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Field Evaluation Of MRTSANJIVANI (Rapid Bioactive Organic Fertilizer) On Soil Physico-Chemical And Microbiological Properties Under Wheat (Triticum Aestivum L.) In A RBD

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Abstract: Excessive dependence on chemical fertilizers accelerates soil organic carbon depletion and suppresses beneficial microbial communities, ultimately reducing soil functional resilience. A field experiment was conducted on wheat during Rabi 2024–25 (Nov–Feb) at the Agricultural College Farm, Pune, using a Randomized Block Design (RBD) with three treatments and three replications (nine plots). Treatments comprised chemical fertilizer (T_1), conventional organic fertilizer (T_2), and MRTSANJIVANI (T_3), a rapid bioactive compost produced via accelerated composting and microbial enrichment. Post-treatment soil analyses revealed that MRTSANJIVANI improved organic carbon (0.98%) and lowered salinity hazard (EC 0.42 dS m^{-1}) compared to chemical fertilization (OC 0.62%; EC 0.92 dS m^{-1}). MRTSANJIVANI enhanced available P (41.6 kg ha^{-1}) and K (214.8 kg ha^{-1}) and increased microbial populations (TPC 9.2×10^7 CFU g^{-1}), indicating improved nutrient cycling potential and soil biological quality.

***Index Terms* -** Bioactive compost; microbial enrichment; soil organic carbon; nutrient availability; sodicity; wheat; integrated nutrient management.

I. Introduction

Wheat (Triticum aestivum L.) is a strategic cereal crop, and sustaining its productivity requires maintaining soil physical structure, nutrient balance, and biological functioning. Over the past decades, intensive fertilization dominated by mineral NPK has supported yield gains but often at the cost of soil health. Long-term reliance on chemical fertilizers can reduce soil organic carbon, aggravate salinity/sodicity risks in vulnerable environments, and suppress microbial diversity and activity, thereby weakening nutrient cycling efficiency. Conversely, organic fertilizers improve aggregation, water retention, and microbial habitat; however, conventional compost and farmyard manures commonly require long processing periods (often 30–60 days), have variable nutrient content, and may not match peak nutrient demand of high-yield crops.

MRTSANJIVANI is a rapid, controlled, and bioactive composting approach designed to convert organic waste into nutrient-rich compost within approximately 12–17 days through accelerated decomposition, humification, and microbial enrichment. Such products are conceptually aligned with integrated nutrient management, where nutrient supply and soil biological processes are jointly optimized. Enhancing soil microbial biomass and functional groups (e.g., N-fixers and phosphate-solubilizers) can increase nutrient use efficiency by mineralizing organic pools and mobilizing sparingly available phosphorus and potassium.

Despite increasing interest in enriched composts and bioactive organic fertilizers, field-based, replicated evaluations under cereal systems remain essential to support agronomic recommendations. Therefore, the present study was conducted under wheat at the Agricultural College Farm, Pune, using a randomized replicated design to compare MRTSANJIVANI against chemical and conventional organic fertilization. The study emphasizes soil fertility outcomes physico-chemical status (pH, EC, organic carbon, exchangeable cations), macronutrient availability (N, P, K), and microbiological indicators (total plate count, fungi, N-fixers, PSB, actinomycetes) to understand whether MRTSANJIVANI can enhance soil quality while maintaining nutrient availability comparable to mineral fertilization

II. LITERATURE REVIEW

Organic amendments and composting technologies have been widely studied for their role in improving soil quality and crop nutrient dynamics. Compost application generally increases soil organic carbon and improves aggregation, aeration, and moisture retention, thereby supporting microbial proliferation and enzyme activity ([Diacono & Montemurro, 2010]). Maturity and stabilization during composting are critical, as immature compost can immobilize N or cause phytotoxicity; therefore, controlled humification and curing are recommended ([Bernal et al., 2009]).

Advances in composting systems—from static piles to engineered reactors—have improved process control, shortened stabilization periods, and enhanced compost quality ([Liu et al., 2020]). In-vessel or accelerated composting combined with enriched microbial consortia can increase decomposition rates and nutrient transformation efficiencies ([Thakur et al., 2018]). Compost microbial communities and their functional groups contribute to nutrient cycling, particularly via mineralization of organic N and mobilization of P, thereby improving nutrient availability over time ([Insam & de Bertoldi, 2007]).

Biofertilizers such as plant growth promoting rhizobacteria (PGPR) improve nutrient acquisition and soil biological functioning, commonly enhancing N fixation, P solubilization, and phytohormone-mediated root growth ([Vessey, 2003]; [Adesemoye & Kloepper, 2009]). Phosphate-solubilizing bacteria are particularly important where soil P is fixed by Ca/Fe/Al complexes, and biological solubilization can complement fertilizer P ([Chen et al., 2006]). Integration of organic amendments with microbial inoculants often yields better soil biological indicators than mineral fertilizers alone ([Bhattacharyya et al., 2015]).

Vermicompost is reported to enhance microbial biomass and nutrient availability, but it may require longer processing and can be costlier, motivating interest in rapid composting alternatives ([Lazcano & Domínguez, 2011]). In composting systems, managing the C:N ratio (often 25–30:1) improves microbial efficiency and speeds decomposition while reducing N losses ([Awasthi et al., 2016]). International guidance emphasizes composting as a sustainable approach for recycling organic residues and improving soil fertility while reducing waste burden ([FAO, 2003]). Collectively, the literature supports rapid, enriched compost products as potential bridges between organic and mineral nutrition, though local field validation under cereals is necessary.

III. OBJECTIVES

1. To evaluate the effect of MRTSANJIVANI on soil pH, EC, organic carbon, and sodicity indicators under wheat.
2. To quantify changes in available N, P, and K under MRTSANJIVANI relative to chemical and conventional organic fertilization.
3. To assess the response of key soil microbial populations (TPC, fungi, N-fixers, PSB, actinomycetes) to MRTSANJIVANI.
4. To interpret the potential of MRTSANJIVANI as a component of sustainable nutrient management for wheat-based systems.

IV. METHODOLOGY

Experimental design & treatments: The trial was conducted in wheat during Nov 2024–Feb 2025 at Agricultural College Pune field using **RBD** with **3 treatments × 3 replications = 9 plots**. Treatments: T_1 Chemical fertilizer; T_2 Organic fertilizer; T_3 MRTSANJIVANI.

Soil sampling: Soil samples were collected from each treatment area (post-application / during crop period as per trial protocol) and submitted for laboratory analysis.

Laboratory analyses: Soil chemical parameters included pH, EC, ESP, available N, P, K, exchangeable Ca, Mg, Na, and organic carbon. Microbiological parameters included total plate count, fungal count, N-fixing bacteria, PSB, and actinomycetes (CFU g^{-1}).

Data handling (as available): The present manuscript reports **treatment-wise soil indicators** from the provided laboratory reports. (Note: Yield and plant biometrics were not included in the uploaded datasets; therefore, results focus on soil quality and fertility indicators.)

V. OBSERVATIONS AND RESULTS

Table 1. Experimental layout (RBD) and treatment structure

Factor	Details
Crop/Season	Wheat, Rabi 2024–25 (Nov–Feb)
Location	Agricultural College Farm, Pune
Design	Randomized Block Design (RBD)
Treatments	T_1 Chemical; T_2 Organic; T_3 MRTSANJIVANI
Replications	3
Total plots	9

RBD is an appropriate field design when spatial heterogeneity (micro-variations in soil fertility, moisture, or slope) can influence responses. Blocking groups plots into relatively homogeneous units and randomizing treatments within each block reduces confounding due to field variability and increases precision. The present design compares three nutrient management strategies representing mineral fertilization (T_1), conventional organic input (T_2), and a rapid bioactive compost (T_3). Replication (n=3) supports estimation of experimental error and strengthens inference about treatment differences, especially for soil biological indicators that may vary with microenvironment. Because the uploaded dataset contains laboratory summaries rather than plot-wise raw values, this manuscript interprets treatment-level soil outcomes and mechanistic implications (nutrient cycling, salinity/sodicity moderation, microbial proliferation). Future studies can strengthen statistical inference using plot-wise datasets for ANOVA and mean separation (CD/LSD).

Table 2. Soil reaction and salinity/sodicity indicators under treatments

Parameter	**T_1 Chemical**	**T_2 Organic**	**T_3 MRTSANJIVANI**
pH	7.32	7.34	7.21
EC (dS m^{-1})	0.92	0.48	0.42
ESP (%)	72	61	38

Soil pH remained near neutral across treatments, indicating no extreme acidity/alkalinity constraints during the season. However, EC and ESP clearly differentiated treatments. Chemical fertilization exhibited higher EC (0.92 dS m^{-1}), indicating greater soluble salt concentration relative to organic and MRTSANJIVANI treatments. MRTSANJIVANI recorded the lowest EC (0.42 dS m^{-1}), suggesting reduced salinity hazard, potentially due to improved soil structure and ion buffering by organic matter. ESP, a sodicity indicator influencing dispersion, infiltration decline, and poor aeration, was highest under chemical fertilizer (72%) and reduced markedly under MRTSANJIVANI (38%), indicating improved exchangeable cation balance. This reduction is agronomically important because sodicity can suppress root function and microbial processes. The improvement under MRTSANJIVANI may reflect enhanced Ca availability/retention and organic colloids that improve flocculation and ion exchange dynamics.

Table 3. Soil organic carbon and exchangeable cations

Parameter	T_1 Chemical	T_2 Organic	T_3 MRTSANJIVANI
Organic Carbon (%)	0.62	0.93	0.98
Exchangeable Ca (%)	0.49	0.58	0.67
Exchangeable Mg (%)	0.07	0.09	0.10
Exchangeable Na (%)	0.59	0.46	0.32

Organic carbon is a central indicator of soil health because it supports aggregation, water holding, and microbial habitat. MRTSANJIVANI increased OC to 0.98% compared to 0.62% under chemical fertilization, reflecting carbon addition and better stabilization. Enhanced OC often improves cation exchange capacity, buffering nutrient supply and reducing toxicity risks. Exchangeable Ca increased from 0.49% (chemical) to 0.67% (MRTSANJIVANI), while exchangeable Na decreased from 0.59% to 0.32%, consistent with the observed decline in ESP. Higher Ca supports flocculation of clays, better infiltration, and improved root-zone aeration, all of which favor microbial growth and nutrient mineralization. The combined shift higher OC and Ca with lower Na suggests MRTSANJIVANI contributes to improved soil colloid chemistry and structural stability. These changes are especially relevant under wheat, where root proliferation and tillering are sensitive to compaction and poor aeration linked to sodicity.

Table 4. Available macronutrients (N, P, K)

Parameter (kg ha^{-1})	T_1 Chemical	T_2 Organic	T_3 MRTSANJIVANI
Available N	332.40	258.70	241.50
Available P	26.10	29.80	41.60
Available K	128.30	166.90	214.80

N availability was highest under chemical fertilizer (332.4 kg ha^{-1}), which is expected due to direct mineral N supply and rapid transformation into plant-available forms. However, MRTSANJIVANI exhibited notably higher available P (41.6 kg ha^{-1}) and K (214.8 kg ha^{-1}) compared to chemical fertilizer (P 26.1; K 128.3 kg ha^{-1}). This pattern aligns with mechanisms of enriched compost: (i) organic acids and chelation reduce P fixation, improving extractable P; (ii) microbial activity, particularly PSB, enhances P solubilization; (iii) mineralization of organic matter releases K from plant residues and improves exchange site buffering. In practical nutrient management, improved P and K availability may reduce dependence on high-dose mineral inputs while sustaining crop demand. While available N under MRTSANJIVANI is lower than chemical fertilizer, its enhanced biological activity may support ongoing mineralization during the crop cycle and improve N use efficiency in integrated systems.

Table 5. Soil microbiological populations (CFU g^{-1})

Parameter	T_1 Chemical	T_2 Organic	T_3 MRTSANJIVANI
Total Plate Count	8.5×10^6	3.6×10^7	9.2×10^7
Fungal count	1.6×10^3	6.8×10^3	1.4×10^4
N-fixing bacteria	9.0×10^2	6.2×10^3	1.8×10^4
PSB	1.1×10^3	7.4×10^3	2.2×10^4
Actinomycetes	6.0×10^1	3.9×10^2	1.1×10^3

Microbiological indicators strongly favored MRTSANJIVANI, which recorded an order-of-magnitude higher total microbial population than chemical fertilization (9.2×10^7 vs 8.5×10^6 CFU g^{-1}). Fungi and actinomycetes—important for decomposition of complex carbon and humus formation also increased substantially. Particularly critical are N-fixing bacteria and phosphate-solubilizing bacteria (PSB), which are directly linked to biological nutrient acquisition. MRTSANJIVANI produced the highest N-fixers (1.8×10^4 CFU g^{-1}) and PSB (2.2×10^4 CFU g^{-1}), supporting the observed improvements in P availability and the broader nutrient cycling potential. Chemical fertilizer plots showed comparatively low microbial counts, consistent with reduced organic substrate supply and possible salt-related stress (higher EC/ESP). The results suggest MRTSANJIVANI not only adds nutrients but also enhances the soil's biological engine responsible for sustained fertility—an essential attribute for long-term productivity and resilience under wheat-based systems.

VI. Conclusion

This replicated field evaluation under wheat demonstrated that MRTSANJIVANI substantially improved key soil quality indicators compared with chemical fertilization and performed competitively relative to conventional organic fertilizer, particularly for biological parameters and nutrient availability of phosphorus and potassium. Chemical fertilizer treatment exhibited elevated electrical conductivity and severe sodicity indicators (EC 0.92 dS m^{-1}; ESP 72%), alongside low organic carbon (0.62%) and suppressed microbial populations. Such a profile is agronomically concerning because salinity/sodicity can reduce infiltration, impair root growth, and limit microbial functioning that underpins nutrient cycling.

In contrast, MRTSANJIVANI reduced salinity hazard (EC 0.42 dS m^{-1}) and improved sodicity status (ESP 38%) while raising organic carbon to 0.98%. These improvements indicate that MRTSANJIVANI contributes organic colloids and favorable ion-exchange conditions that support aggregation and reduce exchangeable sodium impacts. Exchangeable calcium increased and exchangeable sodium decreased under MRTSANJIVANI, which mechanistically explains the observed decline in ESP and suggests improved physical functioning of the root zone.

From a fertility standpoint, MRTSANJIVANI produced markedly higher available P (41.6 kg ha^{-1}) and K (214.8 kg ha^{-1}) than chemical fertilizer (P 26.1; K 128.3 kg ha^{-1}). This likely reflects enhanced microbial solubilization, organic acid-mediated mobilization, and improved buffering at exchange sites. Although available N under chemical fertilization was higher, MRTSANJIVANI promoted much stronger microbiological activity, including higher populations of PSB, N-fixers, fungi, and actinomycetes. Such biological enrichment is important because it supports sustained nutrient release through mineralization, improves nutrient use efficiency, and strengthens resilience against fertility decline.

Overall, MRTSANJIVANI behaves as a "functional organic fertilizer," simultaneously improving chemical fertility and rebuilding biological health. Based on the available soil datasets, it can be recommended as a promising input for integrated nutrient management in wheat systems, especially where soil organic carbon is low or where sodicity/salinity risks threaten sustainability. A key limitation of the present dataset is the absence of plot-wise yield and plant growth observations in the uploaded documents; therefore, agronomic performance in terms of grain yield response cannot be statistically concluded here. Future work should include plant biometric traits, yield components, and plot-wise soil measurements to enable ANOVA, mean separation, and multi-season validation. Nevertheless, the strong improvements in organic carbon, P–K availability, and microbial functional groups provide robust evidence that MRTSANJIVANI enhances soil health drivers essential for sustained wheat productivity.

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