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**Research Article**

# STUDIES ON SOIL FERTILITY STATUS OF COFFEE GROWING REGIONS IN IDUKKI DISTRICT

**SHIVA PRASAD P.*[1], HARIYAPPA N.[2], RAJIB PATI[4], NAGARAJA J.S.[2], CHANDRASHEKAR N.[3], NADAF S.A.[2], HAREESH S.B.[2], VENKATESH D.H.[5] AND SUJATHA K.[5]**
[1]Coffee Research Sub Station, Chettalli, Kodagu District, Karnataka, 571248, India
[2]Central Coffee Research Institute, Chikamagalur, 577 117, Karnataka, India
[3]Regional Coffee Research Station, Narasipatnam, Andhra Pradesh, 531133, India
[4]Regional Coffee Research Station, Thandigudi, Tamilnadu, 624216, India
[5]Regional Centre, ICAR-National Bureau of Soil Survey & Land Use Planning, Bengaluru, Karnataka, 560024, India
*Corresponding Author: Email - shivaprasadccri@gmail.com

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**Abstract:** Soil test based nutrition management will help to use chemical fertilizers prudently, thereby improving fertilizer use efficiency which in turn preserves the environmental quality along with sustainable crop production. To evaluate the fertility of the soils of coffee in Idukki district, systematic soil sampling representing the entire coffee growing areas of the district was carried out. In order to know the fertility status of the soil this study was carried out and observed that prolonged higher acidity (98%) of coffee soils with deficiencies of phosphorus (42%), calcium (39%), magnesium (88%), sulphur (39%) and boron (39%) have limitations on coffee productivity in the district. The vast area of coffee in the district is strongly acidic (67%) 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.

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

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## Introduction

Idukki district was formed on 26 January 1972 and is situated between 76º37'11'' and 77º25'38'' east longitudes and 9º15'28'' and 10º21'22'' north latitudes. The district has altitude varying from 600 to 2,000 meters above mean sea level (MSL) and an area of 5,105 km2. It is the second largest district of Kerala occupied by Western Ghats, covering nearly fifty percent of the district. Districts of Kerala, namely, Pathanamthitta to the south, Kottayam to the southwest, Ernakulum to the northwest and Thrissur to the north and Coimbatore, Dindigul and Theni districts of Tamil Nadu to the east, border Idukki dsitrict. Coffee, cardamom, pepper, rubber, coconut, banana, tapioca and other plantation crops are the major crops grown in Iddukki district. Area under coffee in Idukki district is 13,230 hectares [1] out of which arabica is cultivated in 2,143 hectares and robusta is cultivated in 11,087 hectares. Total production of coffee is 8,040 metric tons and contribution of arabica is 990 tons and of robusta it is 7,050 tons. Soil test based nutrition management will help to use chemical fertilizers prudently, thereby improving fertilizer use efficiency which in turn preserves the environmental quality along with sustainable crop production. To evaluate the fertility of the soils of coffee in Idukki district, systematic soil sampling representing the entire coffee growing areas of the district was carried out. A total of 264 composite soil samples were collected from the three taluks of Idukki district namely, Udumbanchola (116 soil samples), Devikulam (54 soil samples) and Peerumedu (94 soil samples). Soil samples were analyzed for soil reaction, organic carbon, available phosphorus, potassium, exchangeable calcium, magnesium, available sulphur, iron, manganese, copper, zinc and boron contents by following standard procedures. The soil fertility data so generated were utilized to draw inference on the fertility status and to generate soil health cards for the benefit of coffee growers. Discussions and interpretations pertaining to fertility parameters other than EC, available iron and manganese are presented in this chapter as the soil samples collected from Idukki district found to have low electrical conductivity (EC) and also a good status of available iron and manganese [10].

## Materials and methods

The studies envisaged assessment of surface soil fertility of coffee-growing areas in Idukki district. As this study is restricted to assessment of surface soil fertility in Idukki district, 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 Idukki district, number of samples to represent each taluk and village were estimated and a target of about 264 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. A total of 264 samples were collected from three taluks namely Devikulam (54 soil samples), Peermedu (94 soil samples), Udumpanchola (116 soil samples). 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 [10].

## Results and discussion

### Soil Reaction

The soil reaction (pH) of samples collected in Idukki district ranged from 4.1 to 7.0 and lime requirement to correct the soil acidity of these soils ranged from 0.5 to 2.0 tons acre$^{-1}$. Acidic soil reaction was recorded in 98% of the samples tested with 67% of them having strongly acidic pH (5.0 - 5.5), 31 % moderately acidic pH (5.5 - 6.0) and 2% neutral pH (6.5 - 7.3). Further classification of the soils into different classes of pH, namely, extremely acidic (<4.5), strongly acidic (4.5 - 5.0), strongly acidic (5.1 - 5.5), moderately acidic (5.6 - 6.0), slightly acid (6.1 - 6.5) and neutral (6.6 - 7.3) soil reaction is presented in [Fig-1]. Among the three taluks of Idukki district, Devikulam (89%) and Peerumedu (84%) taluks were found to contain larger number of strongly acidic soils [Fig-2]. The high acidity observed in the coffee growing soils of Idukki district is mainly due the high rainfall clubbed with the absence of practice of liming the soils in the district. Thus, there is a need to create awareness among the growers about the importance of liming coffee growing soils regularly to correct the soil acidity and realize better yields.

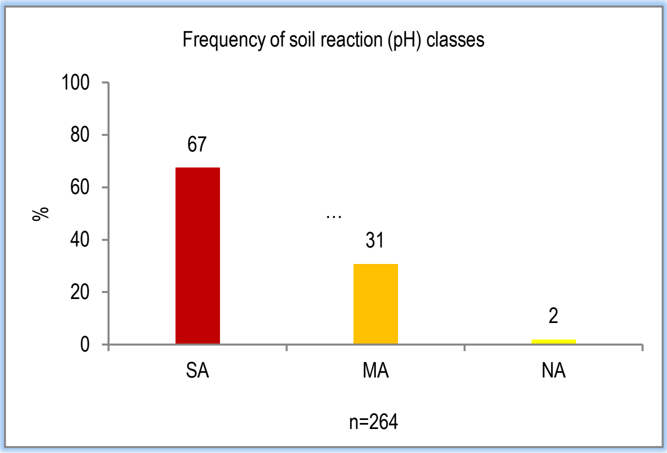


Fig-1 Frequency of soil reaction classes in soils of Idukki district

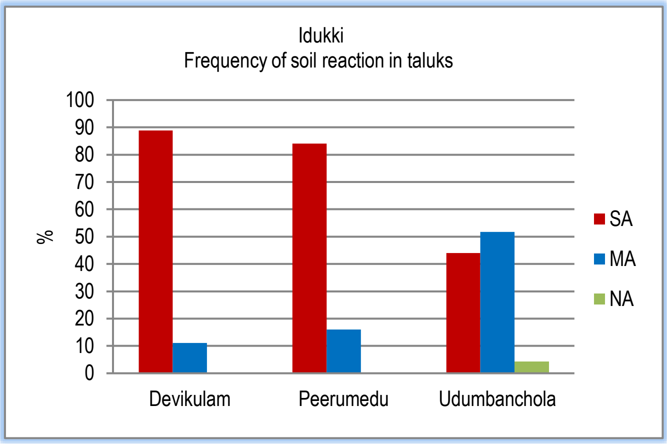


Fig-2 Percent distribution of soils representing different taluks in Idukki district

### Organic carbon content

Assessment of plant available nitrogen in soils through the determination of organic carbon content indicated good status in the Idukki district [Fig-3]. Organic carbon content of the soils ranged from 1.1 to 5.9% in the district. The data representing the soils of taluks indicated that about 77% of soil samples from Udumbanchola taluk, 76% from Devikulam and 73% from Peerumedu taluk have high (>2.5%) organic carbon content. This may be due good shade and the practice of applying organic inputs like farm yard manure or compost to the coffee gardens in Idukki.

### Soil available phosphorus

The analytical data of the soils representing the district indicated that 42% of them contain available phosphorus less than 10 kg ha$^{-1}$ and in 31% of the samples availability of the nutrient ranged from high to extremely high [Fig-4]. In Idukki district available phosphorus ranged from 1 to 461 kg ha$^{-1}$ About 50, 46 and 33 percent of the samples representing the three taluks, *viz*., Peermedu, Devikulam and Udumbanchola respectively were found to be deficient in available phosphorus content [Fig-5] while the remaining samples recorded medium to high available P. The soil available P status of coffee growing soils of Idukki, collected from the soil testing laboratories of the Coffee Board for a period of thirty years indicated a similar trend in which the availability of the nutrient was low in 48%, medium in 28% and high in 24% of soil samples. The soils deficient in available phosphorus need to be supplied with the nutrient by increasing the fertilizer dosage and using suitable nutrient sources. Similarly the fertilizers doses can be reduced for the soils analyzing high and very high availability of the nutrient which will help in reduction in the cost of cultivation besides ensuring balanced nutrient supply. Hence application of lime and fertilizers based on soil test recommendations need to be encouraged in Idukki district to help the growers to use expensive P fertilizers judiciously.

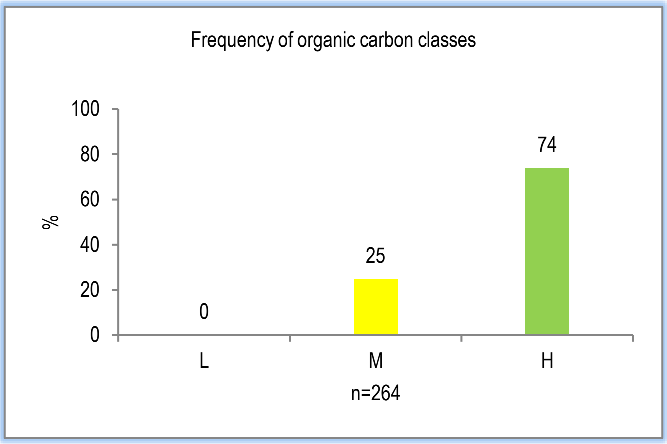


Fig-3 Percent distribution of soils of Idukki under different organic carbon classes

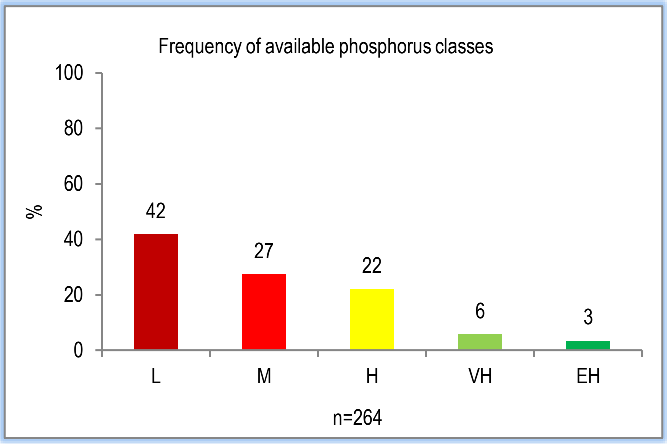


Fig-4 Frequency of available phosphorus classes in soils of Idukki district

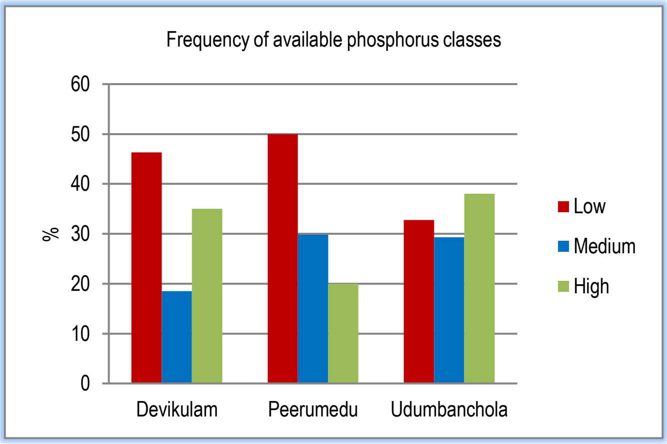


Fig-5 Frequency of available phosphorus classes in soils of taluks in Idukki district

**Available potassium in soils**

The potassium availability in coffee growing soils of Idukki district was found to be good with only one percent of the soils analyzing for low (<125 kg $ha^{-1}$) content of the nutrient [Fig-6]. The available K content of the samples collected from the district ranged from 111 to 1,961 kg $ha^{-1}$. The deficient soils need to be replenished with adequate quantum of K fertilizer and the dose can be reduced for the soils analyzing high available K content. Like nitrogen, potassium also subjected to leaching losses from the soil during heavy rains and application in split doses based on soil test values would help in improving the fertilizer use efficiency. Maintenance of high levels of organic matter and abating soil acidity through liming can improve the fertilizer use efficiency of soils.

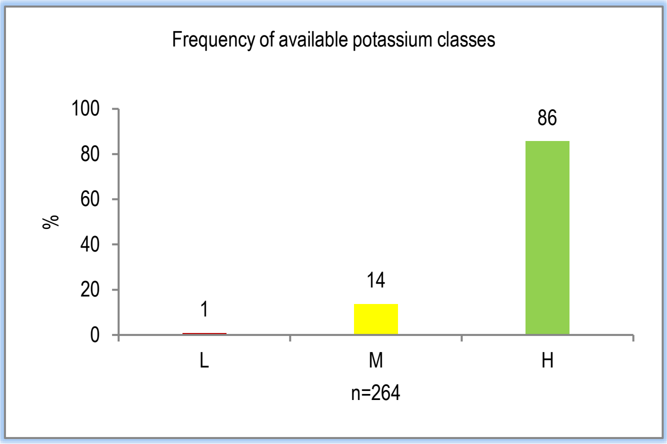


Fig-6 Percent distribution of soils of Idukki under different available potassium classes

**Available calcium in soils**

The available calcium content in the soils of Idukki district ranged from 105.3 to 2,317.6 mg $kg^{-1}$. About 39 percent of the samples of the district were deficient (<600 mg $kg^{-1}$) in calcium [Fig-7]. Among the three taluks, Peermedu was found to have highest (49%), followed by Devikulam (46%) and Udumbanchola (28%) calcium deficient soils [Fig-8]. The deficient soils can be applied with good quality calcite or dolomite lime as per the soil test recommendations to correct the Ca deficiency.

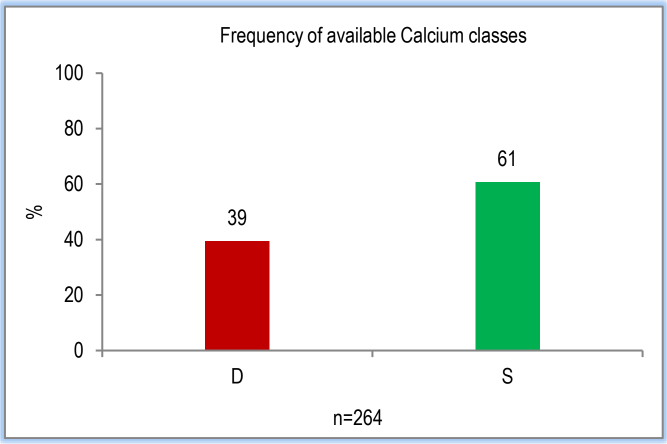


Fig-7 Frequency of available calcium classes in soils of Idukki district

**Available magnesium in soils**

In Idukki district, soil available magnesium ranged from 29.4 to 316.8 mg $kg^{-1}$ and an absolute deficiency of available magnesium was evident in 88 percent of soil samples [Fig-9]. Among the taluks, the available magnesium deficiency was highest [Fig-10] in Devikulam (93%) followed by Udumbanchola (88%) and Peerumedu (86%). To correct the deficiency of Mg dolomite lime stone containing adequate calcium magnesium carbonate (80% neutralization value) can be recommended. The practice of liming the soils to correct soil acidity is hardly seen in the district and it seems to be a reason for the development of acidity in large number of soils. When acute deficiency of available Mg in soils is reported, foliar spray of magnesium sulphate (0.5%) can be recommended to ensure the adequate supply of the nutrient to the plants.

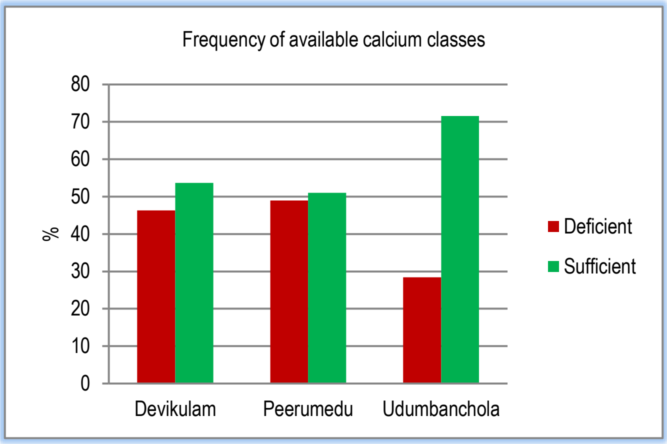


Fig-8 Percent distribution of soils of taluks in Idukki district under available calcium classes

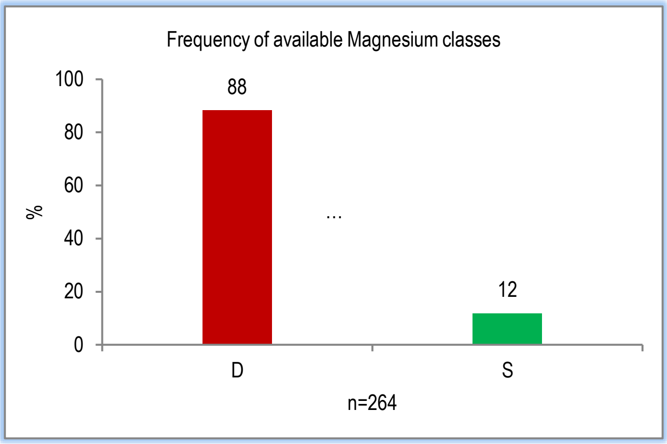


Fig-9 Frequency of available magnesium classes in soils of Idukki district

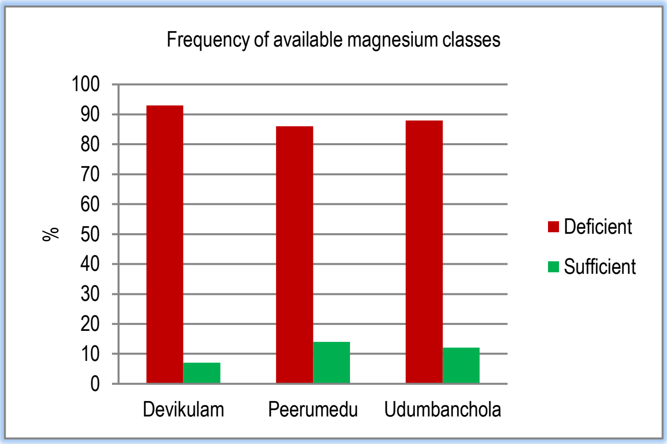


Fig-10 Percent distribution of soils of taluks in Idukki district under available magnesium classes

**Available sulphur in soils**

In Idukki district, soil available sulphur ranged from 2.3 to 75.3 mg $kg^{-1}$ and about 39 percent of the samples analyzed for low (<10 mg $kg^{-1}$) available S content [Fig-11]. Practice of applying S containing fertilizers to coffee gardens seems to be the reason for the sufficiency of available S in 61% of the soils representing the district. However, retention of S in soils is not possible as in the case of P since the soluble sulphate form is subjected to leaching losses. Peerumedu taluk was found to have highest (71%) number of soils deficient in available sulphur followed by Devikulam (31%) and Udumbanchola (16%). The frequency of available sulphur classes corresponding to the soils collected from each taluk is depicted in

[Fig-12]. Sulphur deficiency can be overcome by the application of sulphur containing fertilizers like ammonium phosphate sulphate, magnesium sulphate and elemental S etc. Foliar spray of magnesium sulphate (0.5%) also can help to overcome the deficiency of sulphur.

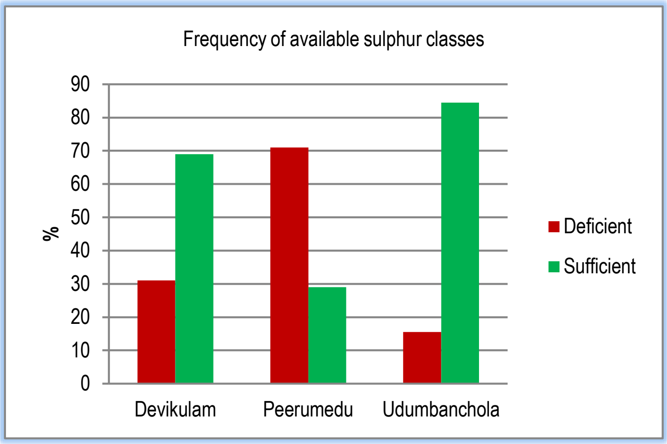


Fig-12 Distribution of soils representing taluks of Idukki under available sulphur classes

**Available copper in soils**

The soil available Cu status in the Idukki district was good [Fig-13] and the content ranged from 0.5 to 42.2 mg $kg^{-1}$. Diversification of coffee gardens with crops like areca and pepper is common in Idukki. Use of copper containing fungicides is a regular practice adopted by farmers to control fungal diseases of these crops and hence the deficiency of available copper occurs very rarely in the soils of Idukki.

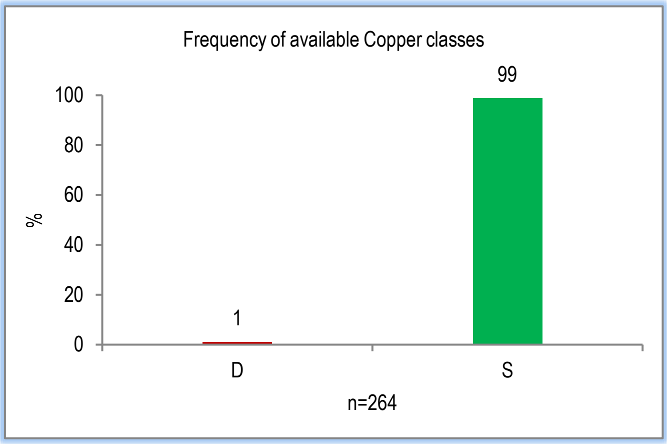


Fig-13 Frequency of available copper classes in soils of Idukki district

**Available zinc in soils**

Soil fertility status of Idukki with respect to available zinc was good [Fig-14] with 92 percent samples analyzing for sufficiency (> 1 mg $kg^{-1}$) of the nutrient. The available zinc in these soils ranged from 0.3 to 20.0 mg $kg^{-1}$. Among the 3 taluks of the district, deficiency of available zinc was lowest (6%) in Udumbanchola taluk and highest (11%) in soils of Devikulam. The element often occurs as a contaminant in phosphatic fertilizers, including rock phosphate. High input of phosphatic fertilizers seems to have resulted in adequate level of zinc in soils. Deficiency of zinc can be overcome through foliar application of properly neutralized 0.25 percent zinc sulphate solution.

**Available boron in soils**

Available boron content in soils of Idukki district ranged from 0.02 to 1.43 mg $kg^{-1}$ and 39% of the samples recorded availability of the nutrient below the critical limit of 0.5 mg $kg^{-1}$ [Fig-15]. Analysis of data of the samples representing each taluk [Fig-16] indicated that the deficiency of the nutrient is highest (45%) in soils of Udumbanchola taluk followed by Devikulam (41%) and Peerumedu taluk (30%). Soil application of boron is not recommended due to the antagonistic relationship with phosphorus. To correct the deficiency of boron, foliar application of 0.3% boric acid or 0.5% borax is suggested.

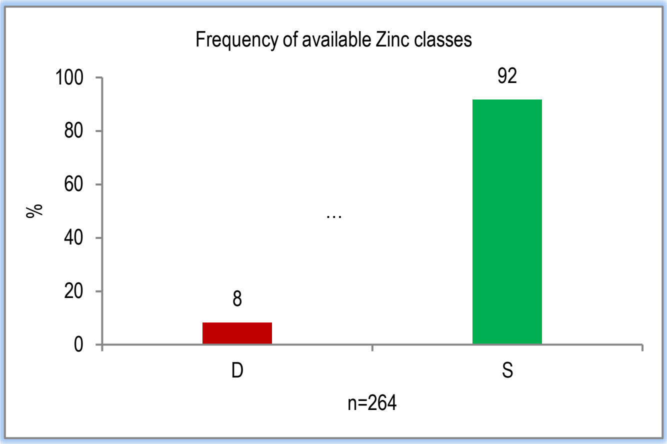


Fig-14 Frequency of available zinc classes in soils of Idukki district

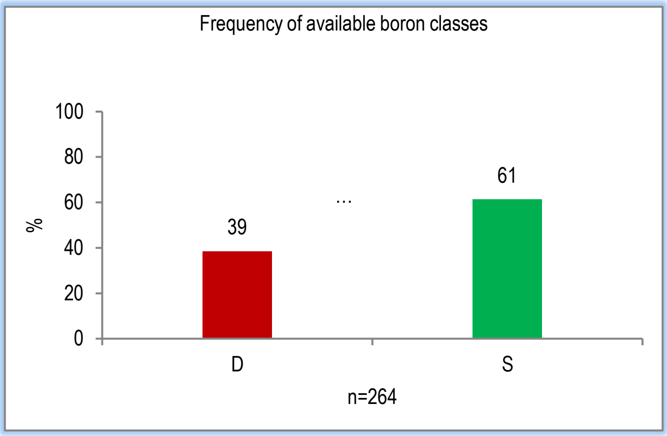


Fig-15 Frequency of available boron classes in soils of Idukki district

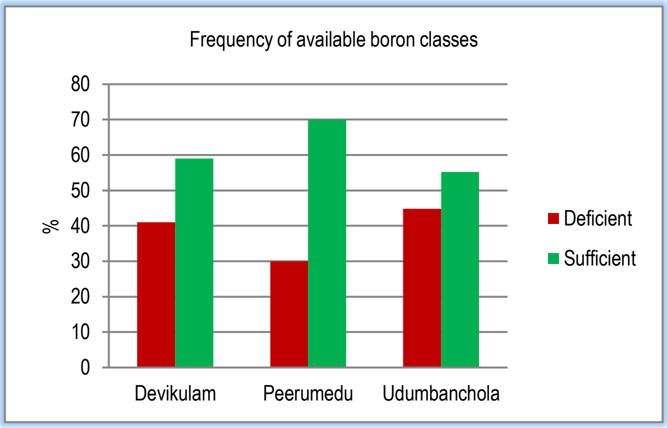


Fig-16 Distribution of soils representing taluks of Idukki under available boron classes

**Discussion**

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.

**Recommendations on soil fertility management**

Soil acidity is a serious problem in Idukki district with 98 percent of the soils being acidic in reaction. Hence soil test based liming programme needs to be popularized among the growers to correct the soil acidity and improve the production / productivity of coffee.

Organic carbon status of majority of the soils cropped to coffee is fairly good. Application of 5 kg of compost / farm yard manure/organic manure per plant is recommended to improve the condition of soils recording low (<1 %) organic carbon content.

Available phosphorus content is low in about 42 percent of the soils. To overcome the problem, application of higher P doses using suitable P sources can be suggested based on the soil test values.

For the soils reporting high P build up, reduction in P fertilizer doses is recommended to provide balanced nutrients to plants and achieve sustainable yields.

Large number of samples (99%) representing Idukki were found to contain good available K status. Increase in K fertilizer dose can be suggested to the soils analyzing low available K to ensure adequate supply of the nutrient to the plants.

To improve the fertilizer use efficiency of the low activity clay soils that are cropped to coffee, application of specified quantities of nitrogen and potassium fertilizers in as many splits as feasible can be adopted.

About 39 percent of soil samples in Idukki district are deficient in available calcium. Application of calcite (calcium carbonate) lime is recommended to correct the deficiency.

Extensive deficiency (88%) of available magnesium is observed in soils of Idukki district. Application of good quality dolomite lime is recommended in magnesium deficient areas. To correct the acute deficiency of magnesium, foliar spray of 0.5 percent magnesium sulphate is suggested.

For balanced supply of calcium and magnesium to soils, application of calcite (calcium carbonate) and dolomite (calcium magnesium carbonate) lime in alternative years is recommended.

About 39 percent of soil samples of Idukki district analyzed low available sulphur content. Foliar spray of 0.5% magnesium sulphate is suggested to ensure the supply of sulphur to coffee planted in S deficient soils.

The soils of Idukki district are found to be well supplied with the micronutrients like iron and manganese. Foliar sprays/ corrective measures suggested in the soil health cards can be adopted when such deficiency is reported in the soil test.

The deficiency of available copper in soils of Idukki was negligible. Foliar spray of properly neutralized copper sulphate solution (0.5%) can be recommended as corrective measure when deficiency of copper is reported in soil test.

The available zinc deficiency is insignificant in soils of Idukki district. Foliar spray of properly neutralized zinc sulphate solution (0.25%) can be recommended while soil tests indicate the deficiency of zinc.

Available boron is deficient in about 39 percent of coffee growing soils of the district. To provide adequate B supply to the plants in deficient soils, foliar spray of 0.3% boric acid or 0.5% borax is suggested.

To conserve the fertile top soil in established plantations certain farm operations like scraping, scuffling and cover digging that disturb thetop soil need to be abandoned. Loss of fertile top soil can prove to be a major constraint in sustaining crop production.

**Application of research** This research has enabled us to identify the deficient and excess nutrients and thereby have recommended remedy along with fertilizer dosage for coffee.

**Research Category** Coffee soil science and chemistry

**Abbreviations**

NBSS & LUP : National Bureau of soil science and land use planning
mg $kg^{-1}$ : milligram per kilogram
kg $ha^{-1}$ : kilogram per hectare
pH : soil reaction

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***Principle Investigator or Research Guide: Dr P Shiva Prasad**
Institute: Coffee Research Sub Station, Chettalli, Kodagu District, Karnataka, 571248, India
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**Author Contributions: All author equally contributed**

**Author statement:** All authors read, reviewed, agree and approved the final manuscript

**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.

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