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Quality of compost tea and its effect on growth and yield attributes of cotton crop in vertisols

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Abstract
A field experiment was conducted to prepare the compost tea and its effect on growth and yield attributes of cotton during the Kharif season of 2024-25 at Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. with three replication and nine treatments viz, T_1-Absolute Control, T_2-100% RDF (150:75:75:25 NPKS), T_3-75% RDF + @ 25% CTF, T_4-75% RDF + @ 50% CTF, T_5-75% RDF + @ 75% CTF, T_6-75% RDF + @ 25% CTS, T_7-50% RDF + @ 50% CTS, T_8-25% RDF + @ 75% CTS and T_9-50% RDF + @ 75% CTS. Compost tea was applied as foliar spray (CTF) at 30, 75, and 120 DAS, and as soil drenching (CTS) at 30 and 45 DAS. Compost tea was prepared with varying brewing methods and nutrient concentrations, focusing on the microbial richness and nutrient composition, including NPK and sulfur content. The study showed that the application of compost tea significantly affected cotton growth, and yield attributes. The maximum plant growth, yield and yield attributes, was observed with treatment T_2 100% RDF on par with Treatment T_5 75% RDF + @ 75% CTF at flowering, boll formation and boll development stage followed by treatment T_4, T_3 and T_6. The data clearly indicated that the foliar application of compost tea reduced the 25% RDF and maintains the optimum yield.

Keywords: Cotton, compost tea and yield

Introduction

Water-based compost preparations, such as compost tea, have attracted growing interest from both producers and researchers. This has led to a wide range of terminologies and preparation methods being developed and used in the field (Ramírez-Gottfried *et al.* 2023) [24]. Compost tea is rich in nutrients, organic compounds, and beneficial microorganisms that enhance the plant rhizosphere. Due to its rich nutrient composition and quick nutrient release, compost tea serves as an effective growth enhancer for plants (Tafaghodinia & Kamalpour, 2008) [33]. Several studies have shown that applying compost teas can significantly enhance plant health, boost yield, and improve nutritional quality particularly when applied to leaves, where they directly support foliar health and disease resistance (Al-Dahmani *et al.*, 2003, Edwards *et al.*, 2006, Elad and Shtienberg, 1994, Pant *et al.*, 2011, Pant *et al.*, 2009, Scheuerell and Mahaffee, 2004, Welke, 2005) [3, 10, 12, 21, 22, 27, 34]. It has shown that using compost tea enhances chlorophyll levels and promotes plant growth and development (Segarra *et al.* 2009) [28]. Compost tea also enhances fruit quality by boosting photosynthetic activity and raising macronutrient levels in the leaves (Shrinivas *et al.*, 2021) [29], which ultimately leads to increased crop yields (Sifatullah *et al.*, 2011) [31]. The application and use of compost teas in organic systems require technical clarification to ensure that the quality associated with the amendment cum fertilizer is not compromised (Eudoxie 2019) [13].

A shift has been underway toward more efficient use of organic fertilizers and a reduction in the reliance on mineral fertilizers in soil management (Srivastava *et al.*, 2012) [32]. Compost tea serves a dual role by enhancing soil productivity and improving crop quality and yield. Therefore, effective management is essential to achieve high economic returns from production while minimizing the environmental risks associated with excessive application (Mercado *et al.*, 2010) [19].

Solid manures and composts require time to decompose in the soil before their nutrients become accessible to plants (Qaisi *et al.*, 2023) [23]. Consequently, using compost tea can be beneficial for crop like cotton, as it provides readily available nutrients and enhances chlorophyll content in leave. There is a lack of comprehensive studies examining the direct impact of compost tea quality on cotton crop productivity. While previous studies have demonstrated the positive effects of compost tea on general soil health and plant growth (Ingham 2005, Koley *et. al* 2025) [17, 18].

Moreover, while compost tea has been suggested as a supplement with synthetic fertilizers, there is limited data on how varying combinations of compost tea application methods (e.g., foliar spray and soil drenching) influence nutrient uptake and crop yield over the course of a growing season (Yin 2025) [35]. This research aimed to fill this gap by assessing how different brewing methods, nutrient concentrations, and application techniques of compost tea influence cotton growth and yield during the Kharif season of 2024-25. By evaluating the role of compost tea in cotton cultivation, this study seeks to provide a more sustainable approach to nutrient management in agriculture, reducing dependency on chemical fertilizers while enhancing crop productivity.

Materials and Methods

The experiment was conducted at the Research Farm of the Department of Soil Science, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, where the soil was classified as Vertisol from the Parbhani soil series, consisting of fine Montmorillonite and belonging to the topic Haplusterts isohyperthermic family. Compost tea, was prepared and biochemical analysis characterized for parameters such as pH, electrical conductivity, total nutrients (N, P, K, S), DTPA extractable micronutrients, Humic acid, organic matter and proteins. The experiment followed a randomized block design (RBD) with a plot size of 5.2 x 4.8 m², and row-to-row and plant-to-plant distances of 90 cm and 60 cm, respectively. The cotton variety used in the study was Rasi (RCH 386 BG II). The study included nine treatments with three replications: T_1-Absolute Control, T_2-100% RDF (150:75:75:25 NPKS), T_3-75% RDF + @ 25% CTF (Compost Tea Foliar Spray), T_4-75% RDF + @ 50% CTF, T_5-75% RDF + @ 75% CTF, T_6-75% RDF + @ 25% CTS (Compost Tea Soil Drenching), T_7-50% RDF + @ 50% CTS, T_8-25% RDF + @ 75% CTS and T_9-50% RDF + @ 75% CTS. CTF was applied at 30, 75, and 120 DAS, while CTS was applied at 30 and 45 DAS. According to the standard procedure (Das, 1999) required quantity of compost tea was prepared, Fertilizers urea, SSP, and MOP were used to supply N, P, and K, respectively. Growth, yield, yield attributes, were assessed at different growth stages of the cotton crop, including flowering, boll formation, and boll development stages.

Results and Discussion

Preparation of compost tea

The compost tea was prepared by decomposing a mixture of 2.5 kg of Gliricidia green leaves, 2.5 kg of fresh cow dung, 1 kg of nimboli, and 50 g of sulfur meal. These ingredients were thoroughly combined and placed in a gunny bag, which was then submerged at the bottom of a drum. To ensure the bag remained submerged, a brick was added on top. The drum was then filled with 100 liters of water. The water was stirred for five minutes at regular intervals. After a period of three weeks, the mixture was fully decomposed, and the liquid compost tea was ready for use. The final liquid had a tea-like color and no unpleasant odour. After removing the gunny bag, 100 to 125 g of molasses was added to enhance the quality of the compost tea. The final product was then filtered before being applied to the soil or plants. The compost tea prepared through this method demonstrated its potential as a sustainable, eco-friendly alternative to synthetic fertilizers. The incorporation of beneficial microorganisms through compost tea can help improve soil structure, increase microbial biodiversity, and promote nutrient cycling. Additionally, the nutrients supplied through compost tea can enhance plant growth, promote disease resistance, and improve overall crop yields. Given its ability to reduce dependency on chemical fertilizers, compost tea could be a valuable tool for enhancing soil health and ensuring the ecological sustainability of agricultural practices. As a result, further research is required to optimize the preparation methods and application parameters of compost tea in the future as reviewed by Yin (2025) [35].

Biochemical Characterization of Compost Tea

The compost tea prepared in this study exhibited favourable biochemical and biological characteristics, indicating its potential to enhance soil health and plant growth as indicated in Table 1. With a neutral pH of 6.90 and an electrical conductivity of 2.73 dS m^{-1}, it provided a balanced environment for nutrient availability and microbial activity. The compost tea contained essential macronutrients 0.89% nitrogen, 0.72% phosphorus, 0.60% potassium, and 0.07% sulphur as well as beneficial micronutrients such as copper (1.08 mg L^{-1}), iron (17.63 mg L^{-1}), manganese (1.48 mg L^{-1}), and zinc (1.69 mg L^{-1}). Additionally, it was rich in humic acid (54.33 mg L^{-1}), organic matter (1.33%), and microbial proteins (55.00 g kg^{-1}), all of which support nutrient retention, microbial activity, and soil structure. Similar findings were also reported by Ali (2015); these properties suggest compost tea can serve as an effective organic amendment, promoting sustainable crop production by improving nutrient uptake and reducing dependency on synthetic fertilizers. Segarra *et al.* (2009) [28] shown that using compost tea enhances chlorophyll levels and promotes plant growth and development when applied to the leaves, it delivers nutrients straight to the plant and also helps manage leaf-related diseases. El Hayany *et al.* (2023) [11] showed the positive effect of compost tea foliar application on chlorophyll content of the leaves was directly related to the quality of compost tea used for spraying.

Growth and growth attributes

Plant population

The cotton plant population per plot as showed in Table 2 ranged from 36.67 to 46.00 at germination. Gap filling was done 6-7 days later to maintain uniformity. At flowering and boll formation stage, populations ranged from 46.33 to 48.00. The highest plant counts at all stages were recorded in Treatment T_2 (100% RDF) followed by treatment T_5 (75%RDF + @ 75% CTF), while the lowest were in T_1 (Absolute Control).These results are supported by Ingham (2005) [17], who linked higher plant populations to improved nutrient availability.

Plant height (cm)

Plant height serves as a metric for overall plant health and growth, indicating the efficacy of nutrient absorption, water accessibility, and environmental factors. Data on plant height at flowering, boll formation and boll development stages, presented in Table 2, showed that compost tea application significantly influenced plant height throughout the crop cycle. Treatment T_2 (100% RDF) recorded the highest plant heights at all stages 27.89 cm (flowering), 114.93 cm (boll formation), and 148.47 cm (boll development). The lowest values were observed in T_1 (Control), with 14.71 cm, 59.93 cm, and 84.07 cm at the respective intervals. Among the compost tea treatments, T_5 (75% RDF + 75% CTF) consistently showed the at par plant heights, which performed significantly better than the control. These results align with findings by Luo *et al.* (2021), who reported that compost tea application increased plant height by 11.8% to 72.8%. Similarly, Shrinivas *et al.* (2021) [29] found that foliar application of compost tea at varying concentrations (10-75%) at 30, 45, and 60 DAS significantly enhanced plant height, reaching 47.1 cm at flowering, 57.9 cm at pod formation, and 63.2 cm at harvest, compared to the control.

Mean leaf area plant^{-1} (cm^2)

The mean leaf area per plant recorded at flowering, boll formation and boll development stages are presented in Table 2. The data indicate that leaf area significantly increased as the crop progressed, with the highest values observed at boll development stage. Treatment T_2 (100% RDF) recorded the maximum leaf area-04.35 cm² at flowering, 160.65 cm² at boll formation, and 172.83 cm² at boll development stages at par with T_5 (75% RDF + 75% CTF), which recorded 156.55 cm² at boll formation and 170.73 cm² at boll development stage, significantly surpassing all other treatments. In contrast, the lowest leaf area was observed in T1 (Control), with 60.22 cm², 119.03 cm², and 125.55 cm² at the respective stages. Similar results were reported by Farrag *et al.* (2017) [14], who observed increased leaf area in cantaloupe plants when compost tea was applied alongside varying fertilizer doses.

Chlorophyll content (mg g^{-1} fresh weight)

Chlorophyll content varied significantly among treatments showed in table 2 and fig.1 during the flowering and boll formation stages. The highest levels were observed in T_2 (100% RDF), with 2.21 mg g^{-1} at flowering and 2.63 mg g^{-1} at boll formation, statistically at par to T_5 (75% RDF + @ 75% CTF). These were followed by T_4 and T_3, all indicating improved photosynthetic capacity due to enhanced nutrient availability. The control (T_1) recorded the lowest chlorophyll content (1.36 and 2.15 mg g^{-1}), reflecting nutrient deficiency. The above results are similar to those of Sidna *et al.* (2021) [30] reported that soil and foliar application of compost tea resulted increase in growth parameters and the maximum chlorophyll content (2.87 mg g-^{1} and 2.65 mg g^{-1}) at 50 DAS.

Yield and yield attributes

Number of bolls plant^{-1}

The number of bolls per plant was significantly influenced by compost tea application across different growth stages, as shown in Table 3.and fig.2 Treatment T_2 (100% RDF) recorded the highest number of bolls at both the boll formation stage (23.7) and boll development stage (31.67), at par with T_5 (75% RDF + @ 75% CTF), which recorded 22.5 and 27.53 bolls, respectively. All treatments demonstrated improved boll production compared to the control (T_1), which recorded the lowest values (11.4 and 18.67) at the boll formation and boll development stages, respectively. These results are consistent with findings by Abubaker *et al.* (2024) [2], who reported enhanced fruit production in tomatoes with combined NPK and compost tea applications, highlighting the potential of compost tea to boost reproductive development in crops.

Boll weight

The application of compost tea had a significant effect on mean boll weight per plant, as recorded at boll development stage (Table 3 and fig.2). The highest mean boll weight was observed in treatment T_2 (100% RDF) with 5.32 g, which was statistically at par with T_5 (75% RDF + @ 75% CTF), recording 5.16 g. These were followed by T_4 and T_3, all of which significantly outperformed the remaining treatments. The control treatment (T_1) recorded the lowest mean boll weight (3.28 g). These findings are similar to those of Buna *et al.* (2020) [8], who reported increased fruit weight in response to higher compost tea concentrations, reinforcing the role of compost tea in enhancing yield parameters.

Dry matter production

The dry matter production of the cotton crop, recorded post-harvest, is presented in Table 3. The results clearly indicate that compost tea application had a significant positive effect on dry matter accumulation. Among the treatments, the highest dry matter yield was observed in T_2 (100% RDF), which recorded 5634.00 kg ha^{-1}. This value was statistically at par with treatment T_5 (75% RDF + @ 75% CTF), which yielded 5526.00 kg ha^{-1}. In contrast, the control treatment (T_1), which received no amendments, recorded the lowest dry matter production at 2660.67 kg ha^{-1}. All other treatments demonstrated significantly higher dry matter accumulation compared to the control, underscoring the efficacy of integrated nutrient management strategies. These findings are in agreement with those reported by Amer *et al.* (2020) [6], who emphasized that the high nutrient content of compost enhances nutrient uptake efficiency, thereby promoting vegetative growth, photosynthetic activity, and dry matter synthesis. Similarly, Salim *et al.* (2025) [26] highlighted the role of compost tea in sustaining a favourable nutrient balance throughout the crop growth period, ultimately contributing to increased biomass production and yield.

Seed cotton yield

Seed cotton yield data presented in Table 3, reveal that treatment T_2 (100% RDF) produced the highest yield (22.77 q ha^{-1}), significantly outperforming all other treatments. However, it was statistically at par with T_5 (75% RDF + @ 75% CTF), which yielded 21.83 q ha^{-1}. The lowest yield was recorded in the T_1 (control without fertilizers) at 8.30 q ha^{-1}. All treatments significantly outperformed the control, underscoring the importance of balanced nutrient application. The superior performance of T_2 is attributed to the adequate supply of essential macronutrients (N, P, K), vital for crop development. These findings are in line with Bako *et al.* (2024) [7], who reported enhanced yield and quality in sweet corn with compost tea application.

Benefit cost ratio

The benefit-cost ratio data presented in Table 3 and fig. 3 showed that the highest benefit-cost ratio was found in T_2-

100% RDF (1.85), followed by T_5-75% RDF + @ 75% CTF (1.83), the lowest ratio was observed in T_1-absolute control (1.27). The results clearly indicate that the foliar applications of compost tea reduce the 25% RDF and help effectively maintained optimum yield. These findings align with Dwivedi *et al.* (2014), who noted that foliar sprays of seaweed extract significantly increased net returns and B: C ratios compared to other treatments.

Table 1: Bio chemical properties of compost tea

SL. NO.	Parameters	Sample 1	Sample 2	Sample 3	Mean
1	pH	6.9	7	6.8	6.90
2	EC (dSm^{-1})	2.7	3	2.5	2.73
3	N (%)	0.89	0.9	0.87	0.89
4	P (%)	0.71	0.74	0.72	0.72
5	K (%)	0.54	0.68	0.59	0.60
6	S (%)	0.06	0.09	0.05	0.07
7	Cu (mg L^{-1})	1.04	1.12	1.08	1.08
8	Fe (mg L^{-1})	18.2	15.5	19.2	17.63
9	Mn (mg L^{-1})	1.36	1.61	1.48	1.48
10	Zn (mg L^{-1})	1.64	1.84	1.6	1.69
11	Humic acid (mg L^{-1})	60	45	58	54.33
12	Organic matter (%)	1.2	1.5	1.3	1.33
13	Poteins (g/kg)	55	56	54	55.00

Table 2: Effect of application of compost tea on plant population, plant height (cm), leaf area (cm^2), and chlorophyll content (mg g^{-1}) of cotton crop.

Sl. No.	Treatments	Plant Population			Plant height (cm)			Leaf area (cm^2)			Chlorophyll content	
		At germination	Flowering stage	Boll formation stage	Flowering stage	Boll Formation stage	Boll development stage	Flowering Stage	Boll Formation Stage	Boll development Stage	Flowering Stage (mg g-1)	Boll formation stage (mg g-1)
T_1	Absolute control	36.67	46.33	46.33	14.71	59.93	84.07	60.22	119.03	125.55	1.36	2.15
T_2	100% RDF (150:75:75:25 NPKS)	46.00	48.00	48.00	27.89	114.93	148.47	104.35	160.65	172.83	2.21	2.63
T_3	75% RDF + @ 25% CTF	43.67	47.00	47.00	24.08	92.53	120.33	95.07	152.59	158.12	1.88	2.41
T_4	75% RDF + @ 50% CTF	43.00	47.67	47.67	24.35	99.87	124.73	93.53	153.25	163.30	1.98	2.47
T_5	75% RDF + @ 75% CTF	45.33	48.00	47.67	23.53	107.93	137.53	97.19	156.55	170.73	2.12	2.57
T_6	75% RDF + @ 25% CTS	43.33	47.33	47.00	24.24	95.87	123.07	85.71	147.59	152.80	1.89	2.47
T_7	50% RDF + @ 50% CTS	42.00	47.33	47.33	20.10	78.00	113.00	84.86	135.83	142.85	1.86	2.35
T_8	25% RDF + @ 75% CTS	39.67	46.67	46.67	16.71	66.93	95.27	76.90	130.98	137.83	1.79	2.28
T_9	50% RDF + @ 75% CTS	42.67	47.00	47.00	19.88	82.20	104.67	84.75	139.41	147.60	1.87	2.42
	S.E m.±	1.10	0.36	0.38	0.81	1.63	1.65	1.39	1.38	2.13	0.05	0.04
	C.D. at 5%	3.29	NS	NS	2.44	4.89	4.95	4.17	4.14	6.40	0.15	0.11

Table 3: Effect of application of compost tea on number of bolls, boll weight (g $boll^{-1}$), Dry matter production (kg ha^{-1}), seed cotton yield (q ha^{-1})

Sl. No.	Treatments	Number of bolls plant-1		Mean boll weight (g $boll^{-1}$)	Dry matter (kg ha^{-1})	Yield of cotton (q ha-1)	B:C Ratio
		Boll formation stage	At boll development				
T_1	Absolute control	11.4	18.67	3.28	2660.67	8.30	1.27
T_2	100% RDF (150:75:75:25 NPKS)	23.7	31.67	5.32	5634.00	22.77	1.85
T_3	75% RDF + @ 25% CTF	18.3	22.00	4.44	4807.00	19.52	1.74
T_4	75% RDF + @ 50% CTF	20.6	24.00	4.57	4946.67	20.11	1.76
T_5	75% RDF + @ 75% CTF	22.5	27.53	5.16	5526.00	21.83	1.83
T_6	75% RDF + @ 25% CTS	19.0	23.20	4.25	4715.67	19.21	1.73
T_7	50% RDF + @ 50% CTS	12.3	20.53	3.92	3222.67	14.78	1.58
T_8	25% RDF + @ 75% CTS	11.2	18.53	3.43	2796.00	11.44	1.42
T_9	50% RDF + @ 75% CTS	16.3	22.47	4.50	3285.67	15.47	1.61
	S.E m.±	0.7	1.40	0.15	46.64	0.35	
	C.D. at 5%	2.1	4.19	0.44	139.82	1.04	

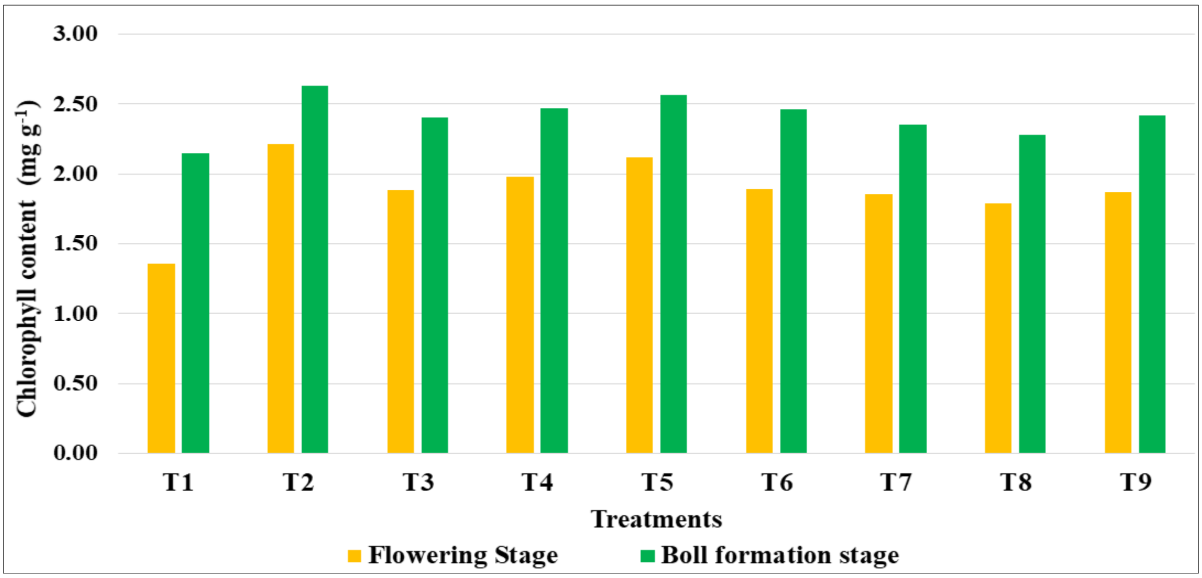

Fig 1: Effect of compost tea on chlorophyll content (mg g^{-1})

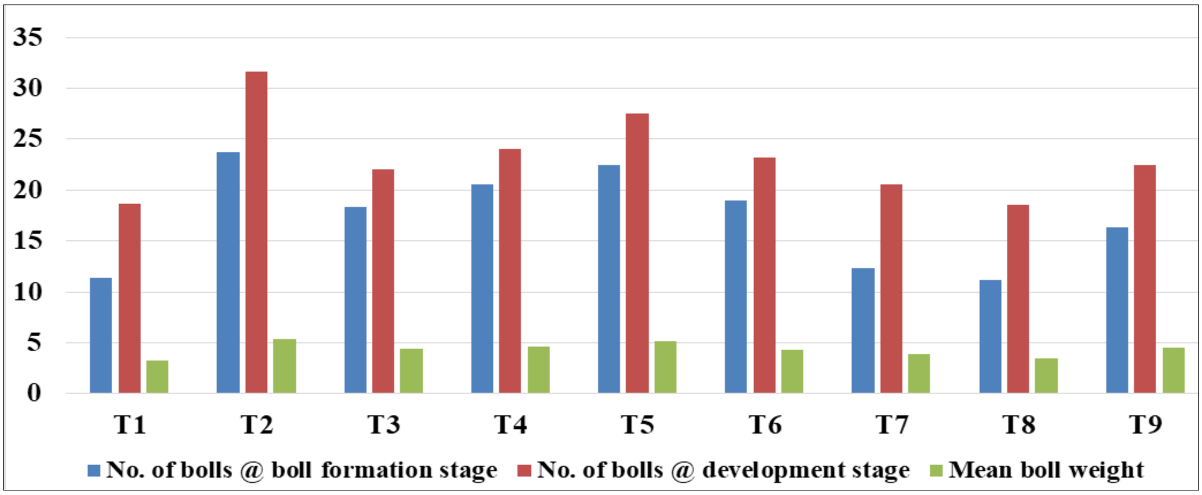

Fig 2: Effect of compost tea on number of bolls and mean boll weight

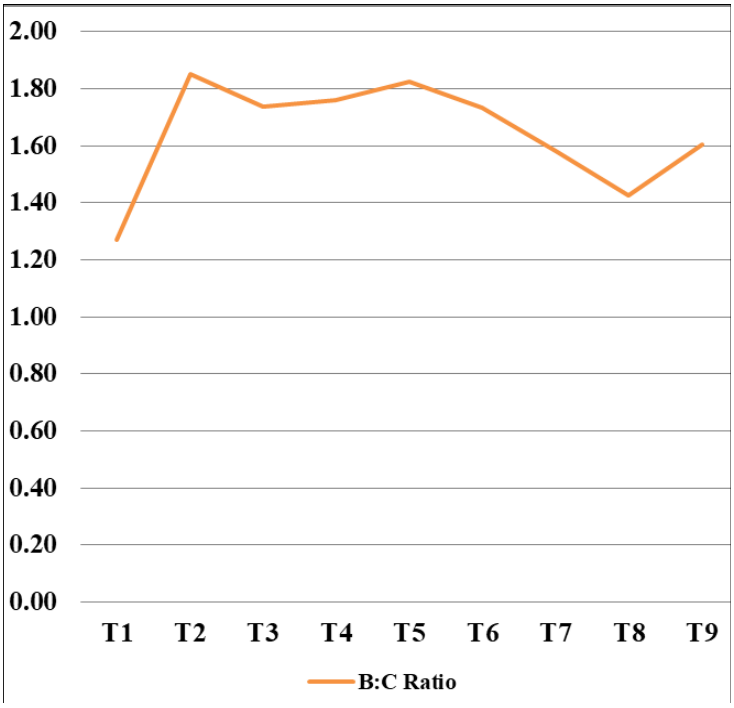

Fig 3: B:C Ratio of cotton crop.

Conclusion

In the context of sustainable agriculture and the on-going need to enhance crop productivity while maintaining soil health, the integration of compost tea into fertilization regimes presents a promising approach. Among the various growth parameters evaluated including plant population, plant height, leaf area per plant, and chlorophyll content the most significant improvements were observed in Treatment T_2 (100% RDF), at par with Treatment T_5 (75% RDF + @ 75% CTF). Yield-related attributes such as the number of bolls per plant, mean boll weight, seed cotton yield, and overall dry matter production exhibited a similar trend, with both T_2 (100% RDF) and T_5 (75% RDF + @ 75% CTF) outperforming the control by a substantial margin. This demonstrates the significant positive influence of compost tea on plant growth with the application of 75% RDF + @ 75% CTF. This indicating reduction of 25% RDF while maintaining the optimum yield of cotton crop in vertisols.

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