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Effect of organic nutrient sources on yield and economics in tea [*Camellia sinensis* (L.) O. Kuntze]

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Abstract
A field experiment was conducted at the Research Farm of the Department of Tea Husbandry and Technology, CSK HPKV, Palampur (Himachal Pradesh) from March 2021 to November 2021. The objective was to assess the impact of organic nutrient inputs on Tea (*Camellia sinensis* L. O. Kuntze). The experiment included ten treatments, including a control group, FYM (Farm Yard Manure) @ 20 t ha^{-1}, vermicompost @ 10 t ha^{-1}, split doses of vermicompost @ 5 t ha^{-1}+ 5 t ha^{-1}, FYM @ 20 t ha^{-1}+ Jeevamrit @ 10%, vermicompost @ 10 t ha^{-1}+ Jeevamrit @ 10%, FYM @ 20 t ha^{-1} + vermiwash @ 10%, vermicompost @ 10 t ha^{-1}+ vermiwash @ 10%, and Jeevamrit @ 10%. The experiment was designed following a Randomized Block Design (RBD) with three replications. The results showed that the growth, yield attributes, and overall tea yield increased significantly with the application of vermicompost @ 10 t ha^{-1}+ Jeevamrit @ 10%. Furthermore, this treatment exhibited notably higher gross returns, net returns, and additional net returns compared to the control group.

Keywords: Jeevamrit, FYM, vermicompost, vermiwash

1. Introduction

Tea, scientifically known as *Camellia sinensis* (L.) O. Kuntze, belongs to the Theaceae family and stands as one of the oldest and most significant globally consumed beverages (Jigisha *et al*. 2012) [8]. It is derived from the tender shoots of the tea plant, typically composed of two or three leaves and a bud. These shoots are harvested at intervals to produce two main types: 'black' tea (which undergoes withering and fermentation) and 'green' tea (which undergoes withering but remains unfermented). Black tea, processed from the young tender shoot of fresh tea (Muthumani and Kumar, 2007) [9]. Tea plant requires a minimum rainfall of 1200 mm per annum, but 2500 to 3000 mm per annum is considered as an optimum (Hajiboland, 2017) [5]. In cultivation, however, the crop is maintained at 0.6-1.0 m tall to facilitate harvesting of the leaves (de Costa *et al*. 2007) [4]. Tea is the most widely consumed beverage in the world, ranked second after water as the most consumed drink worldwide (Zhen 2002) [16]. Tea is a commercial crop cultivated in more than 60 countries around the world. India holds the position of being the second-largest tea producer globally, following China, with an annual production of 1.4 million tonnes, cultivated over 0.6 million hectares of land (Anonymous 2020-21a) [2]. In India, tea cultivation occurs in 15 states, with Assam, West Bengal, and Kerala being the primary tea-producing regions. The growing popularity of tea is attributed to its rich content of beneficial antioxidants, amino acids, and vitamins. Over the years, the tea industry in India has evolved into a comprehensive million-dollar sector, with projections indicating substantial future growth. As indicated in a study conducted by Expert Market Research, the Indian tea sector is projected to witness a Compound Annual Growth Rate (CAGR) of 4.2% between 2021 and 2026, with the possibility of achieving a production volume of around 1.40 million tons by the conclusion of this timeframe.

The tea industry in Himachal Pradesh has a history of approximately 150 years, dating back to its initiation in 1849 (Verma and Gupta, 2015) [15]. While Himachal Pradesh may not be a significant tea-producing state overall, certain regions within Kangra and Mandi districts have gained recognition for their high-quality tea production since the British colonial era. Despite the relatively limited extent of tea gardens in the state, they serve as a primary source of income for numerous farming families. Unfortunately, over the past few decades, both the area devoted to tea cultivation and its production in the region have been steadily decreasing for various reasons.

The tea produced in the Kangra valley of Himachal Pradesh is renowned for its distinct color and flavor. In recognition of its unique qualities, it was granted Geographical Indication (GI) status under the Goods (Registration and Protection) Act of 1999 in 2005. Himachal Pradesh has a total tea cultivation area of 2310.714 hectares, resulting in a tea production of 11.45 lakh kg (Anonymous 2020-21b) [3]. The tea industry in the state has made a significant contribution to the economy, with an estimated contribution of around 20 crores during the last financial year (2021-22). Tea is of significant importance in Himachal Pradesh as it plays a vital role in the state's economy and agriculture. It also supports rural livelihoods, and contributes to the region's tourism industry. Additionally, the unique Kangra tea variety from Himachal Pradesh is renowned for its quality and flavor, further enhancing its economic value and cultural significance in the state. This industry also provides direct and indirect employment opportunities for approximately 5,000 people in Himachal Pradesh (Anonymous 2020-21c) [1].

The optimum soil conditions recommended for tea growth include a well-drained, deep and well-aerated soil with more than 2% organic matter (de Silva 2007) [4]. The negative effects of chemical fertilizers on complex system of biogeochemical cycles have also been reported by Sharma *et al*. (2014) [12]. To combat such adverse consequences and regain of lost resources is to initiate appropriate remediation measures along with soil enrichment strategies with suitable renewable soil nutrients. (Ipinmoroti *et al*. 2011) [6]. Organic farming, which emphasizes the natural growth of crops without the use of chemical fertilizers, pesticides, or foreign elements, is considered a suitable remediation measure. Organic farming prioritizes natural methods and avoids synthetic chemicals, contributing to soil health and reduced environmental harm compared to conventional farming. It serves as a fundamental solution to reverse the cycle of depletion caused by chemical farming practices. (Singh *et al*. 2011. Qui and Wang, (2014)) [13, 11].

2. Materials and Methods

2.1 Experiment site

The field trial took place at the main campus farm of the Department of Tea Husbandry and Technology, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya in Palampur, India. The experimental location is positioned at an altitude of 1291 meters above sea level, with coordinates at latitude 32°61 N and longitude 76°31 E, nestled within the Palam valley of Himachal Pradesh.

From an agricultural and climatic perspective, this experimental location represents the sub-humid temperate and mid-hill zone of Himachal Pradesh. This region is known for experiencing cool winters from November to February and mild summers from March to June. The annual precipitation varies between 1500 to 2300 mm, with approximately 70-75% of it occurring during the monsoon season from June to September. Winter rainfall typically falls during December to February, while April and May usually have minimal or no rainfall.

2.2 Treatments and experimental design

The experiment was carried out in a randomized block design with 10 different treatments and 3 replications. The experiment comprised of 10 treatments *viz*., (1) control, (2) FYM @ 20t ha^{-1}, (3) vermicompost @ 10 t ha^{-1}, (4) Split doses of FYM @ 10 t ha^{-1} + 10 t ha^{-1}, (5) vermicompost @ 5 t ha^{-1} + 5 t ha^{-1}, (6) FYM @ 20t ha^{-1}+ Jeevamrit @ 10%, (7) Vermicompost @ 10t ha^{-1} + Jeevamrit @ 10%, (8) FYM @ 20t ha^{-1} + vermiwash @ 10%, (9)Vermicompost 10t ha^{-1} + vermiwash @ 10% and (10) Jeevamrit @ 10%.

2.3 Yield analysis

In each plot, a quadrate of 50 cm × 50 cm was placed randomly at three spots. The total numbers of new growth in the form of new emerged shoots was recorded one day before each plucking. After averaging the recorded count, converted it into a value per square meter by multiplying it by a factor of 4.

Five plants from each plot were selected randomly and ten shoots per plant were tagged. Total 50 shoots per plot were plucked for shoot biomass and the fresh weight of the 50 shoots was measured and then average weight per shoot was calculated. For dry weight per shoot, fresh shoots were sun dried for 2 days and then oven dried for 48 hrs. at 60 °C and final dry weight $shoot^{-1}$was calculated by taking average weight.

The two leaf and one bud from each plot were plucked manually. Made tea was prepared from the two leaves and a bud which were plucked from each plot and converted into kg ha^{-1}

3. Results and Discussion

3.1 Number of actively growing shoots per square meter

Data pertaining to the effect of organic nutrient sources on number of growing shoots per square meter have been presented in Table 1. A cursory glance of data revealed that the effect of organic nutrient sources on number of growing shoots per square meter were found to be significant during all three seasons. Irrespective of different treatments, number of actively growing shoots was also influenced by seasonal effect. During the monsoon season, a greater number of growing shoots per square meter were observed, followed by the pre and post monsoon seasons. Among all the treatments, a significantly higher number of growing shoots per square meter were recorded in the treatment involving the application of vermicompost @ 10t/ha and Jeevamrit @ 10%. This result was statistically on par with all other treatments, except for the treatment involving only Jeevamrit @ 10% and the control group (which did not use any organic nutrient source). A similar trend was also observed during the monsoon and post monsoon seasons. The increased number of growing shoots per square meter observed with the application of 10 tons per hectare of vermicompost and Jeevamrit @ 10% could be attributed to the relatively higher quantity of organic matter added. This organic matter likely improved the biological properties of the soil, leading to increased nutrient availability for the crop through mineralization and solubilization processes. Organic matter enriches soil by serving as a nutrient storehouse, guarding against nutrient loss, and aiding in nutrient delivery to plants. It stimulates microbial activity, breaking down organic substances into forms accessible to plants. Moreover, its elevated cation exchange capacity (CEC) enables it to draw in and gradually dispense crucial nutrients, guaranteeing a consistent nutrient source for plant development. These results are in close conformity with Negi *et al* (2017) [10], Islama *et al* (2017) [7].

Table 1: Effect of different organic nutrient sources on number of actively growing shoots per square meter

	Treatments details	No. of actively growing shoots m^{-2}		
		Pre-monsoon season	Monsoon season	Post monsoon season
T_1	Control	183	199	174
T_2	FYM @ 20 t ha^{-1}	201	216	190
T_3	Vermicompost @ 10 t ha^{-1}	208	222	198
T_4	FYM @ 10 tha^{-1} (pre-monsoon season) + @ 10 tha^{-1} (monsoon season)	200	218	193
T_5	Vermicompost @ 5 tha^{-1} (pre-monsoon season) + @ 5 t ha^{-1} (monsoon season)	201	223	200
T_6	FYM @ 20 t ha^{-1} + Jeevamrit @ 10% within 2 day after plucking	207	220	194
T_7	Vermicompost @ 10 t ha^{-1} + Jeevamrit @ 10% within 2 day after plucking	212	228	203
T_8	FYM @ 20 t ha^{-1} + Vermiwash @ 10% within 2 days after plucking	203	219	194
T_9	Vermicompost @ 10 t ha^{-1} + Vermiwash @ 10% within 2 days after plucking	210	226	202
T_{10}	Jeevamrit @ 10% within 2 days after plucking	186	201	177
	S.Em±	5.67	5.91	5.38
	CD (P= 0.05)	16.64	17.35	15.77

3.2 Mean dry shoot biomass (mg shoot^{-1})

The data embodied in Table 2 revealed that the effect of organic nutrient sources on dry shoot biomass (mg/shoot) was found to be significant in all the three seasons. Among all the treatments, the treatment comprising vermicompost @ 10t ha^{-1} + *jeevamrit* @ 10% recorded maximum dry shoot biomass in premonsoon season which was statistically at par with vermicompost @ 10 t ha^{-1} + vermiwash @ 10%. Similar trend was also followed in post monsoon season. Significantly higher dry biomass was recorded with application of vermicompost @ 10tha^{-1} + *jeevamrit* @ 10% in monsoon season which was statistically at par with treatments having vermicompost @ 10tha^{-1}+ vermiwah @ 10%, FYM @ 20 t ha^{-1} + *jeevamrit* @ 10% and FYM @ 20 t ha^{-1}+ vermiwash @ 10%. Dry shoot biomass was higher in treatment vermicompost @ 10 t ha^{-1} + *jeevamrit* @ 10% due to increased microbial activity which might have resulted into steady supply of nutrients, which ultimately increased the dry shoot biomass. Organic matter enhances nutrient availability in soil by acting as a reservoir, preventing nutrient leaching, and facilitating nutrient release to plants. It fosters microbial activity, breaking down organic materials into plant-accessible forms. Additionally, its high cation exchange capacity (CEC) allows it to attract and slowly release essential nutrients, ensuring a steady supply for plant growth. These results are in close conformity with Negi and Bisht (2017) [10].

Table 2: Effect of different organic nutrient sources on mean dry shoot biomass

T. N.	Treatments details	Dry shoot biomass (mg shoot^{-1})		
		Pre-monsoon season	Monsoon season	Post monsoon season
T_1	Control	44.0	45.0	40.0
T_2	FYM @ 20 t ha^{-1}	54.0	53.0	49.0
T_3	Vermicompost @ 10 t ha^{-1}	55.0	54.0	51.0
T_4	FYM @ 10 t ha^{-1} (pre-monsoon season) + @ 10 t ha-1 (monsoon season)	49.0	49.7	45.0
T_5	Vermicompost @ 5 t ha^{-1} (pre-monsoon season) + @ 5 t ha^{-1} (monsoon season)	51.0	51.0	47.0
T_6	FYM @ 20 t ha^{-1} + Jeevamrit @ 10% within 2 day after plucking	58.0	57.0	54.0
T_7	Vermicompost @ 10 t ha^{-1} + Jeevamrit @ 10% within 2 day after plucking	63.0	60.0	58.0
T_8	FYM @ 20 t ha^{-1} + Vermiwash @ 10% within 2 days after plucking	58.0	56.0	53.0
T_9	Vermicompost @ 10 t ha^{-1} + Vermiwash @ 10% within 2 days after plucking	60.0	58.0	55.0
T_{10}	Jeevamrit @ 10% within 2 days after plucking	46.0	47.0	42.0
	S.Em±	1.6	1.6	1.2
	CD (P= 0.05)	4.8	4.6	3.6

3.3 Made black tea

The data related to yield of made black tea, as influenced by different organic nutrient sources have been presented in Fig 1. A cursory glance of data revealed that the effect of organic nutrient sources on made black tea yield was found to be significant during all three seasons. In pre-monsoon season among all the treatments, higher made black tea yield was observed with the application of vermicompost @ 10t ha^{-1} + jeevamrit @ 10% which was statistically at par with the application vermicompost @ 10 t ha^{-1} + vermiwash @ 10%. The lowest made black tea yield was recorded in absolute control. Similar trend was also followed in monsoon and post monsoon season. These results are in close conformity with Negi and Bisht (2017) [10].

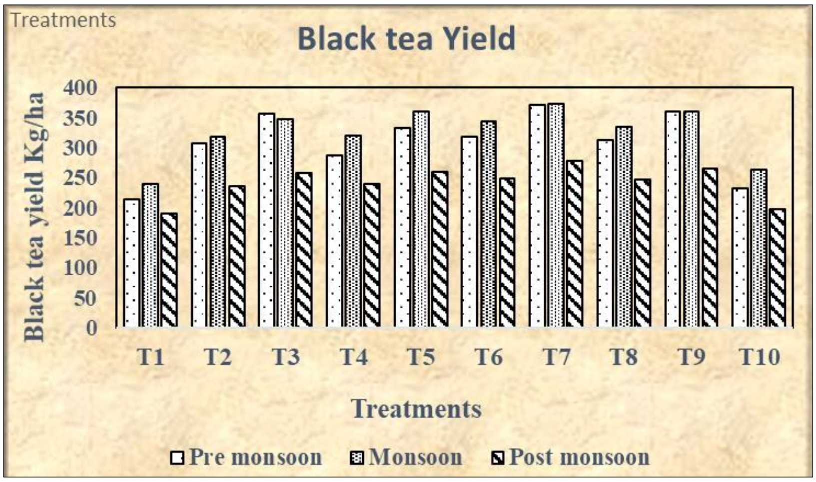

Fig 1: Effect of different organic nutrient sources on made black tea yield

3.4 Economics

The economics of crop production in terms of net return, additional net return over control and net return per rupee invested have greater impact on practical utility and acceptance of any technology. In order to evaluate the economic feasibility of different organic treatments, cost of cultivation, gross return, and additional net return over control and net return per rupee invested were worked out and the results have been depicted graphically in Fig 2.

3.4.1 Cost of cultivation

It is evident from the data presented in Fig 2 that the highest cost of cultivation (240795.6 Rsha-1) was incurred with application of vermicompost @ 10t ha^{-1} + jeevamrit @ 10% as compared to all the remaining treatments. The least cost was incurred in control. The higher cost in vermicompost @ 10t ha^{-1}+ jeevamrit @ 10% could be attributed to the use of multiple inputs like vermicompost and jeevamrit in the treatment.

3.4.2 Gross returns

A cursory glance on data revealed that the application of vermicompost @ 10t ha^{-1}+ jeevamrit @ 10% recorded highest gross return of Rs 562320 ha^{-1} which was followed by vermicompost @ 10t ha^{-1}+ vermiwash @ 10%. The lowest gross return was recorded in absolute control. The significant difference in gross return was mainly because of the difference in made tea yield due to treatment effect.

3.4.3 Net return

A perusal of data revealed that the application of vermicompost @ 10t ha^{-1}+ jeevamrit @ 10% recorded significantly higher net return of Rs 562320ha^{-1} which was followed by vermicompost @ 10t ha^{-1}+ vermiwash @ 10%. The lowest net return was recorded in absolute control. The significant difference in net return was mainly because of the difference in made tea yield and cost of cultivation.

3.4.4 Additional net return over control

The application of vermicompost @ 10t ha^{-1}+ jeevamrit @ 10% recorded higher additional net return of Rs 119288ha^{-1} which was followed by vermicompost @ 10t ha^{-1}+ vermiwash @ 10%.

3.4.5 Net return per rupee invested

"Upon reviewing the data, it became evident that the net profit for each rupee invested was notably influenced by various organic treatments. Specifically, the application of 20 tons per hectare of Farm Yard Manure (FYM) in combination with 10% jeevamrit yielded the highest net return per rupee invested. This superior ratio in net return per rupee invested in the treatment using FYM at 20 tons per hectare and 10% jeevamrit was attributed to the comparatively lower input costs."

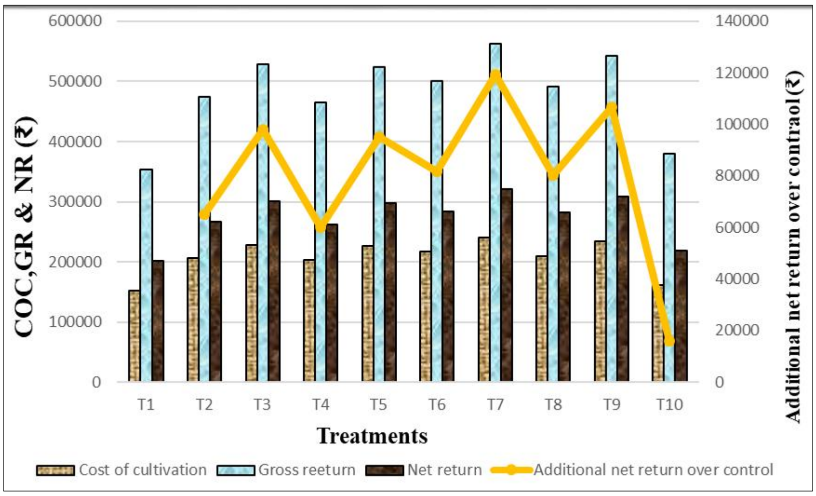

Fig 2: Effect of different organic nutrient sources on economics of made black tea

4. Conclusion

Plant height, number of leaves and mean fresh and dry biomass were enhanced due to application of organic fertilizer. Application of vermicompost @ 10 t ha^{-1} followed by foliar application of jeevamrit @ 10% gave higher green leaf yield as well as black made tea yield. Highest values of economic indices (gross return, net return and additional net return over control) was recorded in treatment having vermicompost @ 10 t ha^{-1} + Jeevamrit @ 10%.

5. Further Research

Experiment should be continued to evaluate the beneficial effect of organic fertilizer on the growth of tea, economics and fertility status of the soil to have ecofriendly plantation and conservation of ecology and natural habitat without polluting air, water and soil and yet maintaining sustainable tea production.

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