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Research Article

STUDIES ON COFFEE SOIL NUTRIENT STATUS IN KARNATAKA KERALA AND TAMILNADU STATE

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Abstract: Coffee as a beverage is grown in few states of India like in Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Orissa and in north eastern states. Among them in Karnataka, Kerala and Tamil Nadu, it is cultivated in a tradition pattern by following regular cultural practices. Soil fertility is crucial to know the nutrient requirement of the crops. Soil test based nutrient management will increase sustained crop productivity there by helping to save the environment. In order to know the fertility status of the soil this study was carried out and observed that soils cropped to coffee in the traditional coffee growing areas of India indicate soil acidity, deficiency of magnesium, sulphur and boron as limiting factors to achieve sustainable yields of coffee. Ninety four percent of samples representing the three states in South India were acidic in reaction and among them 52 percent were strongly acidic (pH: < 5.5). The phosphorus nutrient management also needs attention to improve the deficiency of the nutrient found in 19 percent of the samples representing three states. Kerala is found to contain higher (31 %) number of samples deficient in available P while Tamil Nadu (27 %) and Karnataka (12 %) soils are deficient to lesser extent. Buildup of soil phosphorus levels in 59 percent of samples is observed and this can not only impair nutrient balance but also affect micronutrient availability to the plants. Deficiency of available magnesium is found to be widespread (64 %) in soils of all the three states. The proportion of the deficiency is highest in Kerala (95 %) followed by Tamil Nadu (55 %) and Karnataka (54 %). Available sulphur content of the soils collected from the traditional coffee growing states indicated deficiency in about 39 percent of the samples. Karnataka was found to have higher number (42 %) of S deficient samples compared to Kerala (39 %) and Tamil Nadu (24 %). Deficiency of available boron was reported in 35 % of the soil samples representing the three States and its distribution was nearly the same in all the states (32-36 %). The soil fertility evaluation of the soils cropped to coffee in the traditional coffee growing states of India enabled to know the limiting factors and to draw site specific nutrient management packages to address the problems of each hobli, taluk, district and state.

Keywords: *Coffee, Soil fertility, Major nutrient, Secondary nutrient, Micronutrient*

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Introduction

Coffee cultivation was started during 1840 by the British colonial around Baba Budan Giris and its surrounding hills in Karnataka. Later it is spread to other areas of Wayanad in Kerala, Shevaroys and Nilgiris in Tamil Nadu. In India coffee is grown in three regions namely traditional coffee growing region comprising Karnataka, Kerala and Tamil Nadu of South India, among them Karnataka and Kerala receive more of South West monsoon rains, whereas Tamil Nadu coffee growing region receives more of North East monsoon. Secondly non-traditional region comprises Andhra Pradesh, Orissa and third region comprises the states of North-eastern India. Traditional coffee growing areas in India comprise of three states in the south, *viz*., Karnataka, Kerala and Tamil Nadu. In Karnataka, coffee cultivation is confined to Western Ghats/hilly areas spread in the Chikamagalur, Hassan, Kodagu and Chamarajanagar districts. The Chikamagalur region has got the distinction of having diverse agro-climatic zones varying from high elevation and high rainfall areas to low elevation and low rainfall areas. Arabica coffee is predominantly cultivated in Chikamagalur, Giris, Mudigere, Mallandur, Gonibeedu and Aldur zones. Robusta is predominant in Balehonnur, Koppa and N. R. Pura zones. Both arabica and robusta are cultivated in Kalasa, Basrikatte, Banakal, Kottegehar and Devarunda zones.

The coffee areas in Hassan district are spread over in Sakleshpur, Belur, Alur, Hanbal, Yeslur and Rayarakoppal zones. In Kodagu, coffee is cultivated in the entire area of the district namely Madikeri, Somwarpet and Virajpet taluks. In Chamarajanagar district, coffee cultivation is confined only to the B.R. Hills. In Kerala, coffee plantations are found in Wayanad, Idukki, Neliampathys and Palakkad districts extensively and robusta coffee is grown predominantly in this state. In Tamil Nadu, area cultivated to coffee is less compared to Karnataka and Kerala and primarily arabica coffee is grown in Pulneys, Shevaroys, Nilgiris, also in Yercaud and Valparai districts that are situated in the hilly tracts of Eastern and Western Ghats. Diversification of coffee plantations with other crops like pepper, orange, areca nut, cardamom and vanilla *etc*. is usually adopted in all the three states. This practice not only sustains the environmental quality but also the financial returns from the farm. Presently planted area under coffee is dominated in the hill tracts of South Indian states with the state of Karnataka accounting 54.2 percent [1-3] followed by Kerala (19.7 %) and Tamil Nadu (8 %). Accordingly, coffee production is conquered in Karnataka (72.3 %) next to that Kerala (19.9 %) and Tamil Nadu (5 %) which accounted for 97.2 percent of India's coffee production. Similarly, productivity of coffee was high in Karnataka (1152 kg ha^{-1}) followed by Kerala (817 kg ha^{-1}) and Tamil Nadu (532 kg ha^{-1}).

Soil fertility refers to the capacity of soil to provide nutrients required by plants in adequate quantities in right time to sustain plant growth. In order to carry out this function the soil should have favourable chemical environment and nutrients necessary for plants in forms that can be easily absorbed by plants for its development. To assess the soil fertility status of traditional coffee growing areas in South India, soil samples were collected representing the coffee growing areas spread in the three states.

Materials and methods

The studies are restricted to assessment of surface soil fertility (0 to 22 cm) in Karnataka, Kerala and Tamil Nadu, methods employed for sampling, laboratory analysis of the sampling and organization of the data sets in electronic form are only presented in this paper. Depending on the extent of area cultivated to coffee in Karnataka, Kerala and Tamil Nadu, number of samples to represent each district, taluk and village were estimated and a target of about 6,537 soil samples was finalized for soil sample collection as each soil sample representing 50 ha. The soil samples were collected at the depth of 0-9 inches (0 to 22.5 cms) by using core sampler. In Karnataka a total of 4,198 soils samples were collected from the four districts *viz*., Chikamagalur (1,744), Hassan (636), Kodagu (1,798) and Chamarajanagar (20) representing total area of 2,18,254 ha cultivated to coffee in the state. In Kerala a total of 1,605 soil samples were collected from Waynad (1,341) and Idukki (264) districts representing total area of 84,735 ha under coffee in the state. In Tamil Nadu a total of 734 soil samples were collected from the districts of Dindigul (303), Salem (151), Nilgiri (102), Theni (63), Coimbatore (53), Coonor (41) and Namakkal (21) representing an area of 32,512 ha planted to coffee. The analysis of soil samples for nutrient status was carried out employing the standard methods of analysis prescribed in the manual provided by NBSS & LUP, CCRI analyzed the samples for soil pH, EC, OC, available P, K, S and B contents. NBSS & LUP analyzed all the samples collected under the project for available Ca, Mg, Cu and Zn. The data generated were used for assessing soil fertility and to give nutrient management recommendations. As there was no deficiency of iron, manganese, and negligible quantity of soluble salts, hence analysis and interpretation of the data are not included.

Results and discussion

Soil reaction

The soil pH of the coffee estates of three states clearly indicated acidic soil reaction in 94 percent of samples and among them 52 percent of samples recorded strongly acidic soil reaction (pH < 5.5). Soil acidity is a serious problem in the three states and needs amelioration by liming. The lime requirement to correct the soil acidity ranged from 0.5-2.0 tons acre-1. Percent distribution of soils representing in 8 major classes namely, 1). Ultra-acid (pH < 3.5), 2). Extremely acid (pH: 3.5 - 4.5), 3). Very strongly acid (pH: 4.5 - 5.0), 4). Strongly acid (pH: 5.0 - 5.5), 5). Moderately acid (pH: 5.5 - 6.0), 6). Slightly acid (pH: 6.0 - 6.5), 7). Neutral (pH: 6.5 - 7.5), 8). Slightly alkaline (pH: 7.5 - 8.0) is depicted in [Fig-1].

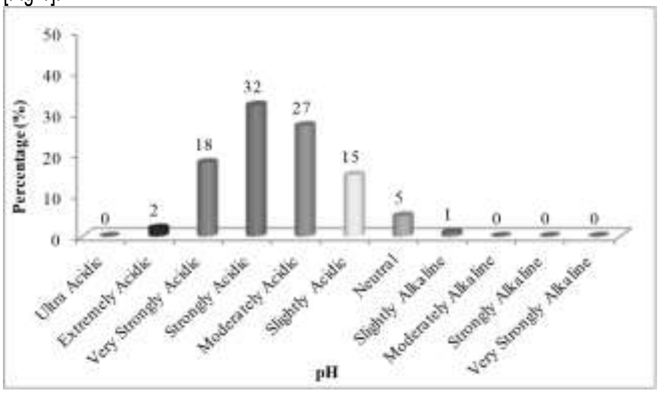

Fig-1Percent distribution of soils in traditional coffee growing areas into pH classes

The soil samples representing each state were classified into strongly acid (SA), moderately acid (MA) and neutral (NA) classes of soil reaction [Fig-2]. Among the three states, Kerala was found to have higher number (69 %) of strongly acidic soils, followed by Karnataka (50 %) and Tamil Nadu (22 %) is depicted in [Fig-2]. In Karnataka, soil acidity is reported in all the districts and the distribution of strongly acidic soils was highest in Hassan (58 %) followed by Kodagu (55 %), Chikamagalur (47 %) and Chamarajanagar (10 %) districts.

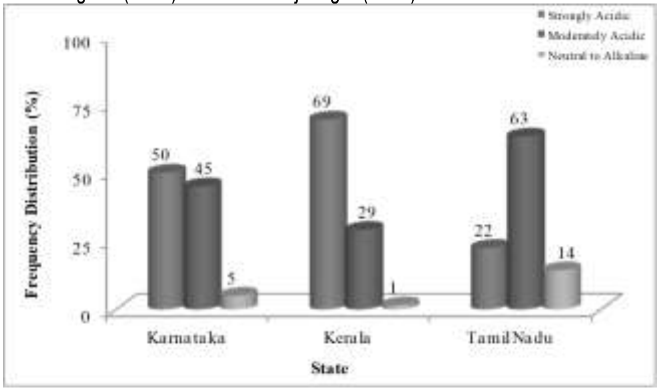

Fig-2 Percent distribution of soils representing each state in different pH classes

In Tamil Nadu, higher number of strongly acidic soils were found in Nilgiris (70 %) while Coimbatore, Namakkal, Coonor, Dindigul, Salem and Theni were found to have strong acidity in 36 %, 24 %, 22 %, 13 %, 12 % and 6 % samples respectively. The higher soil acidity in Nilgiri district can be attributed to the higher rainfall it receives compared to the other districts in the state. The soil low acidity observed in Tamil Nadu compared to Karnataka and Kerala, may be due to the lower quantum of annual rainfall received by it than the other two states.

In Kerala, strongly acidic soils were higher in Wayanad (69 %) than in Idukki district (67 %). The higher soil acidity observed in Kerala compared to the other two states can be attributed to the absence of liming practices for long periods besides the high rainfall and rolling terrain that facilitate leaching of calcium and magnesium from soil. It can be noted that the average annual precipitation in Wayanad and Idukki districts is around 3,000 - 4,000 mm and 2,500 - 4,250 mm respectively. Lack of awareness among growers about the importance of liming could be a reason for not liming the soils regularly in Kerala and hence there is a need to strengthen soil test based liming.

Organic carbon content

The organic carbon content of about 38 % of the samples collected from the three traditional coffee growing states were found to contain organic carbon in medium (1.0-2.5 %) range while 60 % analyzed for high (> 2.5 %) content. The percent distribution of soils of each state into the different organic carbon classes is presented in [Fig-3]. The high organic carbon content of soils cropped to coffee in South India can be attributed to the shaded condition of the plantations.

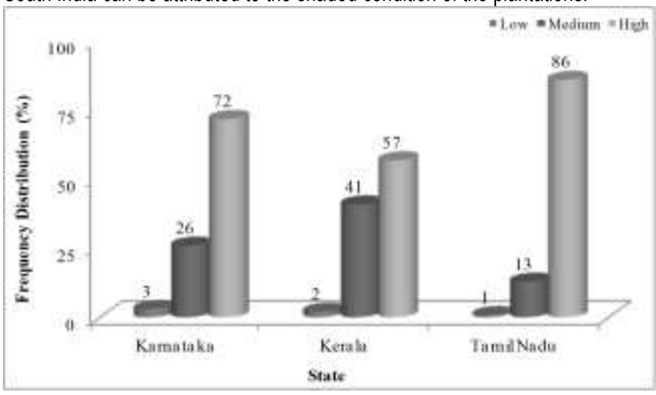

Fig-3 Percent distribution of soils of each state in different organic carbon classes

The shade trees present in the coffee agro-forestry system conserve soil by reducing soil erosion. They restrict weed growth; reduce runoff of surface water which results in greater water retention as well as lower leaching loss of nutrients. The leaf litter from the shade trees enriches soil organic matter and conserves soil moisture. High level of organic matter provides part of the nitrogen requirement of crop plants and improves the physico-chemical and biological properties of soil. The availability of essential plant nutrients is thus governed by the soil organic matter.

Among the three states, soil organic carbon content was found to be high in soils of Tamil Nadu (86 %), followed by Karnataka (72 %) and Kerala (57 %). Tamil Nadu is primarily an arabica coffee growing area and two-tier shade canopy is essential to protect arabica from the incidence of pest like 'white stem borer' (WSB). Thus, the higher shade is responsible for the higher soil organic carbon content of the soils cropped to coffee in Tamil Nadu. Karnataka has both arabica and robusta coffee in equal proportions and as lower shade is maintained in robusta coffee fields compared to arabica, the soils will naturally have lower organic carbon content than Tamil Nadu. Kerala, being a robusta coffee growing area has less shade than the arabica coffee fields and so the soils have lower organic carbon content than the soils of Tamil Nadu and Karnataka.

Available phosphorus in soil

Phosphorous is required for root development, flowering and fruit set. The element is required by plants for energy transformation and photosynthesis. Phosphorus deficiency symptoms begin as slight mottled chlorosis of the older leaves and in advanced stage leaves turn bronze.

The available phosphorus content of the soils of the three states ranged from 1 to 1,302 kg ha^{-1} with an average of 68.3 kg ha^{-1} and only 19 % of the soil samples analyzed were deficient in the availability of P. Classification of the available P data pertaining to 6,537 samples into low (<10 kg ha^{-1}), medium (10-25 kg ha^{-1}), high (26-100 kg ha^{-1}), very high (101-200 kg ha^{-1}) and extremely high (>200 kg ha^{-1}) categories is presented in [Fig-4]. Among the three states, Kerala was found to have higher (31) percentage of P deficient soils compared to Tamil Nadu (27 %) and Karnataka (12 %). The available P status of the soils representing three states is depicted in the [Fig-5].

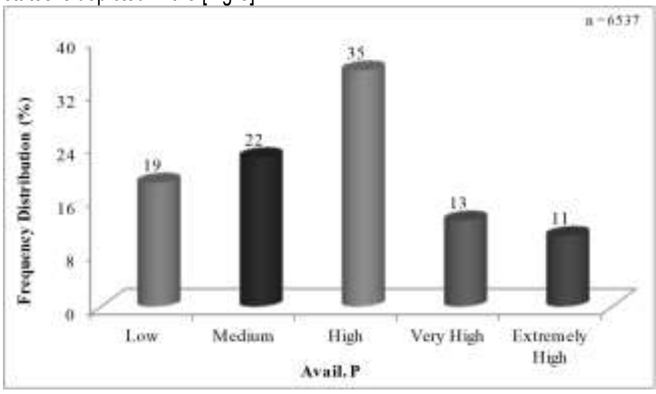

Fig-4 Frequency of available phosphorus classes in soils of South India

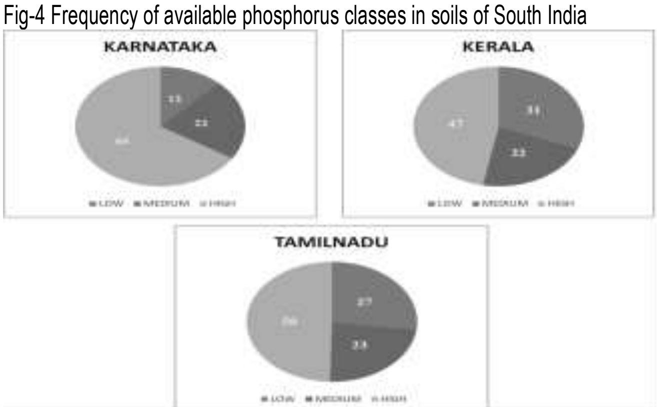

Fig-5 Frequency of phosphorus classes in soils of different states in South India

Among the districts of Karnataka, Hassan had highest (22) percentage of soils that were low in available phosphorous content compared to other districts. In Kerala, Idukki district had highest (42 %) P deficient soils [4 and 5] compared to Wayanad (28 %). In Tamil Nadu, Coimbatore district had highest (51) percentage of soils containing low available phosphorous compared to other districts.

Results of the present study indicated buildup of available phosphorus in the coffee growing soils of Karnataka (66 %), Kerala (47 %) and Tamil Nadu (50 %). Application of water insoluble phosphatic fertilizers like Mussoorie rock phosphate (MRP) was very common in coffee cultivation up to 1990s. Consequent to deregulation of fertilizer policy and non-availability of MRP, use of water-soluble complex fertilizers came in to practice. This could be one of the reasons for buildup available phosphorus in coffee soils. Unlike nitrogen and potassium, phosphorus does not leach out of the soil and under acidic condition gets fixed in the soil by converting to unavailable forms. Accumulation of phosphorus in soils can take place once the P fixing capacity of the soils is satisfied.

Reducing the dose of P fertilizer under high soil available P condition is necessary for ensuring balanced nutrient supply to the plants and this also economises the coffee cultivation. Phosphorus and zinc are known to have antagonistic interaction and so phosphorus inputs in excess can bring about zinc deficiency [4-6]. Soil amendments like lime can release phosphorus fixed by the soil constituents into the available pool. Hence, it is recommended to get the soil tested regularly and apply lime, fertilizers in required quantities only. Where ever the soils are low in available phosphorous content, application of water-soluble P fertilizers will help to overcome the deficiency.

Available potassium in soil

Potassium plays an important role in plant metabolism and development. Potassium deficiency symptoms first appear in older leaves as a chlorotic band along leaf margins and later dark brown necrotic spots develop along the leaf margins. Spots continue to enlarge until entire margins are necrotic, with the central portion of the blade remaining green. Potassium enhances the tolerance of plants to drought and reduces the susceptibility of plants to pest and disease attack. The available K ranged from 11-2,518 kg ha^{-1} with an average value of 371.3 kg ha^{-1} in soils of three states and their percent distribution under available potassium classes is presented in [Fig-6]. Kerala (10 %) to have a greater number of K deficient soils than Karnataka (7 %) and Tamil Nadu (3 %). Maintenance of high levels of organic matter, abating soil acidity through liming, application of K fertilizers in doses recommended based on soil test data and crop requirement would be helpful in managing potassium nutrition to coffee plants effectively.

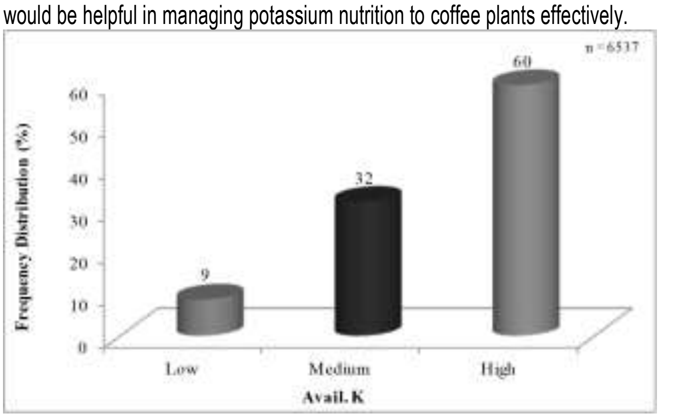

Fig-6 Frequency of available potassium classes in soils of South India

Available calcium in soil

Calcium, a secondary nutrient, has important role in the development of cell walls, roots, terminal buds and flowers. It also contributes to the ripening and quality of coffee. The available calcium status of soils in the three states varied from 5.8 - 4,694 mg kg^{-1} with an average value of 1,102 mg kg^{-1}. About 24 percent of the samples analyzed were found to be deficient in available calcium content [Fig-7].

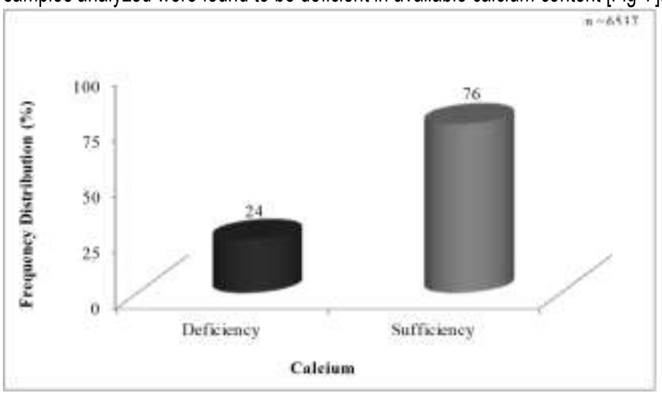

Fig-7 Frequency of available calcium in soils of South India

The distribution of calcium deficient soils in the three states varied from 17 - 33 percent. Getting the soil samples tested periodically and correcting soil pH using a good liming material will help in neutralizing soil acidity as well as improving the calcium status of soils cropped to coffee. In Karnataka, percentage of deficiency of available calcium was highest (29) in the soils of Kodagu and Hassan districts compared to other districts. In Kerala, Idukki district had higher (39) percentage of Ca deficient soils [5] followed by Wayanad (32 %). Among the districts of Tamil Nadu, Ca deficient soils were highest in Nilgiri (54 %) compared to other districts.

Available magnesium in soil

Magnesium is one of the important secondary nutrients and it is constituent of chlorophyll. It is mobile within the plant and deficiencies first appear on older leaves. The typical symptom of magnesium deficiency is expressed as inter-venial chlorosis of the leaves and severe deficiency leads to drying of leaf tips.

The available magnesium status of soils cropped to coffee in three states ranged from 0.1-1,482 mg kg^{-1} and found to be deficient in about 64 percent of the samples. The percentage of soils classifying under deficient (< 180 mg kg^{-1}) and sufficient (>180 mg kg^{-1}) categories is presented in [Fig-8]. Among the three states, deficiency of available magnesium was highest in Kerala (95 %) while Karnataka and Tamil Nadu recorded Mg deficiency in 54 and 55 % of samples respectively [Fig-9]. The higher magnitude of the magnesium deficiency in Kerala soils [4 and 5] is due to the absence of practices like liming and applying magnesium containing farm inputs.

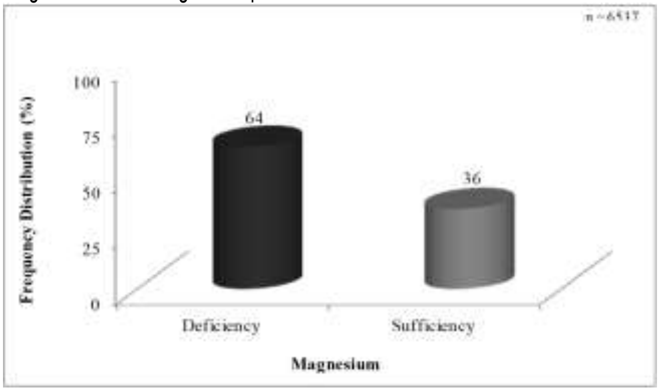

Fig-8 Frequency of available magnesium classes in soils of South India

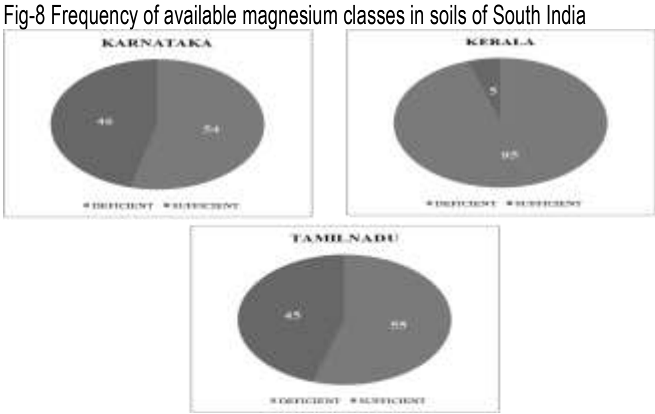

Fig-9 Frequency of available magnesium classes in soils of traditional coffee growing states

In Karnataka, the deficiency of available magnesium was found to be more in Chamarajanagar (75 %), followed by Kodagu (60 %), Hassan (53 %) and Chikamagalur (46 %) districts. In Kerala, the deficiency of Mg was more pronounced in Wayanad district (96 %) compared to Idukki (88 %). In Tamil Nadu, Coimbatore all the samples were deficient in available magnesium content followed by Nilgiris (75 %), Namakkal (67 %), Dindigul (59 %), Theni (51 %) and Salem, Yercaud (40 %) districts.

The higher extent of magnesium deficiency in the coffee growing soils of Karnataka, Kerala and Tamil Nadu can be a limiting factor to achieve higher yields. So, it is essential to correct the deficiency and ensure balanced nutrition to plants. To improve the available magnesium status of these soils' application of dolomite lime stone containing calcium magnesium carbonate can be suggested. Foliar application of magnesium sulphate also can be recommended for quick replenishment of the nutrient to plants in deficient soils.

Available sulphur in soil

Sulphur is a component of amino acids and found to have influence on the coffee quality. Its requirement to coffee plants is estimated to be equal to that of phosphorus. Deficiency of sulphur appears first in younger leaves as chlorosis followed by discoloration. Like nitrogen and potassium, sulphur is likely to be lost from the soil through leaching. In soils of three states available sulphur content ranged from 0.8 - 130.3 mg kg^{-1}. Classification of the data into sufficient (> 10 mg kg^{-1}) and deficient (< 10 mg kg^{-1}) categories indicated the deficiency of available sulphur content in 39 percent of the samples [Fig-10].

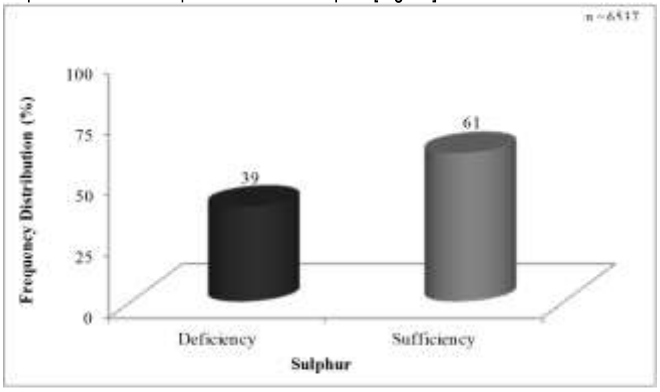

Fig-10 Frequency of available sulphur classes in soils of south India

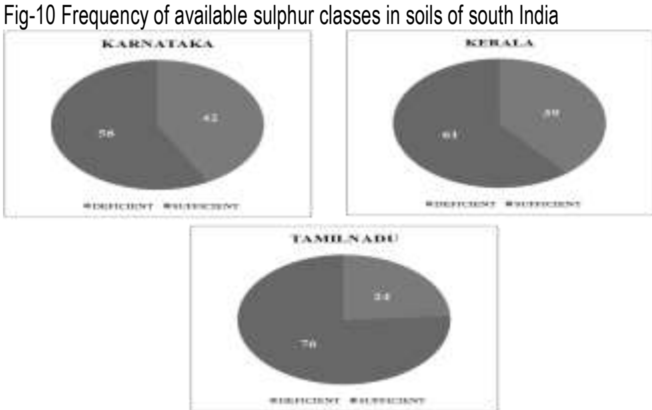

Fig-11 Frequency of available sulphur classes in soils of three states in South India

Karnataka was found to have highest S deficient soils compared to Kerala and Tamil Nadu [Fig-11]. The better available S status of Tamil Nadu is because of the regular use of Bordeaux mixture (containing copper sulphate and lime) as fungicide in arabica plantations. In Karnataka, sulphur deficiency was higher in samples of Hassan (61 %) followed by Kodagu (43 %), Chamarajanagar (40 %) and Chikamagalur (34 %) districts. In Kerala, Wayanad and Idukki districts reported S deficiency in about 39 % samples. In Tamil Nadu, the percentage of soils deficient in available S in different districts followed the sequence; Nilgiri (69 %), Namakkal (47 %), Theni (27 %), Coimbatore (25 %), Salem (20 %) and Dindigul (11 %). Based on the soil test, application of S containing fertilizers like ammonium phosphate sulphate can be recommended to correct the deficiency of sulphur. Foliar spray of magnesium sulphate (0.5 %) solution can be suggested when the deficiency of sulphur is severe.

Available zinc in soil

Zinc is a constituent of many enzymes; influences translocation and transportation of phosphorous in plant, plays major role in many metabolic activities. Deficiency symptoms first appear on younger leaves in the form of inter-venial chlorosis and reduction in the size of young leaves. These leaves are often clustered at the top and this phenomenon is normally known as "rosetting". The available zinc status of the soil samples belonging to three states was fairly good and the soil test values for the element ranged from 0.1 to 185 mg kg^{-1}. Distribution of soil samples under sufficient and deficient classes is presented in [Fig-12].

The deficiency of available zinc was not very prominent in Karnataka (15 %), Kerala (14 %) as well as in Tamil Nadu (5 %) samples.

In Karnataka, samples of Hassan district (22 %) were more deficient than the samples from other districts (0-16 %). In Kerala, the deficiency of available zinc was more [5] in Wayanad (15 %) compared to Idukki (8 %) district. Most of the districts of Tamil Nadu had sufficient level of available zinc except Namakkal and Nilgiris where the deficiency was 14 and 19 percent respectively. The sufficiency of available zinc may be attributed to high organic matter present in coffee soils. Foliar application of properly neutralized zinc sulphate solution (0.25 %) can be recommended to supply zinc to the plants in deficient soils.

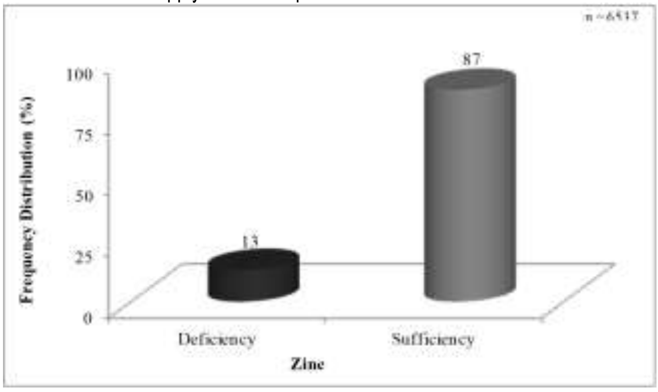

Fig-12 Frequency of available zinc classes in soils of South India

Available copper in soil

Available copper content in coffee growing soils of South India ranged from 0.3 to 430 mg kg^{-1} and the deficiency was found in very insignificant number of samples (6 %). The distribution of soils into sufficiency (>1mg kg^{-1}) and deficiency (<1 mg kg^{-1}) classes of available copper is presented in [Fig-13].

Among the three states, low values for available copper content were reported in 7 % of soil samples collected from Karnataka, 3 % from Kerala and 1 % from Tamil Nadu. In Karnataka state, Chamarajanagar district had the highest (40 %) available S deficient samples while the deficiency of this nutrient ranged from 2 to 12 % in other districts and was not very significant. Foliar spray of properly neutralized copper sulphate solution can be recommended when soil test data reveals deficiency of the nutrient.

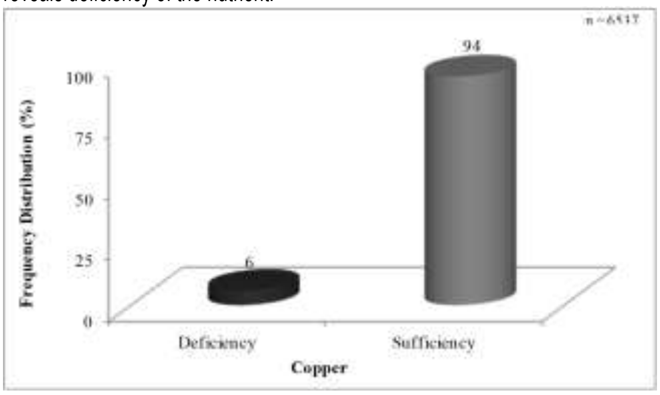

Fig-13 Frequency of available copper classes in soils of South India

Available boron in soil

Boron is a micronutrient required in very minute quantities for plants though it plays vital role in physiology of the plants. It is responsible for cell wall formation, stabilization, lignification and xylem differentiation. It imparts drought tolerance and plays important role in pollen germination. Abnormal growth of young leaves and the apical bud will be seen when boron is deficient in plants. The youngest leaves will turn light green, smaller in size, curved and mottled with small necrotic spots. Failure of leaves to expand normally results in irregular margins and may die under acute deficiency. Boron deficiency also induces deficiency of calcium. The available boron content indicated the deficiency in 35 % of the samples and the availability ranged from 0.01 to 11.4 mg kg^{-1}. The percent distribution of soils under the deficient and sufficient classes is presented in [Fig-14]. The data on the available B content in soils representing three states were examined and found that B deficiency is spread into all the three states more or less equally and the percentage of deficient soils ranged from 32 to 36.

Available B status of soils representing each district in Karnataka, Kerala and Tamil Nadu was examined to know the extent of deficiency. In Karnataka, Hassan was found to have higher number (40 %) of B deficient soils followed by Kodagu (36 %), Chikamagalur (34 %) and Chamarajanagar (30 %). In Kerala, Idukki district had higher (39 %) number of samples deficient in available B content [5] than Wayanad (31 %) district. Among the districts of Tamil Nadu, Nilgiri had higher number (42 %) and Namakkal had the least number (10 %) of B deficient samples. To correct the deficiency of boron foliar spray of 0.3 % boric acid or 0.5 % borax can be recommended.

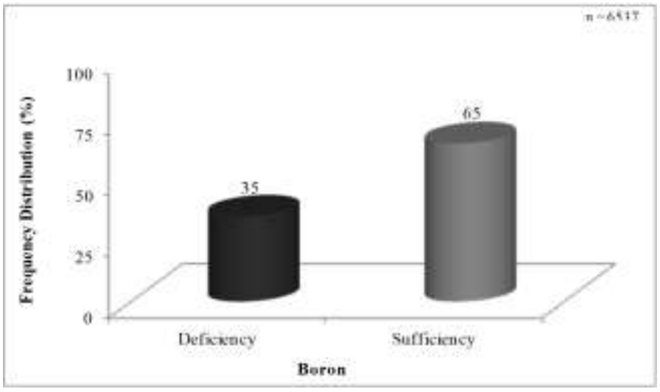

Fig-14 Frequency of available boron classes in soils of South India

Conclusion

The results indicate soil acidity, deficiency of magnesium, sulphur and boron as limiting factors to achieve sustainable yields of coffee. Ninety four percent of samples representing the three states in South India were acidic in reaction. Application of liming materials like calcite (calcium carbonate) and dolomite (calcium magnesium carbonate) is recommended in alternative years for correcting soil acidity and to supply calcium and magnesium in balanced quantities. The phosphorus deficiency was found in 19 percent of the samples representing three states. Kerala is found to contain higher (31 %) number of samples deficient in available P while Tamil Nadu (27 %) and Karnataka (12 %) soils are deficient to lesser extent. Soil test-based P nutrient recommendation will be beneficial to the growers to improve the available P status of the coffee gardens. Buildup of soil phosphorus levels in 59 percent of samples is observed and this can not only impair nutrient balance but also affect micronutrient availability to the plants. Reduction in phosphorus fertilizer doses by 25 to 75 percent can be suggested. Deficiency of available magnesium is highest in Kerala (95 %) followed by Tamil Nadu (55 %) and Karnataka (54 %). Use of good quality dolomite as liming material is recommended in these deficient areas to ensure adequate availability of calcium and magnesium to the plants. Available sulphur content deficiency in Karnataka was found to have higher number (42 %) compared to Kerala (39 %) and Tamil Nadu (24 %). To correct the deficiency of the nutrient, application of sulphur containing fertilizers can be recommended.

Deficiency of available boron was reported in 35 % of the soil samples representing the three states and its distribution was nearly the same in all the states (32-36 %). Soil application of boron is generally not encouraged in coffee cultivation and hence foliar spray of 0.3 % boric acid or 0.5 % borax is recommended for supplying the nutrient to plants when soil test results indicate deficiency of available boron. The soil fertility evaluation of the soils cropped to coffee in the traditional coffee growing states of India enabled to know the limiting factors and to draw site specific nutrient management packages to address the problems of each hobli, taluk, district and state.

Application of research: Based on the research findings we can correct the soil deficiency of nutrients and thereby it will help to improve the coffee crop yield.

Research Category: Coffee Research

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Study area / Sample Collection: Karnataka, Kerala and Tamil Nadu states

Cultivar / Variety / Breed name: Arabica and Robusta coffee

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References

[1] Anonymous (1960-61 to 1980-81) *Coffee Statistics*.
[2] Anonymous (1980-81 to 2015-16) *Annual Report of Coffee Board, Research Department.*
[3] Anonymous (2000-2016) *Coffee Database*.
[4] Apori Samuel Obeng, Adams Sadick, Emmanuel Hanyabui, Mohammed Musah, Murongo Marius, Mark Kwasi Acheampong (2020) *AIMS Agriculture and Food*, 5(4), 938-949.
[5] Marigowda C., Ramesh M., Sujatha K. and Hegde R. (2018) *International Journal of Plant and Soil Science*, 24 (4), 1-13.
[6] Raju T., Thomas M. R. and Ganesh K. A. (1982) *Indian Coffee*, 46(8), 192-196.