Research Article

Impact of Organic and Integrated Nutrient Management Practices on Available Secondary Nutrients Status of Soils Cropped to Robusta Coffee

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Abstract
In India, Coffee occupies a pride position amongst plantation crops grown and contributing substantial foreign exchange to the national exchequer. Coffee is a source of direct employment for about 0.5 million people in the area of cultivation (Anonymous, 2005) and equivalent volumes in the processing and trade sectors. For balanced nutrient management in coffee the secondary nutrients such as sulphur (S), calcium (Ca) and magnesium (Mg) play a vital role in numerous biochemical activities which intern serves as prerequisites for the growth and sustainable coffee production. Present study on soil secondary nutrient status revealed that, the INM mode resulted in higher availability of all the essential secondary nutrients compared to exclusive organic mode of nutrition. The most favorable soil reaction prevailed in the soils under INM mode of nutrition compared to organics.

Keywords: Robusta Coffee, available secondary nutrients, organic and integrated nutrient management (INM)

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Introduction

Soil fertility is the inherent property of the soil to support crop development, which is determined by the entire spectrum of physical, chemical and biological attributes. Recent trends indicate that productivity and fertility of soils are globally declining due to degradation and intensive use of soils without consideration of proper soil-management practices [1]. Integrated forms of organics and inorganics play a vital role considering the present-day deterioration of soil fertility and cost of chemical fertilizers. With increasing emphasis on management practices to enhance productivity of coffee crop, fertilization on soils is inevitable. The availability of soil nutrients depends on many factors, which include the parent material from which the soil is derived, fixation and immobilization of nutrients, leaching of nutrients under high rainfall conditions and nutrient imbalances as a result of unscientific way of fertilizer application to the crops. The available nutrient portion is that part of the total nutrient pool, which is readily accessed by the plants, whereas the remaining portion is not immediately available but utilized over a long period of time. The total nutrient status is a reserved form of nutrients which will be transformed into labile or utilizable fraction based on the plant demand and the prevailing environmental conditions. Coffee being a perennial crop, the plant has the dual role of maturing the present crop besides producing fresh cropping wood for the succeeding years. The advantages of organic and inorganic nutrient management systems need to be integrated to make optimum use of each type of nutrition to achieve balanced nutrient management for optimum crop response with enhanced production and productivity. In India, coffee is grown under mixed shade. Deep-rooted shade trees will render nutrients available from the subsoil in the form of leaf litter decomposition. Rainfall pattern decides the crop production at field conditions, if blossom rains are delayed beyond April, then the production of coffee would be hampered. In coffee, irrigation is a mainly used as an insurance against failure of adequate blossom and backing showers and for overcoming long drought periods. The coffee growing soils in Karnataka are highly weathered with higher clay content having low base and silica owing to pronounced leaching. The major limitations posed by these soils include deficiency of Sulphur (S), Calcium (Ca), Magnesium (Mg), Zinc (Zn) and Boron (B) with extreme acidity coupled with toxicity of Aluminium (Al) and Manganese (Mn). In acid soils not the soil pH per se, but the surplus of micronutrients, aluminium, dearth of secondary nutrients and the imbalance in action/anion uptake is hampering plant growth [2]. Calcium availability and its uptake by plants are influenced by the ratios between calcium and other cations in soil solution [3]. The availability of soil organic S depends primarily on its mineralization. This in turn depends on climatic factors such as temperature and moisture [4], which affect the rate of mineralization as well as the chemical nature of the soil organic S itself [13]. Coffee is sensitive to soil quality and more nutrients are removed annually by the harvested products in comparison to other tree crops like Cocoa and Tea [5].

Materials and Methods

Current field experiments were conducted in selected Robusta coffee estates of Koppa region, Chikkamagaluru District, Karnataka state, India. Among the estates, four estates practice organic mode of nutrition, while four estates follow integrated nutrition management practice and one estate where no nutrition management is practiced (absolute control). Varying shade pattern (open and thick) and irrigation (blossom, backing and winter) are the differentiation factors in the selected estates practicing exclusive organic cultivation and integrated nutrient management. The experiment was laid out in randomized block design (RBD) with 25 plants per treatment (plot size- 112 m^2) with four replications. The selected estates under organic cultivation were practicing organic farming since preceding four years. The other cultural practices were carried out as per the package of practices [6]. The treatment details are as follows

- **T1**- Control
- **T2**-Organic nutrition*, thick shade (TS-50 to60% canopy) + Irrigation **-** I (winter)
- **T3 -** Organic nutrition*, thick shade (TS-50 to 60% canopy) + Irrigation -II (Blossom &Backing)
- **T4**-Organic nutrition*, optimum shade (OS-25 to 30% canopy) + Irrigation - II (Blossom & Backing)
- **T5-** Organic nutrition*, optimum shade (OS-25 to 30% canopy) + Irrigation - I (winter)
- **T6**– INM#, thick shade (TS -50 to 60% canopy) + Irrigation - I (winter)
- **T7**- INM#, thick shade (TS -50 to 60% canopy) + Irrigation (Blossom & Backing) - II
- **T8-** INM#, optimum shade (OS-25 to 30% canopy) + Irrigation – II (Blossom & Backing)
- **T9**- INM#, optimum shade (OS-25 to 30% canopy) + Irrigation - I (winter)
- **Organic nutrition-**100% organics [Farmyard Manure and Compost -2.5 tones ha^{-1}, Rock phosphate 0.2 tones ha^{-1}],
- # **Integrated nutrition** [50% recommended dose of fertilizer [7] + 50% organic manures]
- **Winter-irrigation (I):** At least four irrigations at winter, blossoming, backing and summer (interval of twenty days), extended if dry spell continuous
- **Blossom backing irrigation (II):** Irrigations at blossoming and backing periods

Soil Sample Analysis

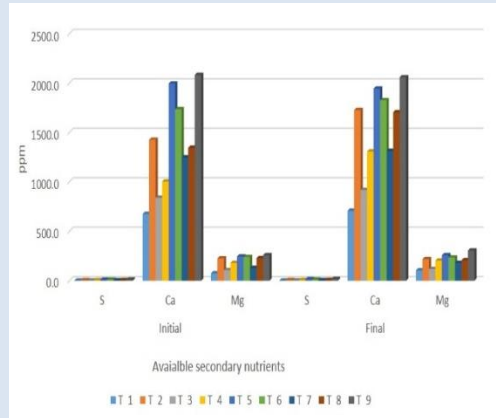
To know the soil fertility status, soil samples were collected during pre-monsoon (March-April) and post-monsoon season (Sept-Oct) at the depth of 0-22.5cm from the experimental blocks. The samples were dried under shade, powdered to pass through 2 mm sieve and stored in clean polythene bags. The soil properties were then determined by adopting standard methods of analysis. Available secondary nutrient S was analysed by using Turbidimetric method and Ca, Mg are analysed by using Atomic Absorption Spectrophotometer (GBC-932AA) as described by Jackson [8] (1973). The analytical data was subjected to appropriate statistical analysis as suggested by Gomez and Gomez [9] (1984) to draw valid inferences.

Results and Discussion

In prevailing changing climatic scenario, it has become necessary to assess the secondary nutrient status in soils as they are of fundamental importance to plants growth and productivity. In recent years, several nutrient deficiencies and toxicities have been observed on coffee in India, adding importance to the study of micronutrients in the coffee soils of South India [10]. Sulphur occurs in organic as well as inorganic forms in soils, while bulk (>95%) of it is associated with organic fractions. It is generally accepted that S is taken up by plants in sulphate form. The nutrient cultures experiments indicate that plant utilize predominantly the organic S [11]. However, availability of soil organic S depends primarily on the mineralization processes. This in turn depends on climatic factors such as temperature and moisture [12], which affect the rate of mineralization as well as the chemical nature of the soil organic S compounds [13]. The highest available S noticed in the treatment which received INM mode of nutrition with open shade and winter irrigation was owing to adequate organic matter coupled with the conditions feasible for transformation like favourable temperature and moisture. The analytical data is presented in **Table 1**.

Table 1 The impact of organic and integrated nutrition on available secondary nutrient contents

Treatments	Initial			Final		
	S (ppm)	**Ca (ppm)**	**Mg (ppm)**	**S (ppm)**	**Ca (ppm)**	**Mg (ppm)**
T 1	1.5	675.0	75.0	1.8	708.0	104.7
T 2	5.9	1425.0	225.5	6.9	1726.0	218.0
T 3	2.7	839.0	107.0	3.5	918.0	118.8
T 4	5.3	1003.0	179.5	6.5	1307.0	203.9
T 5	10.2	1993.0	245.0	15.1	1943.0	257.8
T 6	9.8	1735.0	239.3	10.9	1825.0	234.4
T 7	4.9	1247.0	129.5	5.3	1313.0	179.8
T 8	6.1	1344.0	227.7	7.6	1703.0	207.8
T 9	11.7	2080.0	257.8	17.4	2057.0	305.0
Sem +/-	0.14	3.65	1.37	0.1	5.879	2.22
CD at 5%	0.28	7.5	2.82	0.21	12.08	4.57



Calcium is another important secondary nutrient required for plant growth and development. The role of Ca in maintaining soil reaction in near neutral range by suppression of Al activity besides creation of favourable soil structure is of immense importance. In general, the available Ca in soil ranged from 675 to 2080 ppm in different treatments under consideration. The lowest (675 ppm) was observed in case of absolute control where neither organics nor INM was deployed and was totally deprived of irrigation under open shade. Further, both control (675 ppm) as well as in T3 (839 pm) with organic nutrition, under thick shade and blossom and backing irrigation recorded lower availability compared to the optimum (1000 ppm) required for growth and development. On the contrary, the highest (2080 ppm) was observed in T9 when INM mode of nutrition with open shade and winter irrigation was practiced. On the whole comparisons made between organics and INM practices revealed significant difference in available calcium contents. The mean of the treatments under INM revealed higher (1602 ppm) available Ca compared to those under exclusive organics (1315 ppm). The performance of shade and irrigation under different modes of nutrition resulted in versatile results. In general, available Ca in soil was more (1605 ppm) under open shade compared to thick shade (1312 ppm) irrespective nutrition mode as well as irrigation. Similarly, winter irrigation resulted in higher (1808 ppm) availability of Ca compared to that of blossom and backing irrigation (1108 ppm). Nutrients in soil are strongly affected by soil pH due to reactions with soil particle constituents and other nutrients [14]. Magnesium nutrition is extremely critical in acid soils cropped to coffee. The susceptibility of Mg ion to leaching renders its deficiency in these soils. The concentration of Mg in various treatments varied from 75 to 258 ppm under different modes of nutrition, shade pattern and irrigation schedules. In all the treatments the available Mg remained lower than the optimum (375 ppm) required for normal growth and development. The highest (258 ppm) available Mg was noticed in the treatment which received INM mode of nutrition with open shade and winter irrigation, while the lowest (75 ppm) was observed in the control. The higher availability (214 ppm) of Mg in INM mode over exclusive organics (189 ppm) may be correlated with higher organic matter accumulation besides congenial pH for mineralization. The open shade revealed higher (228 ppm) Mg compared to the soils under thick shade (175 ppm) indicating favourable mineralization process in the former case. Similarly, winter irrigations resulted in higher (242 ppm) Mg recovery compared to blossom and backing irrigation (161 ppm) owing to availability of adequate moisture during dry periods. Similar findings were also reported by Taiz and Zeiger [14] (2002) where, warm temperature and adequate moisture promotes the weathering of rocks that releases Ca^{2+} and Mg^{2+} increases the solubility of carbonates, sulphates, and phosphates. Further, increasing the solubility of nutrients from the organic matter also facilitates nutrient availability to plants roots. However, future line of studies related to micronutrients status will provide beneficial information on sustainable eco-friendly coffee production over the years to come.

Conclusion

Nutrient replenishment either through organic manures or chemical fertilizer means is inevitable to supplement the losses occurred through crop uptake, leaching fixation and volatilization to cope with the plant requirement. The Calcium (Ca) is important secondary nutrient required for plant growth and development, INM treatments resulted in higher Ca content in soil by supplemental liming and in situ organic matter accumulation achieved compared to that of exclusive organics. Magnesium (Mg) nutrition is very critical in acid soils cropped to coffee, since susceptibility of Mg ion to leaching renders its deficiency in these soils. The higher availability (214 ppm) of Mg in INM mode over exclusive organics (189 ppm) may be correlated with higher organic matter accumulation besides congenial pH for mineralization. Therefore, by considering secondary nutrient status of soil INM mode is recommended for sustainable coffee production.

References

[1] Gruhn, P. Goletti, F., Yudelman, M. 2000. Integrated Nutrient Management, Soil Fertility and Sustainable Agriculture: Current Issues and Future Challenges; IFRPI 2020 Vision Brief; IFRPI: Washington, DC, USA.

[2] Marschner, H. 1995. Mineral Nutrition of Higher Plants. 2nd edition, Academic Press, San Diego, USA.

[3] Samuel L. Tisdale., Werner L. Nelson and James D. Beaton. 1985. In: Soil fertility and fertilizers. Macmillan Publishing Company, New York.

[4] Williams, C. H. 1967. Some factors affecting the mineralization of organic sulphur in soils. Plant and Soil, 26: 205-223.

[5] Anonymous, 1989. Agricultural Compendium for Rural Development in the Tropics and Subtropics. Amsterdam: Elsevier Science Publishers BV.

[6] Anonymous. 2003. Coffee guide, Published by Coffee Board, India.

[7] Anonymous. 2004. Coffee guide, Published by Coffee Board, India.

[8] Jackson, M.L. 1973. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi, 498.

[9] Gomez, K.A and Gomez, A.A (eds). 1984. Two factor experiments In: Statistical Procedure for Agricultural Research. New York. Wiley.

[10] Iyengar, B V. 1971. Fertilizer Needs of Coffee in India, Indian Coffee, XXXV, NO. 11. 449-452.

[11] Bardsley, C.E. 1960. Absorption of sulphur from organic and inorganic sources by bush beans. Agron.J.52:485-486.

[12] Williams, C. H. 1967. Some factors affecting the mineralization of organic sulphur in soils. Plant and Soil, 26: 205-223.

[13] Page, A.L., Miller, R.H and Keeny, D.R. 1982. Methods of soil analysis. Part 2. Chemical and microbiological properties - second edition. American Society of agronomy, Inc and Soil Science Society of America, Inc. 9 (2). 313-314.

[14] Taiz, L and Zeiger, E. 2002. Plant physiology, 3rd edn. Sinaeur Associates, Inc, Sunderland.

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