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Influence of organically derived formulations on the rhizosphere microbiome and keeping quality of onion (*Allium cepa* L.) under terrace cultivation

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ABSTRACT

A field experiment was conducted during the Kharif season of 2025–26 at the Terrace Farming Facility, Department of Agronomy, Post Graduate Institute, Dr. Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola, Maharashtra, to evaluate the effects of jeevamrut, vermiwash, humic acid, vermicompost, and chemical fertilizers on the rhizosphere soil microbial population in onion under terrace farming conditions. The experiment was laid out in a randomised block design (RBD) comprising six treatments with four replications. The treatments included organic and natural farming practices (jeevamrut, vermiwash, humic acid, recommended nitrogen through vermicompost), conventional practice (recommended dose of fertilisers through chemical sources), and an untreated control. Rhizosphere soil samples were collected at 30, 50, and 70 days after planting and analysed for bacterial, fungal, and actinomycete populations using the serial dilution plate count method at the Microbial Testing Laboratory, Organic Farming Laboratory, Dr. PDKV, Akola. The results indicated that various practices significantly influenced the soil microbial population. Among the treatments, application of the recommended nitrogen dose through vermicompost recorded the highest bacterial, fungal, and actinomycete populations, followed by vermiwash and jeevamrut, whereas the control treatment consistently showed the lowest microbial counts throughout the crop growth period. The control treatment showed the minimum physiological weight, sprouting, and rotting losses compared to the application of RDF through chemical sources. The findings showed that organic nutrient sources enhance soil biological activity, improve rhizosphere health and keeping quality of the onion under terrace farming conditions.

Keywords: Terrace farming, Organic, Natural, Onion, Soil microbial population, Vermicompost

Introduction

Terrace farming has become an important and sustainable form of urban agriculture, making productive use of rooftop spaces for vegetable cultivation. It enhances urban food security, promotes efficient use of available land, and supports environmental sustainability. In addition to supplying fresh vegetables, rooftop cultivation facilitates the recycling of organic waste, reduces heat absorption by buildings, and helps improve the urban microclimate. Specht *et al.* (2014) [1] introduced this concept as Zero-Acreage Farming, in which crop production is integrated into built environments rather than traditional agricultural land. Likewise, Orsini *et al.* (2013) [2] highlighted terrace farming as a practical approach to vegetable production in densely populated cities where cultivable land is scarce. Nevertheless, the limited rooting space and restricted growing media associated with terrace farming necessitate efficient nutrient management strategies to maintain soil fertility and sustain biological activity.

Onion (*Allium cepa* L.) is one of the most widely cultivated commercial vegetable crops worldwide, valued for its high nutritional, medicinal, and economic value. It is consumed extensively in both fresh and processed forms and serves as a valuable source of carbohydrates, vitamins, minerals, and antioxidant compounds (Pareek *et al.*, 2018; Srivastava *et al.*, 2022) [3, 4]. A biologically active rhizosphere is crucial for sustaining onion production, as soil microorganisms decompose organic residues, mineralise nutrients, and maintain soil fertility, thereby supporting healthy crop growth.

Biofertilization has emerged as an environmentally sustainable strategy for enhancing soil health and maintaining long-term crop productivity. Jeevamrut, a fermented organic preparation, promotes soil microbial activity and accelerates nutrient mineralisation by increasing the population of beneficial microorganisms (Devakumar *et al.*, 2014; Boraiah *et al.*, 2017) [6, 5]. Vermiwash, a liquid organic biofertiliser, contains beneficial microorganisms, enzymes, macro- and micronutrients, and plant growth-promoting substances that enhance microbial activity within the rhizosphere (Sivasubramanian *et al.*, 2004; Sharma *et al.*, 2023) [8, 7]. Likewise, humic acid improves soil structure, increases cation exchange capacity, and enhances nutrient-use efficiency, whereas vermicompost enriches the growing medium with organic carbon and diverse beneficial

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microorganisms, thereby improving the biological properties of the soil (Ampong *et al.*, 2022; Sarangthem & Salam, 2014) [9, 10]. Although inorganic fertilisers ensure an immediate supply of essential nutrients for plant growth, maintaining long-term soil fertility requires the integrated use of organic nutrient sources to preserve microbial diversity and sustain soil biological health (Verma *et al.*, 2012) [11].

Post-harvest spoilage accounts for 16 to 35 per cent of onion losses. Such losses may be higher than estimated in tropical nations (Poonam *et al.*, 2022) [12]. These losses include physiological weight loss (PLW), which comprises moisture loss and weight loss (30-40%), decay (10-12%), and germination (8-10%). Significant storage losses result from weight loss during the dry months, when temperatures are high and humidity is low. Despite advances in production technology, post-harvest damage during storage continues to cause significant losses in tropical countries, according to Tripathi and Lawande (2018).

Soil microorganisms, particularly bacteria, fungi, and actinomycetes, are widely recognised as key indicators of soil biological fertility due to their vital roles in organic matter decomposition and nutrient cycling. Although the use of organic and natural nutrient sources in vegetable production has increased considerably, information on their effects on rhizosphere microbial populations and the keeping quality of onions grown under terrace farming conditions remains scarce. Therefore, the present study was undertaken to assess the influence of organic, natural, and conventional farming practices on the populations of bacteria, fungi, and actinomycetes in the rhizosphere of onions cultivated under terrace farming and on their keeping quality.

Materials and mMethods

A field experiment was conducted during the Kharif season of 2025–26 at the Terrace Farming Facility, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola, Maharashtra, to evaluate the effects of jeevamrut, vermiwash, humic acid, vermicompost, and chemical fertilizers on the rhizosphere soil microbial population in onion under terrace farming conditions. The experiment was laid out in a randomized block design (RBD) with six treatments and four replications, using the onion variety Phule Samarth. Treatments comprised fertigation with jeevamrut, vermiwash, and humic acid at 20, 40, and 60 DAP; recommended nitrogen through vermicompost; recommended dose of fertilisers (RDF); and an absolute control. Rhizosphere soil samples were collected at 30, 50, and 70 DAP and analysed for bacterial, fungal, and actinomycete populations using the serial dilution plate count method at the Microbial Testing Laboratory, Organic Farming Laboratory, Dr.

PDKV, Akola. Microbial populations were expressed as CFU g⁻¹ soil. The physiological weight loss, sprouting loss, and rotting loss were estimated as described by Poonam *et al.* (2022) [12], and the experimental data were analysed statistically using the standard procedure for Randomised Block Design.

Table 1. Treatment details

Sr. No.	Symbol	Details
1.	T ₁	Fertigation of Jeevamrut at 20, 40 and 60 DAP
2.	T ₂	Fertigation of Vermiwash at 20, 40 and 60 DAP
3.	T ₃	Fertigation of Humic Acid at 20, 40 and 60 DAP
4.	T ₄	RDN through Vermi Compost
5.	T ₅	RDF through Chemical sources
6.	T ₆	Absolute Control

Result and Discussion

The effects of different biofertilisation treatments on the rhizosphere microbial population of onion are presented in Table 2. Significant variations in the populations of bacteria, fungi, and actinomycetes were observed among the treatments at 30, 50, and 70 days after planting (DAP). In general, the microbial population increased from 30 to 50 DAP and then declined slightly at 70 DAP. This trend may be associated with vigorous root development and increased availability of organic substrates during the vegetative growth phase, followed by a gradual reduction in microbial activity as the crop approached maturity.

Among the organic and natural farming treatments, T₄ (the recommended nitrogen dose via vermicompost) recorded the highest bacterial population, with values of 36.23, 44.48, and 32.48 × 10⁶ CFU g⁻¹ soil at 30, 50, and 70 DAP, respectively. The same treatment also produced the highest actinomycete population (14.88, 16.25, and 13.70 × 10³ CFU g⁻¹ soil) during the corresponding observation periods. For the fungal population, T₄ recorded the highest value (7.05 × 10⁵ CFU g⁻¹ soil) at 30 DAP, whereas at 50 and 70 DAP its performance was statistically comparable with T₂ (Vermiwash), with both treatments recording 8.20 and 5.93 × 10⁵ CFU g⁻¹ soil, respectively. In contrast, the absolute control (T₆) consistently exhibited the lowest bacterial, fungal, and actinomycete populations throughout the experimental period.

Table 2. Rhizosphere microbial population (CFU/g soil) of substrate in Kharif season as influenced by different treatments

Treatments	Rhizosphere microbial population of substrate								
	Kharif season								
	Bacteria (10 ⁶ CFU/g soil)			Fungi (10 ⁵ CFU/g soil)			Actinomycetes (10 ³ CFU/g soil)		
	30 DAP	50 DAP	70 DAP	30 DAP	50 DAP	70 DAP	30 DAP	50 DAP	70 DAP
T ₁	35.95	43.45	31.68	6.93	8.05	5.90	14.10	14.73	12.97
T ₂	36.18	43.68	32.20	6.95	8.20	5.93	14.45	14.98	13.33
T ₃	35.35	43.33	31.58	6.80	7.85	5.88	14.05	14.83	12.95
T ₄	36.23	44.48	32.48	7.05	8.20	5.93	14.88	16.25	13.70
T ₅	34.70	43.20	30.60	6.45	7.65	5.33	13.73	14.70	12.45
T ₆	32.83	40.35	28.23	6.25	7.43	5.13	13.10	14.60	12.03
SE(m)+	0.73	0.78	0.90	0.11	0.16	0.13	0.20	0.33	0.23
CD (P = 0.05 %)	2.19	2.34	2.70	0.34	0.47	0.38	0.60	1.00	0.69
CV (%)	4.14	3.60	5.75	3.33	3.96	4.47	2.84	4.42	3.56
GM	35.20	43.07	31.12	6.73	7.89	5.67	14.05	15.01	12.90

The enhanced microbial population observed with the application of vermicompost may be attributed to its high organic matter content,

the slow, sustained release of nutrients, and the abundance of beneficial microorganisms that create favourable conditions for microbial

growth in the rhizosphere. Likewise, the application of Jeevamrut and Vermiwash resulted in higher populations of bacteria, fungi, and actinomycetes than chemical fertiliser and control treatments, owing to their rich microbial diversity, enzyme content, and plant growth-promoting compounds that enhance soil biological activity. These findings align with reports by Devakumar *et al.* (2014) [6], Talwar *et al.* (2017) [13], Arunachalam *et al.* (2024) [14], Godase *et al.* (2024) [15], Mukherjee *et al.* (2024) [16], and Naik *et al.* (2026) [17], which also observed improved microbial activity and enhanced soil biological properties following the use of organic nutrient sources.

Physiological loss in weight (%) of onion

The data pertaining to physiological loss in weight (PLW), sprouting losses and rotting losses of onion bulbs during storage as influenced by different nutrient management practices in the *Kharif* season are presented in Table 3. Significant differences among the treatments were observed for all storage parameters. The Absolute Control recorded the lowest physiological loss in weight throughout the storage period, with values of 1.71, 2.10, 3.17 and 3.16% at 15, 30, 45 and 60 days of storage, respectively, resulting in the minimum cumulative PLW (10.13%). It also registered the lowest total sprouting loss

(7.04%) and total rotting loss (6.10%). This was closely followed by fertigation of humic acid at 20, 40 and 60 DAP, which recorded a total PLW of 10.68%, total sprouting loss of 7.42% and total rotting loss of 6.60%. In contrast, RDF through Chemical Sources exhibited the highest cumulative physiological loss in weight (13.30%), total sprouting (10.37%) and total rotting losses (8.54%), followed closely by RDN through vermicompost. Among the liquid organic nutrient treatments, fertigation of vermiwash at 20, 40 and 60 DAP (T_2) showed comparatively lower storage losses than fertigation of jeevamrut at 20, 40 and 60 DAP.

Post-harvest storage behaviour reflects pre-harvest nutrient balance, bulb moisture content, cell wall structure, and membrane integrity. Chemical fertilization (T_5) produces larger bulbs with thinner outer neck scales and higher tissue moisture, increasing transpiration and respiration rates during storage. Higher residual N levels can also delay dormancy breaking, increasing sprout susceptibility. Conversely, unfertilized control bulbs (T_6) develop thicker protective scales and lower internal moisture, reducing moisture loss and rot susceptibility. These patterns confirm findings by Tripathi *et al.* (2013) [18], Gorrepati *et al.* (2018) [19], and Madalageri *et al.* (2022) [20].

Table 3. PLW (%), Sprouting (%), Rotting (%) and Total Losses (%) of Onion during storage as influenced by different treatments during *kharif* season.

Treatments	Kharif season										
	PLW (%)				Sprouting losses (%)			Rotting losses (%)			
	15	30	45	60	Total	45	60	Total	45	60	Total
T_1	1.89	2.39	3.58	3.99	11.84	3.39	5.33	8.72	3.26	4.40	7.67
T_2	1.87	2.49	3.43	3.96	11.75	3.48	5.07	8.55	3.23	4.39	7.62
T_3	1.82	2.27	3.11	3.49	10.68	3.25	4.17	7.42	3.11	3.49	6.60
T_4	2.08	2.52	4.18	4.28	13.06	3.82	6.11	9.92	3.45	4.89	8.33
T_5	2.19	2.54	4.22	4.36	13.30	4.11	6.26	10.37	3.47	5.08	8.54
T_6	1.71	2.10	3.17	3.16	10.13	2.99	4.06	7.04	2.94	3.16	6.10
SE_m^+	0.04	0.13	0.07	0.13	0.18	0.12	0.18	0.13	0.17	0.17	0.23
$CD(P = 0.05\%)$	0.12	0.38	0.20	0.40	0.54	0.36	0.53	0.38	0.52	0.51	0.70
CV (%)	4.12	10.71	3.73	6.87	3.04	6.87	6.84	2.92	10.61	8.00	6.23
GM	1.92	2.38	3.61	3.87	11.79	3.50	5.16	8.66	3.24	4.23	7.47

Conclusion

The findings of the present study revealed that biofertilisation practices significantly affected the rhizosphere microbial population of onions grown under terrace farming conditions. Among the treatments, applying the recommended dose of nitrogen through vermicompost produced the highest populations of bacteria, fungi, and actinomycetes, followed by Vermiwash and Jeevamrut. In contrast, the absolute control treatment consistently recorded the lowest microbial counts throughout the crop growth period. The physiological weight, sprouting, and rotting losses were higher with the application of RDF and were minimum with the absolute control. Overall, the results suggest that using organic nutrient sources enhances soil biological activity, improves rhizosphere health, keeping quality, and supports sustainable nutrient management practices in terrace farming systems.

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