accumulation of carbohydrates ✦ Restriction in growth of tops and roots. ✦ Suppression of development of lateral buds ✦ On continued deficiency, leaf get bronze colour, reddish tips on leaf margins **Management** ✦ Application of P-fertiliser as recommended ✦ Application of biofertiliser containing P-solubiliser ✦ Foliar application of 0.5% phosphoric acid	

Potassium

Deficiency symptoms

- Chlorosis along leaf margin, scorching and browning of tips of older leaves which gradually progresses inwards
- The slow and stunted growth of trees and become susceptible to breakage

Management

- Foliar application of 1% potassium sulphate or potassium chloride
- Application of potash fertiliser as per recommendation based on soil test

Calcium

Deficiency symptoms

- Deficiency symptoms appear on younger structures.
- Young leaves distorted, become small and abnormally green leaves.
- Leaves become cup-shaped and crinkled.
- Terminal buds deteriorate with some breakdown of petioles.
- Desiccation of terminal buds and weakening of the stem structure.

Management

- Application of FYM at 10-15 kg/tree
- Application of lime based on soil test report

Magnesium

Deficiency symptoms

- Interveinal chlorosis, streaked or patchy effects on older leaves
- Affected leaves turn small and curve upwards at the margin

Management

- Application of dolomite based on soil test report
- Foliar application of $MgSO_4$ at 0.5%

Sulphur	
Deficiency symptoms ✦ Deficiency appears on young leaves. ✦ Fading of the normal green colour of young leaves followed by chlorosis **Management** ✦ Apply 10 kg S per ha	
Iron	
Deficiency symptoms ✦ Interveinal chlorosis on young leaves ✦ The entire plant becomes chlorotic. **Management** ✦ Foliar application of 0.5% ferrous sulphate	
Manganese	
Deficiency symptoms ✦ Interveinal chlorosis on middle leaves / upper leaves, the necrotic spots coalesce as leaf matures and the veins remain green ✦ Chlorotic / necrotic spots on interveinal areas **Management** ✦ Foliar application of 0.5% manganese sulphate	
Zinc	
Deficiency symptoms ✦ Interveinal chlorosis on young leaves ✦ Reduction in size of young leaves, get clustered and borne very closely, bronzing, purple, violet, brown colouration of foliage ✦ Short internode (rosetting) and a decrease in leaf expansion (little leaf)	

✦ In seedlings, reddish pigmentation in the middle leaf and later cover entire lamina. Tissues become papery and necrotic **Management** ✦ Foliar application of 0.5% zinc sulphate at flushing, flowering and fruiting	
Copper	
Deficiency symptoms ✦ Deficiency cause male flower sterility, delayed flowering, chlorosis of younger shoot tissues, white tip and die back. ✦ Necrosis of apical meristems cause elongation of axillary shoots ✦ Leaves become light green with twisted tips **Management** ✦ Foliar application of 0.1% copper sulphate at flushing, flowering and fruiting	
Molybdenum	
Deficiency symptoms ✦ Deficiency resembles like N deficiency, chlorotic mottling between the veins on old and middle leaves ✦ Marginal scorching or cupping of leaves **Management** ✦ Foliar application of 0.1% molybdenum salts at flushing, flowering and fruiting	

Boron	
Deficiency symptoms ✦ Deficiency symptoms appear on terminal buds on young leaves which become discoloured and die back ✦ Internodes become shorter and bushy or rosette appearance ✦ Failure to expand young leaves and become rolled, and growing tips die **Management** ✦ Foliar application of 0.1% borax/ solubor at flushing, flowering and fruiting	

There are some limitations in using deficiency symptoms for assessing nutrient status in soil or availability of nutrients to plants. Some of the deficiency symptoms are common to many different nutrients and same deficiency symptoms may be expressed during disease or insect attack. The Fig. 6, depicts a general guideline on delineating among various nutrient deficiencies.

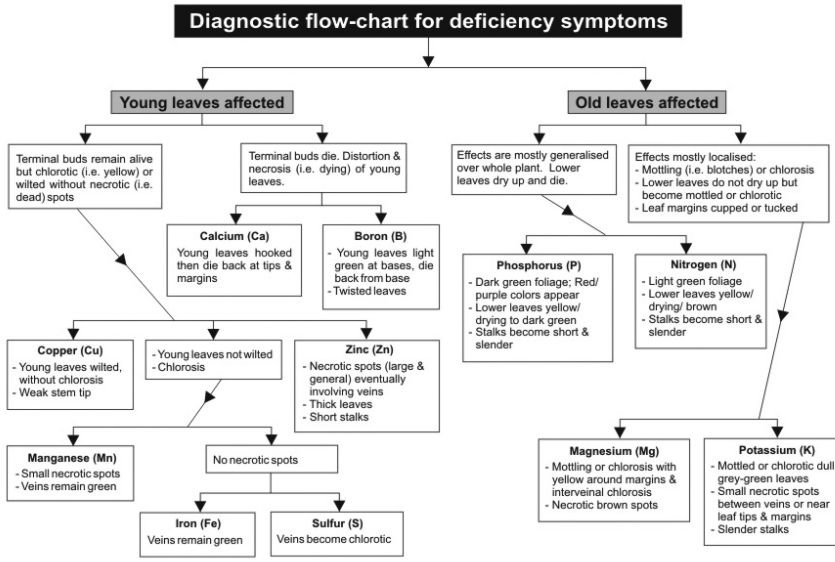

Fig. 6. Diagnostic flow-chart for deficiency symptoms (https://www.floramax.com)

5.3. Leaf sampling, analysis and interpretation

Leaf analysis is the quickest way to assess the nutrient supplying power of the soil. However, the usefulness of leaf analysis depends upon the correctness of leaf sampling. So utmost care should be exercised while collecting leaves for analysis. In tree crops, such as cashew, leaf analysis offers to monitor the plant throughout the growing season and modify the nutrient through fertigation.

5.3.1. Stage of leaf and time of sampling in cashew

In cashew 4th leaf with petiole from the tip of matured branches, just prior to flowering is to be sampled. About 10 leaves are required to be collected from different branches from all sides of the tree.

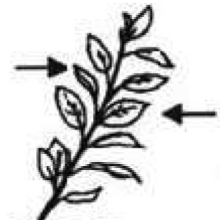

Fig. 7. Position of index leaf in cashew

5.3.2. Precautions in leaf sampling

- Do not sample when the leaves are soiled or covered with dust
- Do not sample leaves damaged by insects / disease
- Do not sample mechanically injured leaves and do not sample when plants are under moisture or temperature stress.

5.3.3. Dispatch for analysis

Enclose the collected leaves in paper bags and send immediately to soil and leaf analysis laboratory along with information such as the name of the farmer, location, the age of the tree, collection date, and the parameters to be tested etc. If the leaf to be sent later, it has to be dried at 60^{o}C after washing with 0.2% detergent solution and 0.1 N HCl. Final washing is to be done with double distilled water.

5.3.4. Interpretation of plant analysis results

In the laboratory, plant samples are subjected to acid digestion and analysis for essential nutrient content. These contents are compared with critical nutrient concentration. The critical nutrient concentration is the level of nutrient in plant part below which yields are not satisfactory. The critical nutrient concentration values for cashew are being developed.

6. Nutrient management in cashew

Like any other crops and organism, cashew too requires additional nutrient inputs for producing potential yield. Being a perennial tree crop, cashew removes considerable amount of nutrients from soil. A 30 year old cashew tree removes 2.8 kg N, 0.75 kg P_2O_5 and 1.26 kg K_2O. If the continuous removal by cashew tree is not balanced by application of manures and fertilisers, the yield and quality of produce will be affected, apart from deterioration of soil health. The response to nutrient application vary from location to location, based on initial soil nutrient status and management practices followed. Integrated use of organic manure, inorganic fertilisers and micronutrients provide sustainable yield while maintaining soil health.

6.1. Management of soil acidity

Cashew growing soils are generally acidic. Under high acidic soil conditions, nutrients such as phosphorus, calcium, magnesium, boron and molybdenum become unavailable, and nutrients such as iron, manganese and aluminium increase to toxic levels to affect plant growth. For correcting soil acidity, liming is to be undertaken with lime, dolomite or other liming materials. Testing of soil for pH will give an idea of soil acidity. However, for finding out lime requirement special test are to be carried out, which can be done in any soil testing laboratory. Liming based on soil test is to be done while establishing plantation and periodically based on soil test. Lime may be applied any time of the year, however, to increase the efficiency, lime is to be applied immediately after cessation of heavy rains since moisture is essential for lime-soil reaction. For new plantations, apply lime 2-3 months before planting. For established plantations, once in 3-5 years will be sufficient. The general liming rates (t/ha) are given in Table 6. In general, 5 tonnes per ha lime is required on clay loam soil and 1.5 tonnes per ha on sandy soils to raise the pH by one unit.

Table 6. Generalised liming rates (t/ha)

Soil texture	Targeted soil pH change	
	From 4.5 to 5.5	From 5.5 to 6.5
Sand and loamy sand	0.6	0.9
Sandy loam	1.1	1.5
Loams	1.7	2.2
Silt loam	2.6	3.2
Clay sand	3.4	4.3

Precautions in liming

- Do not use lime without liming requirement test.
- Apply lime by broadcast and mix thoroughly with soil up to 20 cm depth.

6.1.1. Estimation of lime requirement

Correct liming requirement to increase soil pH to favourable level can be found out by testing soil. Most of the soil testing laboratories carry out lime requirement test either by Woodruffs method or Shoemaker method and provide the lime requirement rate in tonnes/ha. For widely spaced tree crops like cashew, only the areas of root activity need to be limed to reduce the cost. So canopy area based lime application is ideal approach in cashew. Usually only $1/10^{th}$ of the lime requirement estimated in laboratory need to be applied. The soil test laboratories must ensure this factor while recommending liming dosage.

6.1.2. Liming materials

Agricultural lime includes carbonates, oxides and hydroxides of calcium and magnesium. Liming is usually carriedout with calcite or dolomite. Other liming materials commonly available are basic slag, lime shells, paper mill sludge and basic slag.

6.1.3. Method of application

Ground liming materials can be either incorporated into the soil or be broadcasted as per the lime requirement. The top-dressed lime gets leached into the soil with rainfall. Incorporation of liming materials gives faster results. The time of application is April – May before the onset of monsoon.

6.2. Manuring

Since the cashew growing soils are deficient in organic matter, application of 10-15 kg farmyard manure or compost per grownup tree is recommended. This has to be undertaken in August-September, during the receding periods of monsoon. This can be applied in the circular trench along with the application of fertilizer discussed below.

Fig. 8. Manure application to cashew

6.2.1. Manuring alternatives

In the absence of FYM, green manuring can be adopted as an alternative. Green manure crops such as glyricidia, sesbania and sunhemp can be grown along boundaries and in between two rows of cashew. Application of green manure increase organic matter content in soil. It also improves soil structure and help to reduce runoff and soil erosion. Wherever available the poultry manure can be used in place of FYM by applying at the rate of 10 kg per tree per year. The contents of different manures and oil cakes are given in Table 7.

Table 7. Nutrient contents in different manures and oil cakes

Source	Nitrogen (N) (%)	Phosphate (P_2O_5) (%)	Potash (K_2O) (%)
Farm Yard Manure	0.5 - 1.5	0.4 - 0.8	0.5 - 1.0
Compost (Urban)	1.0 - 2.0	1.0	1.5
Compost (Rural)	0.4 - 0.9	0.3 - 0.6	0.7 - 1.0
Green manure's	0.5 - 0.7	0.1 - 0.2	0.6 - 0.8
Castorcake	5.5 - 5.8	1.8 - 1.9	1.0 - 1.1
Cotton seedcake (undecorticated)	3.9 - 4.0	1.8 - 1.9	1.6 - 1.7

Mahuacake	2.5 - 2.6	0.8 - 0.9	1.8 - 1.9
Karanjecake	3.9 - 4.0	0.9 - 1.0	1.3 - 1.4
Neem cake	5.2 - 5.3	1.0	1.4 - 1.5
Safflower cake (Undecorticated)	4.8 - 4.9	1.4 - 1.5	1.2 - 1.3
Poultry manure	2.2	1.8	1.1

6.3. Management of major nutrients

Research studies showed that nutrient application can significantly improve the yield levels in cashew. Application of 10-15 kg farm yard manure per tree is recommended along with N, P and K fertilisers to maintain soil organic matter.

6.3.1. Fertiliers to supply nutrients

Different fertilisers are available in market to provide required nutrient. Some of the commonly used fertilisers and nutrient contents are listed in Table 8 to 11.

Table 8. Nitrogen fertilisers

Name of the fertilizer	Nitrogen (N) (%)
Urea	46
Ammonium Sulphate	20.6
Calcium Ammonium Nitrate	25
Ammonium Chloride	25

Table 9. Phosphatic fertilisers

Name of the fertilizer	Phosphate (P_2O_5) (%)
Single Super Phosphate (SSP)	16
Triple Super phosphate (TSP)	46
Rock phosphate	18

Table 10. Potassium ferilisers

Fertiliser	K_2O (%)
Muriate of Potash (KCl), MOP	60
Potassium sulphate	50
Potassium magnesium sulphate	22

Table 11. Complex fertilisers

Fertiliser	N (%)	P_2O_5 (%)	K_2O (%)
Urea Ammonium phospate	24	24	0
	28	28	0
	14	35	14
Ammonium phosphate sulphate	16	20	0
Diammonium phosphate (DAP)	18	46	0
Mono Ammonium phosphate (MAP)	16	20	0
Nitro phosphate	20	20	0
	23	23	0
Nitrophosphate with potash	15	15	15
N P K complex fertilizers	17	17	1
	14	28	14
	19	19	19
	10	26	26
	12	32	16

6.3.2. Rate of application

The general nutrient recommendation for various cashew growing regions is presented in Table 12. These fertiliser doses are to be adjusted based on the soil test results, age of the plant and spacing followed. The recommendation is for normal spacing. In high density planting system of cashew, the fertilizer recommended is reasonable up to 80-100 per cent canopy coverage which is normally achieved during the initial 6-8 years after planting. After certain stage of the crop, reduction in recommended doses of fertilizers per plant may be necessary due to the nutrient build up in soil contributed from the decomposing cashew biomass fall out. It again re-iterates the need for soil test based site specific nutrient management.

Table 12. Recommended dose of fertilizers to cashew in different states

State	Nutrient dose for mature cashew plantations (5^{th} year of planting) (g/tree/year)		
	N	P_2O_5	K_2O
Kerala	500 750	125 325	125 750

Karnataka	500 750	250 125	250 125
Tamil Nadu	500	200	300
Andhra Pradesh	500 1000	125 125	125 125
Maharashtra	1000	250	250
Odisha	500	250	250
West Bengal	1000	250	250

6.3.3. Time and methods of application

Fertiliser is to be applied after cessation of heavy rains and after weeding and clearing the base of individual trees. The key to enhance fertilizer use efficiency is to synchronize the time of fertilizer application with the growth need of the crop and period of high root activity. Flushing and early flowering phase (September to December) is the period of increased root activity aiding enhanced absorption of nutrients from soil. Therefore effort should be made to coincide the fertiliser application with this phase. During flushing phase there is heavy internal demand for nutrients as the tree is entering reproductive phase. Hence proper fertiliser application is essential during this growth phase. Preferably the fertilizers to cashew are to be applied in two split doses; one at the onset of the monsoon and the second during the post-monsoon period, ensuring adequate soil moisture availability. If only single application is possible due to labour constraint or other reasons, then this can be done during post monsoon period when sufficient soil moisture is available. Circular trenches of 25 cm deep and 15 cm wide are opened at distance of 0.5, 0.75, 1, 1.5 m away from trunk during 1st, 2nd, 3rd and 4th year after planting and onwards respectively in laterite soils in heavy rainfall areas in west coast (Fig. 9). In loamy soils of low rainfall east coast fertiliser can be applied in 50 cm circular strips. The trench should be closed immediately after the application of fertilizers and green leaves can be spread as mulch. During 1st, 2nd, 3rd, 4th and 5th year of planting 1/5th, 2/5th, 3/5th, 4/5th and full quantity of recommended dose is to be applied.

Fig. 9. Fertiliser application to grown up tree

6.4. Management of micronutrients

Among 17 essential nutrients, the nutrients that are required by plant in small quantities are called as micronutrients. These include iron, manganese, zinc, copper, boron and molybdenum. The functions of these nutrients in cashew are summarised below (Table 13).

Table 13. Micronutrients and their role in plants

Micronutrient	Role in plant
Iron	It plays a major role in synthesis of chlorophyll and photosynthetic activity within the plant and plays major role in nitrogen assimilation.
Manganese	Manganese play role in chlorophyll synthesis, and are important in functioning of many enzymes in plants.
Zinc	Zinc is required for protein synthesis and for the formation of growth regulating compounds in plants.
Copper	It is important in chlorophyll formation. It is also a component of different enzymes in plant.
Boron	In plants B is required for cell division and elongation. It plays a major role in flower and seed production and hence directly related to yield.
Molybdenum	Important in protein synthesis.

The widespread occurrence of micro nutrient deficiencies in cashew growing areas is to be tackled by adequate supplemental application of micro nutrient fertilisers either through soil application or foliar spray.

6.4.1. Micronutrient fertilisers

Commonly used micronutrient fertilisers are listed below; however, the list is not exhaustive.

Table 14. Micronutrient fertilisers

Micronutrient	Source	Content (%)
Iron	Ferrous suphate heptahydrate	20
	Fe-EDTA	12
Manganese	Manganese sulphate	30.5
	Mn-EDTA	5-12
	Manganese chloride	17
Zinc	Zn-EDTA	12
	Zinc sulphate monohydrate	33
	Zinc suphate heptahydrate	21
Copper	Copper sulphate penthydrate	24
	Copper sulphate monohydrate	35
Boron	Borax	10.5
	Boric acid	17
	Di-sodium octaborate tetrahydrate	20
	Solubor (for foliar application)	19
Molybdenum	Ammonium molybdate	52
	Sodium molybdate	39

6.4.2. Rate and method of application

6.4.2.1. Foliar application

Table 15 Illustrates the general recommended rates of micronutrient fertilisers for cashew. A grown up cashew tree requires about 5 litre of spray solution. The foliar spray is to be carried out at start of flushing, panicle initiation and fruit setting stages.

Table 15. Rate of micronutrient for foliar application

Nutrient	Fertiliser to be used	Rate (g/litre)
Iron	Ferrous sulphate	5
Manganese	Manganese sulphate	5
Zinc	Zinc sulphate hepta hydrate	5
Boron	Boric acid	1
	Solubor	1
	Borax	1
Molybdenum	Ammonium molybdate	1
Copper	Copper sulphate penta hydrate	1

Fig. 10. Foliar application of micronutrients to cashew

6.4.2.2. Soil application of micronutrients

The general rates for soil application of micronutrients are available. The rate is 5 kg/ha for Zn, 2 kg/ha for B, and 1 kg/ha for Cu, 2.5 kg/ha for Mn and 0.5 kg/ha for Mo. This rate is as per nutrient basis, and while applying this has to be converted on fertiliser basis, based on the micronutrient fertiliser to be used by the farmer. It is better to provide the micronutrient by including canopy coverage area in calculation. At any cost excess application of micronutrients to soil should not be done as it will adversely affect other nutrients, crop growth and yield. Soil application is only required once in two years. Since the quantity of micronutrient to be given per tree is very small, it is better to mix it with sand while applying.

Precautions in micronutrient soil application in soil.

- Apply only once in 2 years.
- Zinc fertilisers should not be applied along with phosphatic fertilisers.
- Apply only if deficiency is detected in soil testing and apply just the recommended dose.

7. Manuring and fertilisation in high density planting systems

Under high density planting the rate of fertilisers are to be adjusted based on the number of trees per unit area. For some regions, specific fertiliser recommendations are available for high density planting. For tree density of 400 plants/ha, 75:25:25 kg N, P_2O_5 and K_2O per ha per year is recommended.

8. Composting of cashew biomass

Large amount of biomass is available in cashew orchards with the potential for recycling. Annually a mature cashew plantation produces approximately 1.38 to 5.2 tonnes of cashew biomass fall out (leaves, twigs, flowers and apples) per hectare (10-15 to 25-40 year old cashew plantations respectively). Composting of cashew biomass is done by adding 20 per cent cow dung slurry and the composted biomass can be used after 6 months as matured compost with 60-65% recovery. Recyclable cashew biomass is spread in three layers intermixed with 20% cowdung slurry (20% of total weight of biomass). Water is sprinkled to maintain 50% moisture. Decomposing biomass needs to be turned once in 30 days to provide aeration and to release the heat generated in the compost heaps.

Preparation of vermicompost from cashew biomass using earthworm *Eudrillus* sp. has been standardized. The reported recovery from 5.5 tonnes of cashew biomass is 3.5 tonnes of compost or vermicompost. It can be easily adopted in cashew plantations. Earthworms increase the decomposition of waste materials, and enhance the aeration in sub-soil, add micronutrients and increases the microbial activity.

Construction of vermicompost shed: The size of the chamber can be of 80 cm height, 5m length with 1.5m width. The ants can be prevented by constructing an external cement channel with standing water. Shaded nets and silpauline sheet or any local thatching materials like coconut or arecanut leaves can be used to provide shade and protection from rain. For drainage of vermiwash a hole should be provided at the base of the chamber and can be connected with suitable PVC pipes for its collection.

Application of vermicompost to soil supplies 1.2% N, 0.89% P, 0.59% K, 2.75% Ca, 0.82% Mg, 29.6 ppm Zn, 24.3 ppm Mn, 12.2 ppm Cu and 162 ppm Fe besides containing a large population of beneficial microorganisms such as bacteria (39×10^6 cfu), Fungi (39×10^5 cfu), actinomycetes (28×10^5 cfu) and Azospirillum (0.52×10^4 cfu). It is estimated that about 50% of the nutrient requirement of cashew can be met with cashew biomass recycled vermicompost/ compost. Application of Vermicompost to soil adds a huge quantity of organic matter besides supplying a sizeable quantity of plant nutrients.

9. Nutrient management under organic farming in cashew

Soil fertility and nutrient supply are one of the important factors deciding yield. It is reported that only 20% of the cultivated area under cashew receives the nutrient application. Although cashew plantations are reported to produce 1.38 to 5.20 t ha^{-1} of cashew leaf litter biomass with reported composting efficiency of 65%, these are not adequately recycled in cashew plantations. The leaf litter are removed to facilitate picking of nuts during harvest season. During other periods these may be burned or composted. However, the prepared composts are applied to other crops such as arecanut, coconut etc. These practices year after year lead to depletion of soil nutrients. Chemical fertilisers though easier way to increase growth and yield, nowadays there is more preference for organic cashew by some of the consumers. Also, there is also growing concern of increasing cost of fertilisers due to government policies and environmental concerns.

9.1. Potential of organic cultivation of cashew in India

In India cashew is raised as rainfed crop in soils of poor fertility status with limited attention. So a majority of cashew produced are organic by default. The major concern

of such farming practices is the inability to realise the potential yield. To address this, extension efforts are required on technologies available for sustainable and profitable production of cashew under organic farming which can be marketed at premium prices.

As discussed earlier, about 50% nutrient requirement of cashew can be met by recycling of biomass generated in a grownup plantation. In addition, application of 5-8 kg castor cake or 30 kg FYM or 10 kg poultry manure or 15 kg vermicompost (as per local availability) along with 50 g bio-fertilisers can be applied. If the external application of manures is not possible, farmers can go for green manuring by planting green manure crops such as *Glyricidia maculeata* in the interspaces of cashew orchards, which yield 60 kg green biomass/tree/3 cuttings in a year.

8. Conclusions

Like any other crops, nutrient management is important in cashew also. The studies have indicated the potential to increase yield by nutrient application in cashew. Being primarily grown in lateritic acidic landscapes of low fertility, liming and nutrient application found to significantly improve the net farm income. This bulletin comprehensively covers different aspects of integrated nutrient management in cashew.

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