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Research Article

STUDIES ON COFFEE SOIL NUTRIENT STATUS OF TAMIL NADU

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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 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 Tamil Nadu indicate soil acidity, deficiency of Phosphorus, Magnesium, Sulphur and Boron as limiting factors to achieve sustainable yields of coffee. Eighty five percent of samples representing the coffee growing regions of Tamil Nadu were acidic in reaction and among seven coffee growing districts of Tamil Nadu, Nilgiri was found to have higher number of acidic soils. The phosphorus nutrient management also needs attention to improve the deficiency of the nutrient found in 27 percent of the samples representing the state. Deficiency of available Magnesium is found to be widespread (55 %) in soils of all the seven districts. Available sulphur content of the soils collected from the traditional coffee growing districts indicated deficiency ranging from 2 to 69 percent of the samples. Deficiency of available boron varied from 10 to 49% among the districts. The soil fertility evaluation of the soils cropped to coffee in the traditional coffee growing areas of Tamil Nadu enabled to know the limiting factors and to draw site specific nutrient management packages to address the problems of each hobli, taluk and district.

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

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Introduction

Tamil Nadu is geographically situated between the northern latitude of 8º5' and 13º35' and the eastern longitude of 76º15' and 80º20'. It is bordered by Andhra Pradesh in the north, Karnataka and Kerala in the west, the Indian Ocean in the south and the Bay of Bengal in the east. High altitude and hilly zone of Tamil Nadu is divided into Eastern and Western Ghats. The Eastern Ghats rise steeply above the plateau level of 1,525-1,650 m in the Shevroys and comprises of a line of hills, the Javadis, Shevroys, Kalrayans, Pachamalais and Kollimalasi between the Palar and Cauvery rivers and beyond. The Western Ghats comprise the highest mountains like the Nilgiris located on the northern side of the Palghat, Anamalais in south of the Palghat, Pulney hills overlooking the river Vaigai, Cardamom hills *etc*., of the peninsula. Coffee is grown in hilly regions of the state that are spread over seven districts *viz*., Dindigul, Salem, Nilgiris, Theni, Coimbatore, Coonoor and Namakkal. The total coffee planted area is 35,652 hectares out of that Arabica is 29,338 hectares and Robusta is 6,314 hectares [2]. The total coffee production in Tamil Nadu is 18,325 metric tons.

Materials and methods

Composite soil samples were collected from the farmers' fields using GPS and core samplers in such a way that the sampling spots represent villages, taluks and districts of the state where coffee is cultivated. The sample size was fixed based on the extent of area cultivated to coffee in each district and accordingly 303 samples from Dindigul, 151 samples from Salem, 102 samples from Nilgiri, 53 samples from Coimbatore, 63 samples from Theni, 21 samples from Namakkal, 41 samples from Conoor and thus a total of 734 samples were collected from State.

All the 734 samples representing the coffee growing soils of Tamil Nadu were analyzed for 13 soil fertility parameters such as soil reaction, electrical conductivity, major nutrients nitrogen, phosphorus, and potassium [2-7], secondary nutrients (Calcium, Magnesium and Sulphur) and micronutrients (iron, manganese, copper, zinc and boron) [3,5] following the standard methods of analysis. The analytical results obtained were used for assessing soil fertility and generating the plant nutrient management recommendation cards or soil health cards for the benefit of planters. Apart from this, the database served to identify the fertility constraints and generate suitable crop nutrient management plans for the coffee area in each village, taluk, district and also Tamil Nadu state. Soluble salts content in these soils were very negligible and none of the samples analyzed were deficient in available iron and manganese contents. Hence the data pertaining to parameters other than these are presented and discussed.

Soil reaction

The pH of the samples collected from the seven coffee growing districts of Tamil Nadu ranged from 4.2 to 7.8. About 85 percent of the soil samples analyzed were acidic while the remaining 15 percent of the samples were neutral in reaction. The soil reaction of samples collected from different districts of Tamil Nadu was classified into strongly acid (SA), moderately acid (MA) and neutral (NA) classes [Fig-1]. Among the seven coffee growing districts of Tamil Nadu, Nilgiri was found to have higher number of acidic soils while Theni had the lowest number of acidic soils. The higher soil acidity observed in Nilgiri district can be attributed to the higher rainfall (3,520.8 mm) received by the district compared to Theni (833.5mm).

Productivity of soil and nutrient assimilation depend on the soil reaction (pH). Soils cropped to coffee are found to perform well when the soil pH is maintained around 6.1 and so the acidic soils of Tamil Nadu need to be corrected for soil pH by liming based on soil test results.

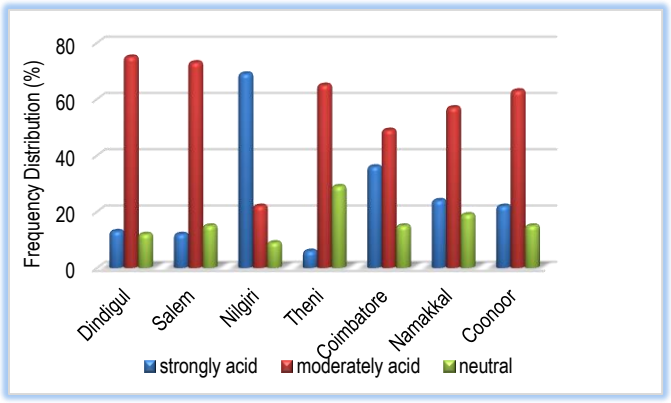

Fig-1 Percent distribution of soil reaction classes in the Districts of Tamil Nadu

Soil Organic Carbon

The organic carbon content of the soil samples was estimated as a measure of plant available nitrogen and the data was classified into low (<1.0 %), medium (1.0 - 2.5 %) and high (>2.5 %) classes. The organic carbon status of coffee growing soils of Tamil Nadu was quite good with 93 per cent of the samples testing for the high levels [Fig-2]. No significant variation in organic carbon status was noted among the districts.

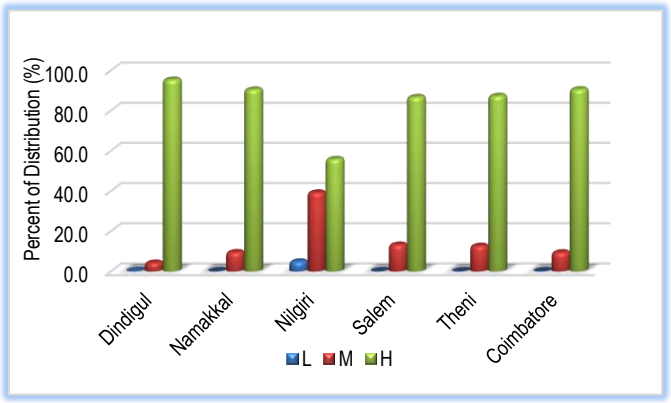

Fig-2 Frequency of organic carbon classes in the Districts of Tamil Nadu

Plant available phosphorous in soils

Soils cropped to coffee in Tamil Nadu were found to have medium to high levels of available P in large number of samples with about 27% of the samples recording low P availability. Classification of the available P data of 734 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-3].

Soil available P data of the soils representing each district was classified into low (<10 kg ha^{-1}), medium (>10 - 25 kg ha^{-1}) and high (>26 kg ha^{-1}). Among the seven districts, Dindigul recorded the lowest (18%) and Coimbatore the highest (51%) available phosphorus deficient soils. The percentage of P deficient soils in Namakkal, Nilgiri, Coonoor, Theni and Salem districts followed a descending order.

Considerable build-up of available P was recorded in coffee growing soils of Theni, Dindigul, Salem and Coonoor districts of Tamil Nadu. This may be due to the practice of applying large quantities of phosphorous fertilizers in those areas. Reduction in the quantum of P fertilizers can be suggested to the soils testing high to extremely high to avoid the build-up of P in soils. 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 economizes the coffee cultivation. Phosphorus and Zn are known to have antagonistic interaction and so P inputs in excess can aggravate zinc deficiency. Correction of soil acidity by liming the soils is also essential for releasing phosphorous fixed in the soil. Hence it is recommended to apply inputs like lime and fertilizers based on the soil test to meet the needs of the plant and crop.

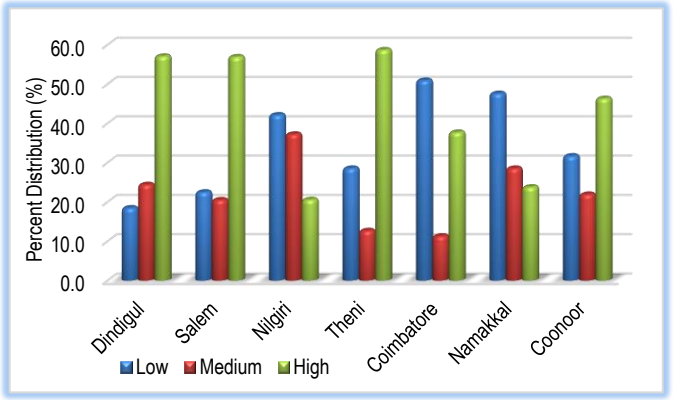

Fig-3 Frequency of available phosphorus in the Districts of Tamil Nadu

Plant available potassium in soils

Available potassium in soils of Tamil Nadu ranged from medium to high and the deficiency of the nutrient was recorded in only 3% of the samples analyzed. Classification of the data into low (<125 kg ha^{-1}), medium (126 - 250 kg ha^{-1}) and high (>250 kg ha^{-1}) presented in [Fig-4].

Among the seven districts, Nilgiri was found to have about 16% of soils recording available K below 125 kg ha^{-1}, while in other districts the available K deficiency was in 1-2% of the samples only. The good status of available K could be due to the application of sufficient quantities of potassium fertilizers. Reduction in potassium fertilizer levels to the soils analyzing high levels of available K can be recommended. Low activity clay minerals in the coffee growing soils do not retain the applied potassium in significant amounts and hence abating soil acidity through liming and maintaining high levels of organic matter will be beneficial in managing potassium nutrition in these soils. To ensure balanced nutrient supply to the plants, soil test based lime and fertilizer application is also recommended.

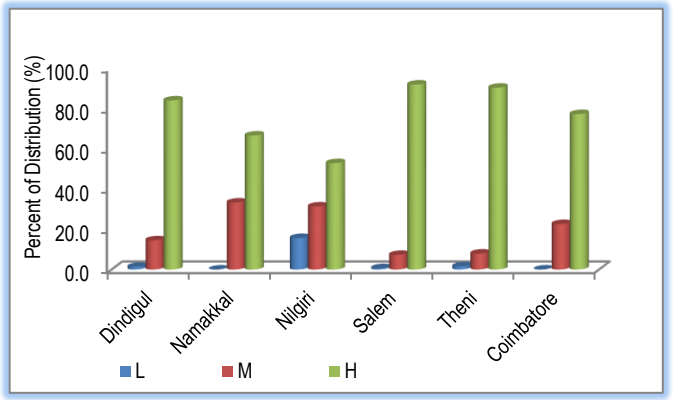

Fig-4 Frequency of available potassium classes in the Districts of Tamil Nadu

Available calcium in soils

Availability of Calcium in the highly weathered tropical soils is generally low. The available Calcium status of the coffee growing soils was fairly good with merely 17 percent of the samples analyzing low Ca content. The distribution of the soils into sufficient (>600 mg kg^{-1}) and deficient (<600 mg kg^{-1}) levels is presented in [Fig-5].

The available Ca data of the soils representing the seven districts of Tamil Nadu was examined and found that Ca deficient soils were higher (54%) in Nilgiri and lowest (2%) in Theni districts. The deficiency of exchangeable Calcium is also reflected in the higher number of strongly acidic (70%) soils in Nilgiri district. Hence abating the soil acidity using a good liming material containing Calcium and Magnesium carbonate is recommended for these soils.

Exchangeable / available Magnesium soils

The available Magnesium status of the soils representing the Tamil Nadu State

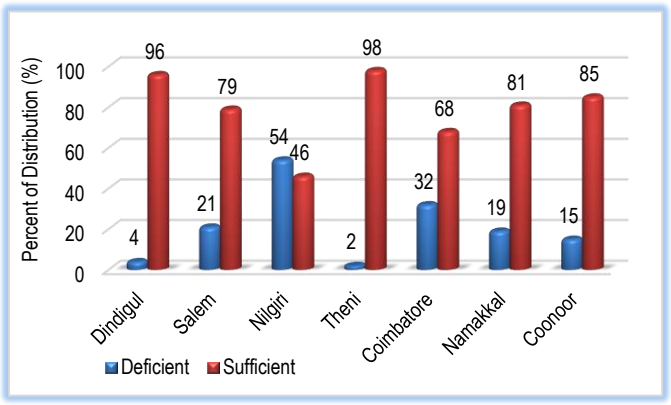

Fig-5 Frequency of available Calcium classes in the Districts of Tamil Nadu

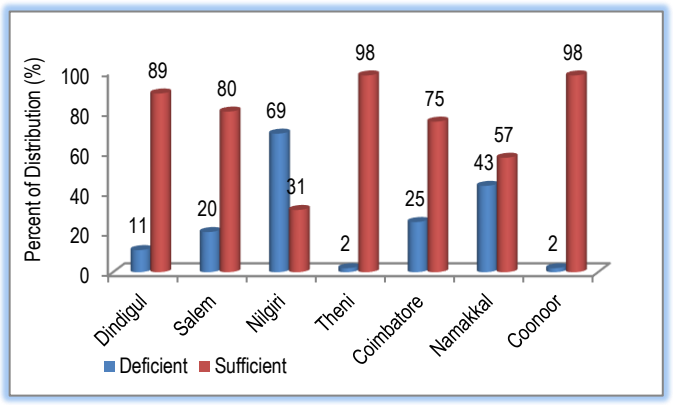

Fig-7 Frequency of sulphur classes in the Districts of Tamil Nadu

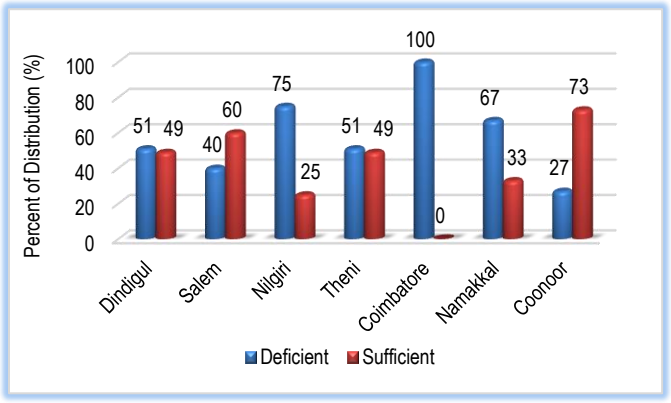

Fig-6 Frequency of available Magnesium classes in the Districts of Tamil Nadu

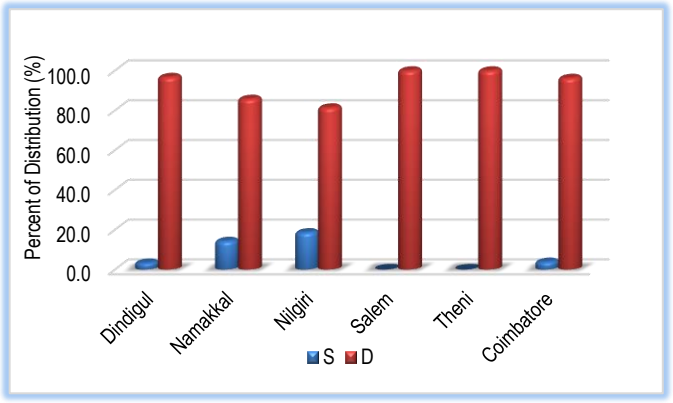

Fig-8 Frequency of zinc classes in the Districts of Tamil Nadu

was examined and found to range from 0.8 to 286.3 mg kg^{-1}. The categorization of the data into sufficient (>180 mg kg^{-1}) and deficient (<180 mg kg^{-1}) classes indicated the deficiency of the element in large number (55%) of samples [Fig-6].

The deficiency of the nutrient was found to be wide spread in all the districts of Tamil Nadu with the highest Mg-deficient soils in Coimbatore (100%) and lowest in Coonoor (30%) districts. Absence of the practice of applying Magnesium containing liming material as well as fertilizers seems to be the reason for the severe deficiency of available Magnesium reported in the coffee growing soils of Tamil Nadu. This calls for immediate attention for amelioration through the use of dolomite lime that can supply both Calcium and Magnesium. Acute deficiency of Magnesium can be corrected by the foliar spray of 0.5 per cent Magnesium sulphate solution to the plants

Available Sulphur in soils

The available sulphur status of Tamil Nadu soils is fairly good with majority of the samples (75%) recording the availability of the nutrient above 10 mg kg^{-1} [Fig-7].

The available sulphur status of the soils belonging to different districts of Tamil Nadu was examined and the deficiency was found to range from 2 to 69%. Soils of Nilgiri district were reported to have highest S-deficiency while Theni and Coonoor districts recorded lowest number of sulphur deficient soils.

For the soils that are not highly deficient in available S, application of any sulphur containing fertilizers can be suggested to improve the availability of the nutrients. Foliar application of 0.5 percent Magnesium sulphate will be ideal to ensure adequate supply of the nutrient to the plants while the soil test data indicates acute deficiency of the nutrient.

Plant available zinc in soils

Soil available zinc status of soil samples representing Tamil Nadu was found to be good with insignificant number (5%) of samples recording low content [Fig-8]. Foliar application of properly neutralized zinc sulphate (0.25%) solution can be suggested when the soil test values indicate deficiency of the nutrient.

Plant available copper in soils

Coffee growing soils of Tamil Nadu were found to have very good status with respect to the available copper content. The distribution of soils into sufficiency and deficiency classes of available copper is presented in [Fig-9].

Tamil Nadu is primarily an arabica coffee growing area and foliar spray of copper containing fungicides is practiced regularly in arabica coffee fields as a protective measure against the coffee leaf rust (CLR), a fungal disease caused by *Hemileia vastatrix* B. & Br. Due to the use of copper containing fungicides, deficiency of copper is seldom seen in plantations/soils cultivated to arabica coffee.

Plant available boron in soils

The status of availability of boron in coffee soils of Tamil Nadu was reasonably good and ranged from 0.01 to 1.5 mg kg^{-1}. The per cent distribution of soils in sufficient and deficient categories is depicted in [Fig-10].

The percentage distribution of soils representing different districts of Tamil Nadu into available boron classes is presented in [Fig-10]. The data indicated that the soils analyzing low available boron (< 0.5 mg kg^{-1}) varied from 10 to 49% among the districts. Coonoor was found to have highest number of B-deficient soils followed by Nilgiri, Salem, Dindigul Coimbatore and Theni while Namakkal has the least number of B-deficient soils.

The plantations having deficiency of soil available boron need to be recommended with foliar application of boric acid (0.3 %) or borax (0.5 %) to correct the deficiency. As a greater number of samples recorded deficiency of B in Coonoor and Nilgiri districts, the soils from these areas need to be essentially checked for B availability for planning better nutrient management programme.

Recommendations on soil fertility management

In Tamil Nadu, 22 percent of the soils were found to have extreme to strong acidic reaction (pH: <5.5). So, liming of acid soils depending on the requirement determined through soil test is highly essential. Amelioration of soil acidity in plantations of Nilgiri and Coimbatore districts has to be strictly adopted for achieving higher yields consequent to the neutralization of soil acidity and improved uptake of the applied fertilizers.

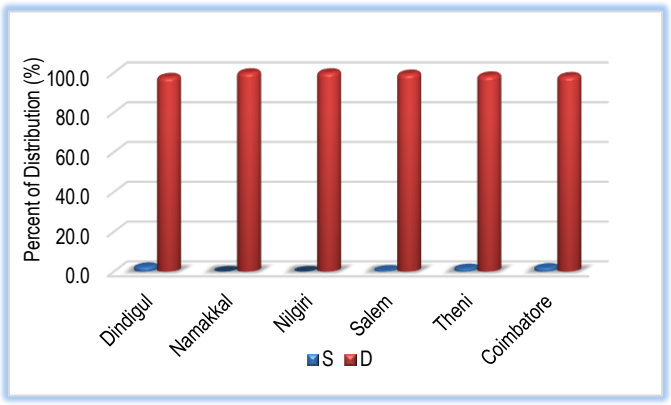

Fig-9 Frequency of copper classes in the Districts of Tamil Nadu

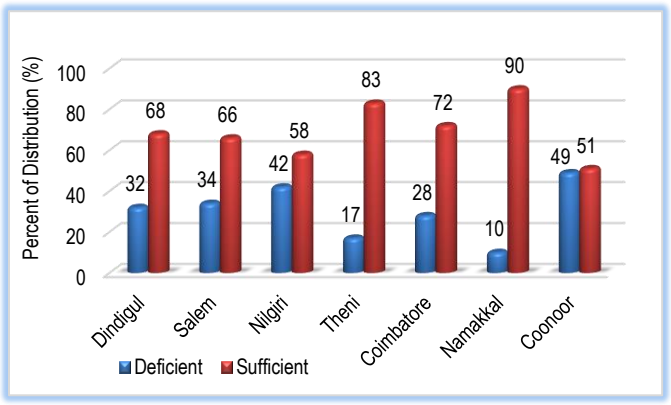

Fig-10 Frequency of boron in the Districts of Tamil Nadu

The coffee growing soils of Tamil Nadu were found to have good organic carbon status and the deficiency was insignificant. Application of 5 kg of organic manure per plant can be recommended for soils analyzing low content of organic carbon to improve the physical, chemical and biological properties.

Considering the low nutrient retention capacity and the nutrient availability status, split application of nitrogen and potassium fertilizers will be beneficial.

Reduction in P doses can be suggested for the soils analyzing high (>25 kg ha^{-1}) to extremely high (>200 kg ha^{-1}) levels of soil available P to avoid the P build up in soils. Deficiency of Magnesium was more prominent than Calcium in soils of Tamil Nadu. To replenish the soils with Calcium and Magnesium, use of good quality dolomite (having neutralization value above 80%) as liming material would be ideal. To correct acute deficiency of Magnesium, spraying Magnesium sulphate solution (0.5%) to the foliage can be recommended.

Soil application of calcite (Calcium carbonate) and dolomite (Calcium Magnesium carbonate) lime in alternative years can be recommended for ensuring the balanced supply of Calcium and Magnesium to plants.

Foliar spray of Magnesium sulphate (0.5%) can be recommended for the blocks in which soils analyze low (< 10 mg kg^{-1}) for available sulphur content to ensure adequate supply of sulphur to the plants.

Soils of Tamil Nadu coffee areas were found to be well supplied with micronutrients like iron, manganese, copper and zinc. Foliar sprays/ corrective measures suggested in the soil health cards can be adopted if the deficiency of any micronutrient is found in soils. In Tamil Nadu about 32 percent of the soils were found to be deficient in available boron content. The B deficient soils were high in Coonoor, Nilgiri, Dindigul and Salem districts. For soils testing low in available boron content, foliar spray of 0.3% boric acid or 0.5% borax will be beneficial.

Conclusion

Prolonged higher acidity of coffee soils with low level of phosphorus, deficiencies of Calcium, Magnesium, Sulphur and Boron have limitations on coffee productivity in the district. The vast area of coffee in the district is acidic due to lack of liming and continuous use of acid producing fertilizers.

Deficiency of Calcium and Magnesium affects uptake of other nutrients in turn effect cellular functions. In coffee, boron deficiency will affect the productivity by poor flowering and fruit set. Amelioration of soil acidity and optimal use of major, secondary and micronutrients are must to enhance coffee productivity in the district. Based on soil test values, application of manures and fertilizers will save the fertilizers and also sustain the soil health. Integrated management of plant nutrients is essential to achieve sustainable coffee crop production.

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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Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Tamil Nadu

Cultivar / Variety / Breed name: Coffee

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

References

[1] Anonymous (2021) Coffee database.
[2] Bray R.H. and Kurtz L.T. (1945) *Soil Sci*., 59, 39-45.
[3] Gupta U.C. (1967) *Soil Sci*., 103, 424-428.
[4] Jackson M.L. (1973) *Soil chemical analysis. Asia Publication House, New Delhi*, 448.
[5] Lindsay W.L. and Norwell W.A. (1978) *Soil Sci. Am, J*., 42, 421-428.
[6] Walkley A. and Black I.A. (1934) *Soil Sci*., 37, 29-38.
[7] Watanabe F.S. and Olsen S.R. (1965) *Soil Sci. Soc. Am. Proc*., 29, 677-678.