Chemical Science Review and Letters ISSN 2278-6783

www.chesci.com Research Article

Total Protein and Free Amino Acids Constituents of Green Robusta Coffee (*Coffea canephora var. sln.274*) Beans Produced by Organic and Integrated Nutrient Management Practices

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Abstract

Proteins and amino acids are important components of coffee aroma, primarily because of the association between amino acids and carbohydrates. Consequently, these biochemical constituents of bean will attribute to the quality, final flavor, and aroma of coffee. Nutrient management, cultivation techniques and processing at the field and industry levels all have an impact on the synthesis of various chemical elements in coffee beans. It is well known that the application of fertilizers in crop production affects the composition of plant material. However, several reviews of studies in coffee on comparing the nutritional quality of organic and conventional produce were inconclusive. Modern management practices are implementing meticulously chosen high yielding varieties, optimum utilization of external agrochemical inputs, irrigation facilities and intensive shade management for sustainable coffee production. Meanwhile, coffee agroforestry production systems have potential to boost farmer profits and mitigate the effects of climate change. In order to increase plant productivity Integrated Nutrient Management (INM) is essential. In light of this, the current study is being carried out in nine Robusta coffee estates in the Koppa region, each with a different irrigation schedule, shading patterns, and methods of nutrition management (organic and INM).

Representative ripened coffee fruit samples were collected from all treatments and processed by parchment method. The biochemical chemical properties in green coffee beans were determined by adopting the standard methods. The analytical data is revealed that, the bean total protein content was significantly higher (4.9%) in INM mode of nutrition compared to that of exclusive organics (4.1%). Within INM mode of nutrition, the shade pattern and irrigation schedule imparted difference in protein content. The open shade resulted in slightly elevated (5.1%) bean protein compared to thick shade (4.6%). Within organic nutrition, open shade resulted in slightly elevated (4.2%) bean protein compared to thick shade (3.9%). However, the concentration of free amino acids remained unaltered irrespective of nutrition mode and shade pattern. In the meantime, higher amount (0.8%) observed over control (0.4%).

Keywords: Protein, Amino acids, green coffee beans, organic and integrated nutrition management

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Introduction

Coffee is a vital export-oriented agricultural commodity cultivated in India. Indian coffees are esteemed globally for their unique quality. Coffee is a perennial plant of the Rubiaceae family and one of the most widely consumed on-alcoholic beverages globally. Currently green coffee beans are produced in more than 70 countries worldwide [1]. The *Coffea canephora* (Robusta) is one of the most cultivated varieties for commercial production, accounting for about 40% of the world coffee market and most widely consumed beverage crops globally [2]. The quality of coffee is influenced by its cultivars, geographical origin, and climatic factors, including altitude temperature, nutrients, and soil composition. Recently, the increasing awareness of the significance of green coffee beans for potential health benefits has garnered considerable interest due to their unique composition and qualities [3]. Concentrations of minerals, secondary metabolites, and micronutrients can be utilized to assess crop quality. The chemical constituents in coffee significantly influence the beverage's quality, contributing to the aroma of roasted coffee. Proteins constitute the major nitrogen reserve in the coffee seeds, representing approximately 60 % of the total nitrogen [4]. Meanwhile, it is reported that coffee protein has high levels of branched-chain amino acids, which are beneficial for recovering from malnutrition and sports nutrition [5]. Proteins and amino acids are believed to affect coffee quality and aroma development due to their interaction with sugars during roasting via the Maillard reaction. Amino acids, proteins, and other nutrients are

among the many components found in coffee beans. Hence, nutrient management in the soil can have an impact on the coffee's quality.

In India, the usage of organic manures (such as farmyard manure, compost, and green manure) is the traditional and most prevalent method for nutrient replenishment. Organic manures play a crucial function in nutrient provision while enhancing soil physico-chemical characteristics and overall soil health. The unfavourable nutritional balance resulting from the exclusive use of organic manures is apparent in coffee plant cultivation. At this juncture, integrated nutrient management can provide a favourable nutrient balance for sustained coffee production. Previously, numerous studies have concluded that, integrating organic and inorganic fertilizers is competitive in terms of growth and economic returns for crops. Although the nutrient cycling processes in soils treated conventionally and organically are similar, by adopting integrated nutrient management (INM) balanced and sufficient levels of plant nutrient availability and sustainable coffee yield can be achieved [6]. In view of above, present study was conducted to know the Protein and amino acids components of Green Robusta Coffee (*Coffea canephora var. Sln.274*) beans cultivated by organic and INM practices.

Materials and Methods

Study Location

This field experiment was carried out at nine selected robusta coffee estates located at Western Ghats of India, i.e., Koppa region of Chikkamagaluru District, Chikkamagaluru district is situated in the south western part of Karnataka State, between 12º 54′ and 13º 53′ north latitude and between 75º 04′ and 76º 21′ east longitudes. 2,509 m above sea level. The climate in study location is having three distinct seasons; 1) Summer season - March to early June, 2) Monsoon season – early June to September, however very less rainfall occurs during October to November due to impact North East Monsoon, 3) winter season initiates in mid-November and ends in mid-February. Among the selected 9 coffee 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 [7]. The analytical data was subjected to appropriate statistical analysis as suggested by Gomez and Gomez (1984) to draw valid inferences. The treatment details of present field experiment are as follows:

T1- Control
T2 - Organic nutrition*, thick shade (TS - 50 to 60% canopy) + Irrigation - I
T3 - Organic nutrition*, thick shade (TS - 50 to 60% canopy) + Irrigation -II
T4 - Organic nutrition*, optimum shade (OS - 25 to 30% canopy) + Irrigation - II
T5 - Organic nutrition*, optimum shade (OS - 25 to 30% canopy) + Irrigation - I
T6 – INM#, thick shade (TS - 50 to 60% canopy) + Irrigation - I
T7 - INM#, thick shade (TS - 50 to 60% canopy) + Irrigation - II
T8 - INM#, optimum shade (OS - 25 to 30% canopy) + Irrigation – II
T9 - INM#, optimum shade (OS - 25 to 30% canopy) + Irrigation - I
***Organic nutrition** -100% organics [Farm Yard Manure and Compost -2.5 tones ha^{-1}, Rock phosphate 0.2 tones ha^{-1}],
INM [50% recommended dose of fertilizer (Anonymous, 2003) + 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

Experimental Design and sample collection

The experiment was laid out in randomized block design (RBD) with 25 plants per treatment (plot size- 112 m^2) with four replications. The organics estates were selected where organic farming practices were practiced in the preceding 4 years. The other cultural practices were carried out as per the package of practices. Fully ripen coffee berries were harvested from the selected estates and dried until a constant weight was reached (moisture 9 to 12 %) after being passed through the wet processing steps. Further, beans were passed through a series of sieves with round perforations of 16, 15 and 14 of an inch and weight fractions retained on each sieve were recorded and converted to weight percentages of the total sample [8]. Total proteins of green coffee beans were extracted by grinding the sample in a mortar with 0.1 N

NaOH and protein content in the bean was analysed by using Folin-Ciocalteau reagent and total free amino acids by Ninhydrin method [7]. The data was subjected to appropriate statistical analysis as suggested by Gomez and Gomez [9] to draw valid inferences. Coffee yield was evaluated by harvesting the entire selected plants (10 plants per treatment per replication) as per standard methods.

Results and Discussion

Coffee quality is multifaceted consequence that is influenced by the presence or variation in primary metabolite concentrations. Previous studies have concluded that, INM mode facilitates higher availability of all the essential nutrients in coffee plantations [10]. In the present investigation, comparison was made between total protein, free amino acid, physical characters of green coffee beans and yield between organic and INM against the backdrop of an absolute control. The biochemical results have revealed that, protein content was significantly higher (4.9%) in INM mode of nutrition compared to that of exclusive organics (4.1%). Within INM mode of nutrition, the shade pattern and irrigation schedule imparted difference in protein content. The open shade resulted in slightly elevated (5.1%) bean protein compared to thick shade (4.6%). Within organic nutrition, open shade resulted in slightly elevated (4.2%) bean protein compared to thick shade (3.9%). However, the concentration of free amino acids remained unaltered irrespective of nutrition mode and shade pattern. Meanwhile, higher amount (0.8%) observed over absolute control (0.4%). Similarly, data of physical properties revealed that, INM nutrition mode favoured good quality bean formation (A grade- 43.2%, B grade- 42.3%, C grade-9.3% with cuts and bits- 5.2%) compared to exclusive organics (A grade- 30.5%, B grade- 45.5%, C grade-16.9% with cuts and bits- 7.1%). This clearly indicated that INM nutrition mode resulted in higher proportion of A and B grade beans with least cuts and bits, while exclusive organics resulted in higher proportion of B grade beans with larger proportion of cuts and bits. The protein and biochemical components of coffee may be enhanced by judicious nutrient management which will also correct the previously existing inadequate level of nutrient availability [11]. The analytical results of total protein and free amino acids are presented in **Table 1** and depicted in **Figure 1** similarly, green coffee bean physical characters (percentage grading) of coffee beans in **Figure 2**.

The average of 2 years yield data (clean coffee kg ha^{-1}) revealed that, highest (1875 kg ha^{-1}) yield was observed in the treatment with INM nutrition mode under open shade and winter irrigation followed by T5 (1790 kg ha^{-1}) where all the things remained constant except a shift in the nutrition pattern from INM to exclusive organics. The hierarchy of yield attributes were nutrition mode were better than organics. The yield data is presented in **Table 2**.

Table 1 Effect of organic and integrated nutrition on robusta coffee bean protein and amino acid composition

Treatments	Proteins (%)	Amino acids (%)
T1- Control	1.9	0.36
T2 - Organic nutrition*, thick shade + Irrigation - I	4.0	0.82
T3 - Organic nutrition*, thick shade + Irrigation -II	3.8	0.78
T4 - Organic nutrition*, optimum shade + Irrigation - II	4.1	0.70
T5 - Organic nutrition*, optimum shade + Irrigation - I	4.3	0.90
T6 – INM#, thick shade + Irrigation - I	4.7	0.88
T7 - INM#, thick shade + Irrigation - II	4.5	0.60
T8 - INM#, optimum shade + Irrigation – II	5.0	0.74
T9 - INM#, optimum shade + Irrigation - I	5.2	0.93
Sem +/-	0.13	0.04
CD at 5%	0.26	0.10

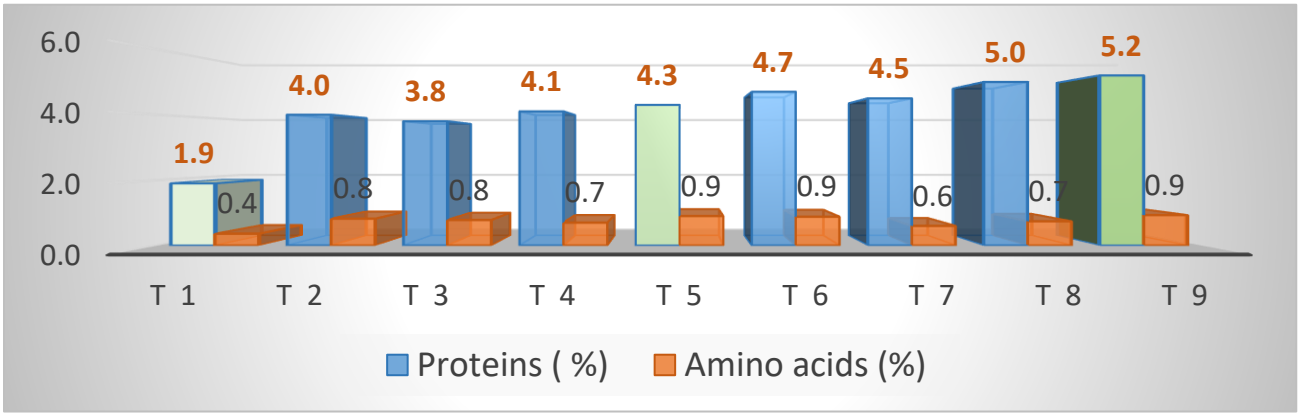

Figure 1 Effect of organic and integrated nutrition on bean protein and free amino acid contents

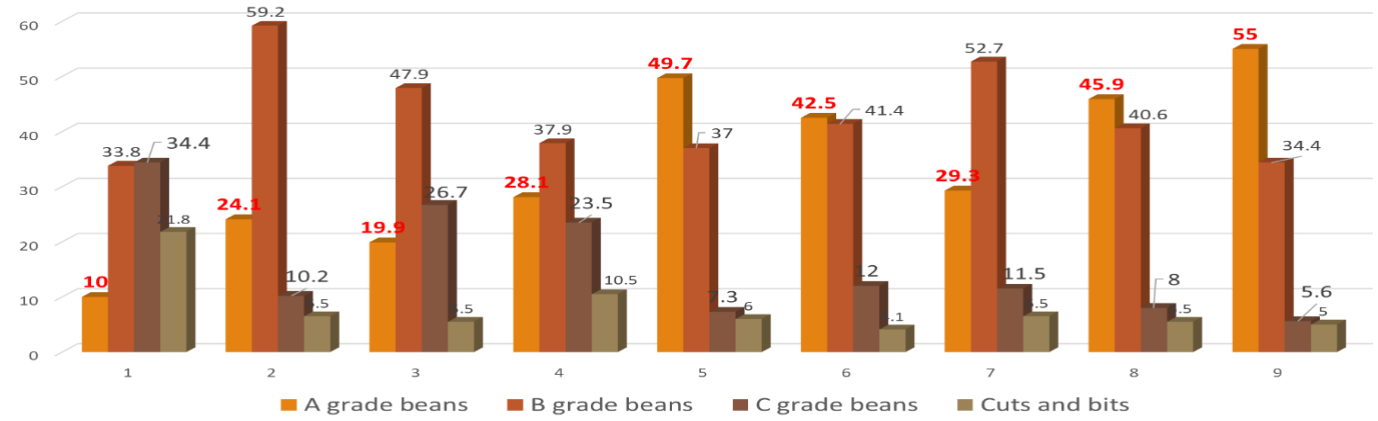

Figure 2 Physical characters (percentage grading) of coffee beans influenced by organic and integrated nutrition with varying shade and irrigation management practices

Table 2 yield (cc kg/ha) of robusta coffee influenced by organic and integrated nutrition with varying shade and irrigation management practices.

Treatments	First yr.	Second yr.	Mean
T 1	340	310	325
T 2	1225	1075	1150
T 3	625	500	562.5
T 4	950	850	900
T 5	1800	1780	1790
T 6	1456	1400	1428
T 7	692	652	672
T 8	990	900	945
T 9	1895	1855	1875
F' test			*
Sem +/-			40.87
CD at 5%			86.24

Conclusion

Integrated nutrient management is found to be superior to exclusive organics in maintaining higher bean protein content, yield and quality of Robusta Coffee. Though, the supply of essential nutrients during growth and developmental periods, INM mode found to be suitable to realize sustained higher production.

Acknowledgement

Authors are thankful to Coffee Board of India for providing all the facilities to carry out this experiment.

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Publication History
Received 02.10.2024
Revised 20.12.2024
Accepted 20.12.2024
Online 29.12.2024