International Journal of Agriculture and Plant Science
www.agriculturejournal.in
Online ISSN: 2664-7664
Received: 21-07-2026, Accepted: 20-08-2026, Published: 04-09-2026
Volume 8, Issue 3, 2026, Page No. 380-384

Optimizing growth viability of black turmeric (*Curcuma caesia* Roxb.) through organic manures and biofertilizers in the Konkan agro climatic condition

V J Kelaskar[1*], P C Mali[2], A V Mane[3], R G Khandekar[4], R V Dhopavkar[5], R C Gajbhiye[6], G D Shirke[7]

[1] Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, D.B.S.K.K.V, Dapoli, Maharashtra, India

[2] Professor (CAS) & Head, Department of Fruit Science, College of Horticulture, Dapoli, D.B.S.K.K.V, Dapoli, Maharashtra, India

[3] Deputy Director of Research (Seed), D.B.S.K.K.V, Dapoli, Maharashtra, India

[4] Ex-Professor, College of Horticulture, Dapoli, D.B.S.K.K.V, Dapoli, Maharashtra, India

[5] Ex-Associate Professor, Department of Soil Science and Agricultural Chemistry, College of Agriculture, D.B.S.K.K.V, Dapoli, Maharashtra, India

[6] Professor (CAS) and Head, Department of Plantation, Spices, Medicinal and Aromatic Crops College of Horticulture, D.B.S.K.K.V, Dapoli, Maharashtra, India

[7] Head & Associate Dean, College of Horticulture, Dapoli, D.B.S.K.K.V, Dapoli, Maharashtra, India

Corresponding Author: V J Kelaskar

DOI: https://doi.org/10.66856/ijaps.2026.8.3.8247

Abstract

An experiment was conducted across two consecutive years at the Asond farm, CES, Wakawali (Ratnagiri, Maharashtra), to evaluate the individual and interaction effects of organic manures and biofertilizers on black turmeric growth. The trial was laid out in a Factorial Randomized Block Design (FRBD), comprising four organic manures *i.e.,* Poultry manure at 7.5 t/ha (O_1), Vermicompost at 12 t/ha (O_2), Neem cake at 10 t/ha (O_3) and FYM at 30 t/ha (O_4) and five biofertilizers *i.e., Azospirillum* (B_1), *Azotobacter* (B_2), PSB (B_3), VAM (B_4) and a control (B_5), each at 5 kg/ha. Individual application of vermicompost at 12 t/ha (O_2) and Phosphate-Solubilizing Bacteria at 5 kg/ha (B_3) recorded maximum values for plant height (68.03 cm and 65.74 cm), leaf count (11.46 and 11.70), tiller production (2.69 and 2.85), leaf length (42.98 cm and 41.22 cm), leaf width (12.81 cm and 12.85 cm) and leaf area (429.45 cm^2 and 420.67 cm^2), respectively. The combined treatment O_2B_3 (Vermicompost + PSB) achieved absolute dominance, securing the highest overall plant height (76.77 cm), leaf number (12.90), tiller count (3.40), leaf length (46.13 cm), leaf width (14.36 cm) and maximum leaf area (516.69 cm^2). Conversely, the control combination O_4B_5 consistently recorded the minimum growth values. This study demonstrates that the integrated application of vermicompost at 12 t/ha and PSB at 5 kg/ha serves as a highly effective nutrient management framework for optimizing the structural and canopy development of black turmeric.

Keywords: Organic manures, biofertilizers, vermicompost, PSB, growth parameters

Introduction

Medicinal plants are a timeless global treasure for human health, deeply rooted in traditional Indian systems like Ayurveda, Siddha and Unani. Among these resources, the genus *Curcuma* has been revered for over 4,000 years (Rajkumari & Sanatombi, 2017) [1]. A particularly valuable yet understudied species is black turmeric (*Curcuma caesia* Roxb.), a rare perennial herb native to India and Southeast Asia. Characterized by its distinctive bluish-black inner rhizomes and deep red-violet leaf streaks, this crop holds profound cultural significance and diverse ethno medicinal utility among tribal communities for treating ailments ranging from inflammation to asthma. However, high demand and indiscriminate exploitation have led to its classification as an endangered and vulnerable species, restricting unauthorized export and emphasizing the need for sustainable cultivation (Tamang, 2022) [2].

Despite its immense potential as a natural antioxidant source for cosmetic and medicinal applications, the production of *Curcuma caesia* is severely hindered by a lack of documented agronomic practices (Chitra, 2022) [3]. This issue is particularly pronounced in nutrient-constrained lateritic soils. Black turmeric has high nutritional requirements due to its shallow root system and significant dry matter production. While long-term reliance on chemical fertilizers degrades the soil's ecological balance, integrated plant nutrient management offers a sustainable alternative. Recent research underscores that combining organic amendments such as farmyard manure, vermicompost, and poultry manure with microbial bio-inoculants significantly improves crop morphology, soil fertility and rhizome yield (Jyotirmayee, 2024) [4].

Therefore, this study aims to evaluate the individual and interactive effects of various organic manures and biofertilizers on the growth of black turmeric, establishing eco-friendly cultivation practices to unlock its full therapeutic and economic potential.

Material and Methods

The experiment was conducted at Asond farm, CES, Wakawali, Tal. Dapoli, Dist. Ratnagiri, State Maharashtra. Sites with favorable soil and topographical features were identified and chosen for cultivation. Wakawali is located at 17.76° N latitude and 73.18° E longitude on the western coast of Maharashtra. It is 244 meters above mean sea level. Wakawali falls under the Coastal Maharashtra Agro-Climatic Zone (Zone 11). The experiment was laid out in FRBD design and treatment comprised of four organic manures (O_1: Poultry manure at 7.5 t/ha, O_2: Vermicompost at 12 t/ha, O_3: Neemcake at 10 t/ha and O_4: FYM at 30 t/ha) and five Biofertilizers (B_1: *Azospirillum* at 5 kg/ha, B_2: *Azotobacter* at 5 kg/ha, B_3: PSB at 5 kg/ha, B_4: VAM at 5 kg/ha and B_5: No biofertilizer). Organic manures were applied on the basis of the recommended dose of nitrogen (200 kg/ha) and according to the treatment specifications. Biofertilizers were applied as per the specified treatment protocols. To comprehensively document the pre-harvest characteristics, five plants were randomly selected from each treatment plot and growth parameters were recorded. The statistical analysis of the data obtained over the two-year period was performed using standard methods of analysis of variance, as provided by Panse and Sukhatme (1985) [5]. Wherever the results were significant, the critical difference (C.D.) at 5 % was calculated along with the standard error of the mean (S.Em).

Results and discussion

1. Plant height (cm)

Based on the pooled analysis, the plant height of black turmeric was significantly influenced by the individual and interaction effects of organic manures (O) and biofertilizers (B). Separately, treatment O_2 (Vermicompost at 12 t/ha) recorded the highest plant height (68.03 cm), while O_4 (FYM at 30 t/ha) recorded the lowest (53.71 cm); meanwhile, biofertilizer treatment B_3 (PSB at 5 kg/ha) achieved the highest plant height (65.74 cm) compared to the lowest (52.67 cm) in the control B5 (No biofertilizer). When integrated, the treatment combination O_2B_3 (Vermicompost at 12 t/ha + PSB at 5 kg/ha) yielded the overall highest plant height of 76.77 cm, whereas the combination O_4B_5 (FYM at 30 t/ha + No biofertilizer) consistently resulted in the lowest plant height of 48.50 cm. This pronounced growth enhancement is attributed to a synergistic dual mechanism where the humic substances in nutrient-rich vermicompost increase cell wall elasticity, while Phosphate-Solubilizing Bacteria (PSB) efficiently convert insoluble phosphates to optimize nutrient uptake, thereby triggering cell division, gibberellin production and stem elongation. These pooled findings are strongly supported by the definitive results of prior scientists. Specifically, Vadiraj *et al.* (2004) [6] proved that vermicompost treatments successfully boost plant height up to 33.9 cm from a control baseline of 18.3 cm, while Mannikeri *et al.* (2010) [7] established a direct link between a 15.65 t/ha vermicompost dosage and substantial vertical growth. Furthermore, Singh (2013) [8] demonstrated that a 5 kg/ha application of PSB significantly maximizes plant height compared to untreated crops and Macherla Chandana *et al.* (2022) [9] explicitly validated that integrating a vermicompost matrix (14 t/ha) with a microbial biofertilizer consortium produces a matching superior plant height of 79.47 cm. These integrated nutrient management advantages are in complete agreement with the broader growth-enhancing frameworks outlined by Bhende *et al.* (2013) [10], Khedkar (2023) [11] and Mondal and Hore (2024) [12].

2. Number of leaves

Based on the pooled analysis, the number of leaves per plant in black turmeric was significantly influenced by the individual and interaction effects of organic manures (O) and biofertilizers (B). Separately, treatment O_2 (Vermicompost at 12 t/ha) produced the highest number of leaves (11.46), whereas O_4 (FYM at 30 t/ha) consistently recorded the lowest (10.28); simultaneously, biofertilizer treatment B_3 (PSB at 5 kg/ha) achieved the highest number of leaves (11.70) compared to the lowest (9.86) observed in the control B_5 (No biofertilizer). When integrated, the treatment combination O_2B_3 (Vermicompost at 12 t/ha + PSB at 5 kg/ha) significantly outperformed all other treatments, yielding the absolute maximum pooled leaf count of 12.90, while the combination O_4B_5 (FYM at 30 t/ha + No biofertilizer) resulted in the lowest count of 9.40. This enhanced leaf production is attributed to a favorable rhizosphere environment and a synergistic dual mechanism: the rich microbial diversity and plant growth-promoting rhizobacteria (PGPR) in vermicompost exhibit hormone-like activities that increase the production of auxins, cytokinins and gibberellins to stimulate cell division and expansion, while the Phosphate-Solubilizing Bacteria (PSB) efficiently solubilize insoluble phosphates to ensure steady phosphorus availability for optimal plant nutrition. These pooled findings are strongly corroborated by the results of prior researchers who documented identical growth benefits. Specifically, Mannikeri (2010) [7] reported a substantial increase in leaf number with a vermicompost application at 15.65 t/ha, and Singh (2013) [8] validated that a 5 kg/ha application of PSB significantly increases leaf production over control setups. Furthermore, Bhende *et al.* (2013) [10] explicitly achieved a maximum of 12.07 leaves by applying vermicompost (25 t/ha) alongside a multi-strain microbial inoculant, while Macherla Chandana *et al.* (2022) [9] demonstrated matching vegetative improvements combining vermicompost (14 t/ha) with the Arka Microbial Consortium (AMC). These integrated nutritional advantages align seamlessly with the supporting results published by Khedkar (2023) [11], Mondal and Hore (2024) [12] and Kumar and Chanchan (2024) [13].

3. Number of tillers

The combined pooled data indicated that the individual and interaction effects of organic manures (O) and biofertilizers (B) significantly influenced the tiller production of black turmeric. Individually, treatment O_2 (Vermicompost at 12 t/ha) generated the highest tiller count (2.69), whereas O_4 (FYM at 30 t/ha) consistently produced the lowest (2.03); simultaneously, the biofertilizer treatment B_3 (PSB at 5 kg/ha) maximized tiller development with an average of 2.85, while the control B_5 (No biofertilizer) lagged behind at a minimum of 1.80. When evaluating their combined impact, the integrated treatment O_2B_3 (Vermicompost at 12 t/ha + PSB at 5 kg/ha) demonstrated absolute dominance, establishing a maximum pooled tiller count of 3.40, whereas the dual omission in O_4B_5 (FYM at 30 t/ha + No biofertilizer) suppressed development to a minimum of 1.45. This notable expansion in tillering is driven by a distinct dual-action mechanism. The dense nutrient profile, rapid decomposition and diverse microbial ecology of vermicompost enhance soil structure and hormonal regulation to accelerate early rhizome development. Concurrently, the PSB efficiently mobilize fixed phosphorus, which critically advances leaf formation, axillary bud activation and canopy expansion by maximizing photosynthetic surface area and carbohydrate allocation. Together, the slow-release nutrition from vermicompost pairs with the phosphorus-unlocking capabilities of PSB to create an optimal rhizosphere environment that surpasses the capabilities of standalone applications. These aggregated outcomes are strongly supported by data of prior researchers. Mannikeri *et al.* (2010) [7] found that vermicompost treatments directly optimize tiller yields in turmeric, a growth trend later mirrored in the trials of Khedkar (2023) [11]. On the microbial front, Singh (2013) [8] confirmed that a 5 kg/ha inoculation of PSB significantly maximizes tiller generation over uninoculated control crops. Furthermore, the outstanding performance of the integrated treatment matches the findings of Bhende *et al.* (2013) [10] and Macherla Chandana *et al.* (2022) [9], both of whom reported that coupling a vermicompost base with multi-strain biofertilizer inoculants triggers a strong synergistic surge in vegetative structures. This cumulative advantage is further supported by Mondal and Hore (2024) [12] and Kumar and Chanchan (2024) [13]in turmeric.

4. Leaf length (cm)

Based on the aggregated pooled data, both the individual and combined applications of organic manures (O) and biofertilizers (B) exerted a highly significant influence on the leaf length of black turmeric. Independently, treatment O_2 (Vermicompost at 12 t/ha) generated the highest leaf length (42.98 cm), whereas O_4 (FYM at 30 t/ha) consistently recorded the lowest (37.55 cm); concurrently, the biofertilizer treatment B_3 (PSB at 5 kg/ha) maximized individual leaf development with a superior average of 41.22 cm, while the control B_5 (No biofertilizer) produced the shortest leaves at a minimum of 37.26 cm. When evaluating their interaction, the combined treatment O_2B_3 (Vermicompost at 12 t/ha + PSB at 5 kg/ha) displayed absolute dominance, establishing the maximum pooled leaf length of 46.13 cm, whereas the dual omission in O_4B_5 (FYM at 30 t/ha + No biofertilizer) significantly restricted leaf development to a minimum of 34.33 cm. This notable expansion in foliage length is driven by a harmonized physiological mechanism. The superior efficacy of vermicompost stems from earthworm gut micro biota and active enzymatic networks (such as phosphatase and dehydrogenase) that accelerate organic decomposition and release critical nutrients in highly bioavailable forms. Concurrently, the PSB efficiently unlocks fixed soil phosphorus, which fundamentally advances leaf development, axillary bud activation and shoot canopy architecture. This combined action maximizes the plant's overall photosynthetic surface area and carbohydrate utilization efficiency. By pairing the slow-release nutrition, minimized oxidative stress, and enhanced microbial proliferation of vermicompost with the phosphorus-mobilizing capacity of PSB, this integrated approach optimizes nutrient uptake, hormonal regulation, and antioxidant activity far better than individual treatments. These pooled growth dynamics are strongly supported by Mannikeri *et al.* (2010) [7] and Khedkar (2023) [11] both demonstrated that vermicompost treatments exert a highly positive, direct impact on the leaf expansion parameters of turmeric. On the microbial side, Singh (2013) [8] explicitly reported that a 5 kg/ha application of PSB biofertilizer records the longest leaf dimensions compared to uninoculated control crops. Furthermore, the outstanding performance of the integrated treatment matches the broader systemic findings of Kumar and Chanchan (2024) [13] who observed that plots treated with a combined matrix of vermicompost, balanced inputs and a biofertilizer consortium (including PSB) recorded superior leaf lengths up to 73.01 cm, validating that integrating organic amendments with targeted microbial inoculants significantly optimizes vegetative structures.

5. Leaf width (cm)

Based on the consolidated pooled analysis, both the individual and combined applications of organic manures (O) and biofertilizers (B) significantly dictated the leaf width development of black turmeric. Independently, treatment O_2 (Vermicompost at 12 t/ha) generated the maximum leaf width (12.81 cm), whereas O_4 (FYM at 30 t/ha) consistently recorded the narrowest leaves (11.23 cm); simultaneously, biofertilizer treatment B_3 (PSB at 5 kg/ha) asserted absolute statistical superiority to achieve the highest aggregate leaf width (12.85 cm), while the uninoculated control B_5 (No biofertilizer) regularly produced the lowest (11.32 cm). When evaluating their interaction, the combined treatment O_2B_3 (Vermicompost at 12 t/ha + PSB at 5 kg/ha) displayed distinctive dominance by capturing peak integrated leaf widths of 14.36 cm, whereas the dual omission in O_4B_5 (FYM at 30 t/ha + No biofertilizer) locked in the absolute lowest corresponding means of 10.79 cm. This structural expansion in leaf width is driven by a highly optimized rhizosphere environment. The superior efficacy of vermicompost is primarily attributed to enhanced nutrient assimilation, accelerated meristematic activity and the hormone-like effects of earthworm casts that stimulate the uptake of essential micronutrients like iron and magnesium, while humic acids increase cell wall elasticity. Concurrently, the PSB leverage their specialized capacity to solubilize insoluble phosphorus into plant-available forms, which accelerates cell division and elongation to enhance overall vegetative development and expand the shoot canopy. These aggregated outcomes are strongly supported by prior scientific literature. Chamroy *et al.* (2015) [14] and Riya Tirkey *et al.* (2020) [15] both demonstrated that vermicompost treatments exert a highly positive, direct impact on stimulating the uptake of essential nutrients for leaf expansion. On the microbial side, Singh (2013) [9] explicitly confirmed that a 5 kg/ha application of PSB biofertilizer significantly maximized leaf width dimensions compared to untreated control crops. Furthermore, the outstanding performance of the integrated treatment matches the broader systemic findings of Kumar and Chanchan (2024) [13], who validated that combining organic amendments with targeted microbial inoculants provides a synergistic dynamic that optimizes vegetative structures and leaf development.

6. Leaf area (cm) [2]

The aggregated pooled findings revealed that the photosynthetic canopy size of black turmeric was markedly altered by the single and combined inputs of organic manures (O) and biofertilizers (B). Evaluated independently, plots amended with O_2 (Vermicompost at 12 t/ha) developed the largest leaf area (429.45 cm [2]), whereas

O_4 (FYM at 30 t/ha) generated the lowest surface expansion (328.92 cm [2]). Simultaneously, the biofertilizer inoculation B_3 (PSB at 5 kg/ha) led the microbial treatments by securing a maximum average leaf area of 420.67 cm [2], contrasting with the uninoculated control B_5 (No biofertilizer), which finished at a minimum baseline of 332.35 cm [2]. When looking at the interplay between both factors, the integrated treatment O_2B_3 (Vermicompost at 12 t/ha + PSB at 5 kg/ha) demonstrated definitive superiority by driving the pooled leaf area to its absolute peak of 516.69 cm [2]. Conversely, the dual omission of quality organic matter and microbes in O_4B_5 (FYM at 30 t/ha + No biofertilizer) severely limited canopy development, recording the absolute lowest mean of 288.93 cm [2]. This substantial expansion in the leaf canopy is driven by a harmonized structural and physiological mechanism. The superior efficacy of vermicompost stems from the direct expansion of underlying leaf parameters (length and width), optimizing the total photosynthetic architecture. Simultaneously, the PSB trigger localized physiological cascades through phosphorus mobilization, accelerating cell elongation, division and gibberellin production to maximize meristematic activity. In the integrated approach, the nutrient-dense humic components of vermicompost work in tandem with the phosphorus-unlocking mechanisms of PSB within an optimized rhizosphere, inducing synergistic microbial interactions that elevate cell wall elasticity and total leaf area expansion. These pooled growth dynamics are strongly supported by prior scientific literature. Mannikeri *et al.* (2010) [7], Kumar *et al.* (2016) [16], Joshi *et al.* (2017) [17] and Nirmalatha (2019) [18] all demonstrated that vermicompost treatments exert a highly positive, direct impact on expanding the leaf canopy of turmeric. On the microbial side, Velmurugan (2002) [19] and Khedkar (2023) [11] explicitly confirmed that PSB application significantly maximizes total leaf expansion compared to untreated crops. Furthermore, the outstanding performance of the integrated treatment matches the broader systemic findings of Macherla Chandana *et al.* (2022) [9] who validated that combining organic amendments with targeted microbial inoculants provides a synergistic dynamic that optimizes vegetative structures and leaf canopy development.

Table 1: Effect of organic manures and biofertilizers on plant height, number of leaves and number of tillers of black turmeric.

Treatment	Plant height						Number of leaves						Number of tillers					
	B_1	B_2	B_3	B_4	B_5	Mean	B_1	B_2	B_3	B_4	B_5	Mean	B_1	B_2	B_3	B_4	B_5	Mean
O_1	64.11	68.66	70.36	56.84	53.45	62.68	11.15	11.30	11.60	10.20	10.05	10.86	2.55	2.70	2.80	2.10	1.85	2.40
O_2	70.05	71.95	76.77	63.71	57.68	68.03	11.60	11.90	12.90	10.80	10.10	11.46	2.80	3.05	3.40	2.15	2.05	2.69
O_3	58.14	58.40	59.78	55.35	51.05	56.54	10.80	11.00	11.50	10.20	9.90	10.68	2.55	2.65	2.80	1.95	1.85	2.36
O_4	55.23	55.48	56.04	53.32	48.50	53.71	10.35	10.80	10.80	10.05	9.40	10.28	2.25	2.35	2.40	1.70	1.45	2.03
Mean	61.88	63.62	65.74	57.30	52.67		10.98	11.25	11.70	10.31	9.86		2.54	2.69	2.85	1.98	1.80	
	S.Em ±		CD at 5%		F- test		S.Em ±		CD at 5%		F- test		S.Em ±		CD at 5%		F- test	
O	0.449		1.329		SIG		0.027		0.080		SIG		0.025		0.074		SIG	
B	0.502		1.486		SIG		0.030		0.090		SIG		0.028		0.083		SIG	
O X B	1.004		2.972		SIG		0.060		0.179		SIG		0.056		0.166		SIG	

Table 2: Effect of organic manures and biofertilizers on leaf length, leaf width and leaf area of black turmeric.

Treatment	Leaf length						Leaf width						Leaf area					
	B_1	B_2	B_3	B_4	B_5	Mean	B_1	B_2	B_3	B_4	B_5	Mean	B_1	B_2	B_3	B_4	B_5	Mean
O_1	37.79	38.23	40.18	37.51	37.05	38.15	12.67	12.56	12.92	12.20	11.58	12.38	385.71	389.23	435.15	371.58	348.20	385.48
O_2	42.93	43.45	46.13	42.08	40.34	42.98	12.46	13.37	14.36	12.14	11.74	12.81	417.23	453.12	516.69	398.14	369.40	429.45
O_3	38.26	39.18	39.44	38.05	37.34	38.45	11.45	11.66	12.43	11.38	11.18	11.62	341.40	356.03	382.08	337.75	325.33	348.20
O_4	37.91	38.51	39.16	37.86	34.33	37.55	11.01	11.60	11.71	11.03	10.79	11.23	325.56	348.44	357.68	325.72	288.93	328.92
Mean	39.22	39.84	41.22	38.87	37.26		11.90	12.29	12.85	11.68	11.32		366.70	385.56	420.67	357.67	332.35	
	S.Em ±		CD at 5%		F- test		S.Em ±		CD at 5%		F- test		S.Em ±		CD at 5%		F- test	
O	0.165		0.488		SIG		0.048		0.143		SIG		2.532		7.496		SIG	
B	0.184		0.545		SIG		0.054		0.160		SIG		2.831		8.381		SIG	
O X B	0.368		1.090		SIG		0.108		0.320		SIG		5.663		16.762		SIG	

Conclusion

The integrated application of vermicompost at 12 t/ha combined with Phosphate-Solubilizing Bacteria (PSB) at 5 kg/ha provides an optimized rhizosphere environment. The synergistic interaction of nutrient-rich organic humic components with microbial phosphate mobilization maximizes nutrient uptake, cell division and vegetative architecture, offering an eco-friendly and highly effective agronomic strategy for the sustainable cultivation of black turmeric in the Konkan agro-climatic region.

References

1. Rajkumari S, Sanatombi K. Nutritional value, phytochemical composition, and biological activities of edible *Curcuma* species: A review. International Journal of Food Properties,2017:20(2):2668–2687.
2. Tamang S. Black turmeric (*Curcuma caesia* Roxb.) and its medicinal properties: A review. International Journal of Agriculture and Environmental Research,2022:8(1):168–175.
3. Chitra R. Conservation strategy for endangered medicinal plant - black turmeric (*Curcuma caesia*). Indian Forester, 2022, 148(1).
4. Jyotirmayee B. The impact of organic fertilizers on growth, yield, and rhizospheric bacterial diversity in black turmeric (*Curcuma caesia*). Angiotherapy,2024:8(1):51–59.
5. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, New Delhi, 1985.
6. Vadiraj BA, Siddagangaiah, Poti N. Effect of vermicompost on the growth and yield of turmeric. South Indian Horticulture,2004:46(3/6):176-179.

7. Mannikeri IM, Dharmatti PR, Shashidhar TR. Growth and yield of turmeric (*Curcuma longa* L.) as influenced by different organic manures. J. Ecobiology,2010:26(3/4):273-279.
8. Singh RP. Effect of bio-fertilizers and organic manures on growth and yield of turmeric (*Curcuma longa* L.). M.Sc. (Agri.) Thesis, J. N. K. V. V, Jabalpur, 2013.
9. Macherla C, Padma M, Prabhakar NB, Joshi V, Mahender B, Gouthami P, et al. Studies on effect of organic manures and biofertilizers on growth, yield and economics of turmeric (*Curcuma longa* L.) varieties. The Pharma Innovation J.,2022:11(11):824-832.
10. Bhende SS, Jessykutty PC, many, Duggi S, Magdum S, Handral HK, Shruthi SD. Studies on growth, yield and economic parameters of kasthuri turmeric (*Curcuma aromatica* Salisb.) under organic manuring practices. Int. J. Advancements in Res. and Tech.,2013:2(5):414-420.
11. Khedkar SP. Effect of organic manures and bio fertilizers on turmeric. Ph.D. (Hort.) Thesis, College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, 2023.
12. Mondal R, Hore JK. Studies on the impact of integrated nutrient management on growth and quality parameters of turmeric. Agricultural Science Digest,2024:1:1-6.
13. Kumar S, Chanchan M. Role of organic manures with inorganic and various biofertilizers on growth and yield of turmeric (*Curcuma longa* L.). Plant Archives,2024:24(1):938-944.
14. Chamroy T, Rajwade VB, Bajd VV. Effect of organic and inorganic manurial combinations on turmeric (*Curcuma longa* L.). Plant Archives,2015:15(1):67-69.
15. Tirkey R, Toppo P, Trivedi J. Effect of organic manure on growth and yield of tikhur (*Curcuma angustifolia* Roxb.) under eucalyptus (*Eucalyptus tereticornis*) based agro forestry system. The J. Rural and Agril. Res.,2020:20(2):76-79.
16. Kumar RK, Rao SN, Kumar NR. Effect of organic and inorganic nutrient sources on growth, quality and yield of turmeric (*Curcuma longa* L.). Green Farming,2016:7(4):889-892.
17. Joshi KK, Sharma G, Chandrakar T, Shankar D. Influence of graded doses of organic and inorganic nutrients on growth, yield and economics of tikhur (*Curcuma aungustifolia* Roxb.) in inceptisol of bastar plateau. Int. J. Curr. Microbiol. App. Sci.,2017:6(10):1269-1277.
18. Nirmalatha JD, Sulekha GR. Effect of organic manures on quality of kasthuri turmeric (*Curcuma aromatica* Salisb.) of high cosmetic value. Int. J. Sci. and Res.,2019:9(4):1125-1127.
19. Velmurugan M. Effect of Organic manures and biofertilizers on growth, yield and quality of turmeric (*Curcuma Longa* L.) cv. BSR-2. Ph.D. (Hort.) Thesis, Tamil Nadu Agricultural University, Coimbatore, 2002.