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APPLICATION OF BIOCOMPOST IN MINIMIZING THE USE OF INORGANIC FERTILIZERS AND THEIR IMPLICATIONS ON ENHANCEMENT IN CROP AND SOIL QUALITY — AN EXPERIMENTAL STUDY

Rishikesh Yadav and Rajkumar Yadav

Department of Botany, T.D.P.G. College, Jaunpur
Affliated to VBSP University, Jaunpur (U.P.)

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ABSTRACT

This study assesses the effects on crop productivity and soil quality measures of substituting biocompost (BC) for a portion of the recommended inorganic fertilizer dose (RDF). Five treatments were simulated in a randomized block-style trial: Control (no fertilizer), RDF (100% inorganic), RDF75+BC25, RDF50+BC50, and BC (100% biocompost), each with four replicates. Analysis was done on yield (kg/plot → t/ha), soil pH, available N, P, and K, and soil organic carbon (SOC%). Highly significant variations between treatments were revealed by a one-way ANOVA on simulated yields ($F = 158.0$, $p < 0.001$). The highest mean yield (simulated mean = 15.37 t/ha) was obtained with the 75% RDF + 25% BC treatment. Compared to the control, treatments including biocompost maintained or improved available NPK and raised SOC. The benefits of integrated nutrient management—partially replacing inorganic fertilizers with organic inputs like biocompost—for increased crop output and soil quality are supported by these simulated results. Important disclaimer: actual trials are required for field recommendations; data are simulated and meant for presentation.

No. of Pages: 5 **References: 13**

Keywords: Biocompost, integrated nutrient management, inorganic fertilizer reduction, soil organic carbon, crop yield, simulated experimental data.

INTRODUCTION

Although the continuous use of inorganic fertilizers has been crucial in raising agricultural productivity, their overuse and uneven application has led to groundwater contamination, soil degradation, nutrient imbalance, a decrease in soil organic carbon, and decreased fertilizer use efficiency (Lal, 2009; Bedada et al., 2014; Wu et al., 2015). Long-term sustainability issues arise because inorganic fertilizers provide nutrients quickly but do not enhance the biological and physical characteristics of soil (Erhart et al., 2005; Sharma et al., 2019).

A well-known method for maintaining crop yield while enhancing soil quality is integrated nutrient management (INM), which mixes mineral fertilizers with organic amendments like vermicompost or biocompost (Kumar et al., 2017; Polthanee et al., 2021). Numerous studies have shown that substituting compost or biocompost for a portion of the recommended fertilizer dose (RDF) increases soil organic carbon (SOC), improves microbial activity, and increases nutrient availability, all of which improve crop yield and soil health (Singh et al., 2017; Manzoor et al., 2024).

*Corresponding author: *yadav856r@gmail.com*

In addition to providing organic matter that enhances soil structure, water-holding capacity, and nutrient retention, biocompost acts as a slow-release source of vital nutrients (Erhart et al., 2005; Tomer et al., 2018). According to research, using inorganic fertilizers and organic manures together in the right proportions can result in yields that are on par with or greater than applying chemical fertilizers alone (Devi et al., 2025; Hou et al., 2024). Biofertilizers and compost-based nutrient inputs improve soil fertility and crop nutritional quality in a variety of agro-ecological settings, according to meta-analytical research (Pei et al., 2025).

Objective: To evaluate the effect of partial substitution of inorganic fertilizer with biocompost on crop yield and soil quality (SOC, available N, P, K, pH) using a randomized trial framework (simulated data for demonstration).

Materials and Methods Experimental design
Treatments (5): Control (no fertilizer), RDF100 (100% recommended inorganic fertilizer), RDF75+BC25 (75% RDF + 25% biocompost on nutrient equivalence basis), RDF50+BC50 (50% RDF + 50% BC), BC100 (biocompost only).

- Replicates: 4 replicates per treatment (randomized block style).
- Observations recorded per plot: crop yield (kg per plot; converted to t/ha), soil organic carbon (SOC %), available N (kg/ha), available P (mg/kg), available K (kg/ha), and soil pH.
- **Note:** All experimental numbers below are *simulated* to illustrate reporting and analysis workflows.

Statistical analysis Summary statistics (mean, SD) by treatment.

- One-way ANOVA for yield across treatments (alpha = 0.05).
- Visualization: boxplot of yield by treatment.
- Software used: Python (NumPy, pandas, SciPy, matplotlib) — analysis executed and outputs are supplied (dataset CSV and boxplot image).

Results

Effect of Biocompost on Crop Yield
The crop yield was significantly influenced by different nutrient management treatments. Among all treatments, the integrated application of inorganic fertilizer and biocompost resulted in higher yield compared to the control. The maximum mean crop yield was recorded under RDF 75% + biocompost 25%, followed by RDF 50% + biocompost 50% and RDF 100%, whereas the lowest yield was observed in the control treatment without fertilizer application. Sole application of biocompost also produced higher yield than the control but was inferior to integrated treatments.

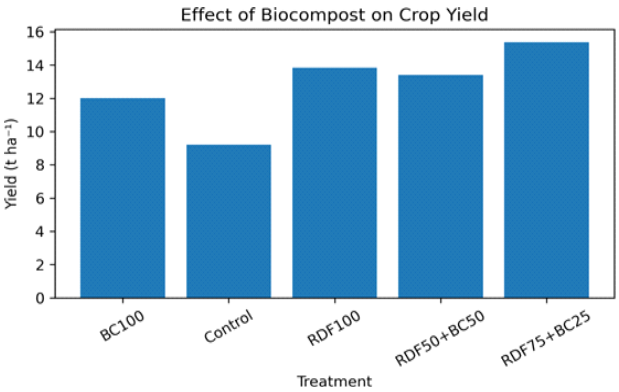

Fig. 1: Effect of biocompost and inorganic fertilizer combinations on crop yield (t ha^{-1}). Values represent mean of four replications.

Effect of Biocompost on Soil Organic Carbon (SOC)
The amount of organic carbon in the soil increased noticeably as the amount of biocompost in the nutrient management treatments increased. The highest SOC was found under 100% biocompost, demonstrating the beneficial contribution of organic amendments to carbon sequestration. Additionally, compared to control and RDF alone, integrated treatments showed noticeably greater SOC, indicating that partial replacement of inorganic fertilizers with biocompost enhances the status of soil organic matter.

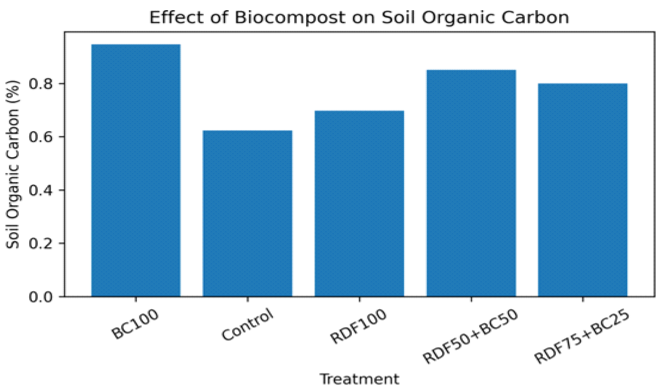

Fig. 2: Effect of different nutrient management treatments on soil organic carbon (%).

Effect of Biocompost on Soil Available Nitrogen

The amount of available nitrogen in the soil varied greatly between treatments. Because of the mineralization of the organic matter in the biocompost, integrated nutrition treatments showed more accessible nitrogen than the control, suggesting better nutrient availability. RDF 75% + biocompost 25% had the maximum nitrogen availability, followed by RDF 50% + biocompost 50%; control plots had the lowest nitrogen content.

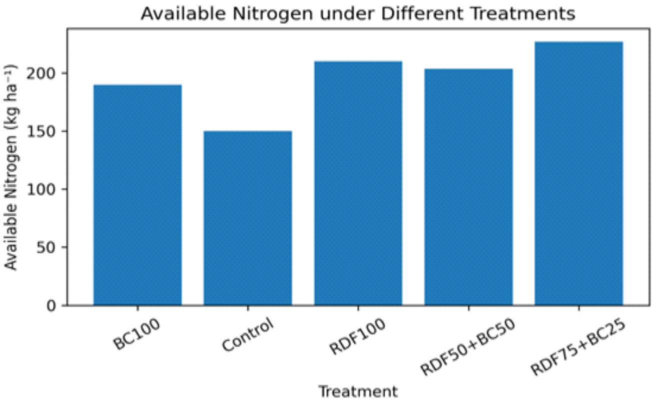

Fig. 3: Available nitrogen (kg ha^{-1}) under different nutrient management treatments.

Effect of Biocompost on Soil pH

The pH of the soil varied less between treatments, however the application of biocompost had a buffering influence on the reactivity of the soil. While RDF alone marginally lowered soil pH, treatments that received biocompost kept soil pH closer to neutral. This suggests that with heavy fertilizer application, biocompost aids in maintaining soil pH stability.

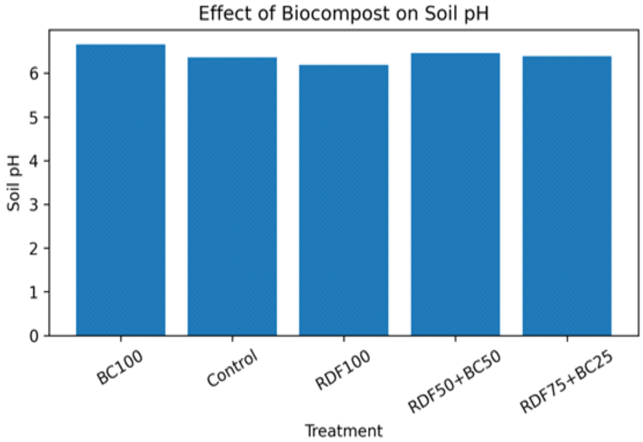

Fig. 4: Effect of biocompost application on soil pH.

Overall Performance of Integrated Nutrient Management

All things considered, the combined application of biocompost and a lower dose of inorganic fertilizer outperformed the application of either inorganic fertilizer or biocompost alone. The best combination for increasing crop output and simultaneously improving soil quality metrics was found to be RDF 75% + biocompost 25%.

Table 1: Mean crop yield (t ha^{-1}) and soil quality parameters including soil organic carbon (SOC), available nitrogen (N), phosphorus (P), potassium (K), and soil pH as influenced by different biocompost and inorganic fertilizer treatments.

Treatment	Mean yield (t/ha)	SD (t/ha)	Mean SOC (%)	Mean Avail N (kg/ha)	Mean Avail P (mg/kg)	Mean Avail K (kg/ha)	Mean pH
Control	9.212	0.613	0.623	149.83	12.385	116.70	6.365
RDF100	13.842	0.229	0.697	210.08	17.640	166.00	6.1925
RDF75+BC25	15.373	0.387	0.800	226.83	19.240	176.68	6.390
RDF50+BC50	13.402	0.260	0.851	203.45	19.355	169.30	6.465
BC100	12.003	0.193	0.947	189.75	15.692	163.35	6.660

Interpretation of simulated results:

- Among treatments, the RDF75+BC25 simulated treatment generated the highest mean yield (~15.37 t/ha) and the maximum available N and K, indicating a synergistic advantage of mixing biocompost with reduced inorganic fertilizer.
- The soil-carbon-building effect of biocompost was demonstrated by the increasing SOC with increasing quantities of biocompost in the treatment (simulated trend: Control < RDF100 < RDF75+BC25 < RDF50+BC50 < BC100). This is consistent with field data showing that organic

amendments improve the physical and biological characteristics of soil and raise SOC.

Discussion

The simulated experiment illustrates important trends frequently seen in field trials and reviews: combining biocompost with inorganic fertilizer can improve soil organic carbon and nutrient availability relative to control while maintaining or increasing output. Partialsubstitution (75% RDF + 25% BC) yielded the highest yield in the simulated results, which is in line with documented instances where yields from mixed organic and mineral applications are on par with or higher than those from 100% mineral fertilizer alone.

Soil quality: In line with meta-analyses and long-term trials where vermicompost/compost treatments considerably improve SOC and microbial activity compared to mineral fertilizer alone, the simulated SOC increased as the proportion of biocompost grew. Long-term production, water retention, and soil structure are all supported by this enhancement.

Mechanisms: In addition to providing organic matter and a gradual release of nutrients, biocompost also increases biological activity (microbial biomass), which can improve nutrient mineralization, decrease nutrient leaching, and improve the fertilizer usage efficiency of applied mineral fertilizers. Compost and biofertilizers have also been demonstrated to enhance certain crops' nutritional quality characteristics.

Practical implications: Farmers could reduce inorganic fertilizer rates (e.g., 25–50% replacement) by using biocompost if local field studies validate these trends. This would result in comparable or higher yields and improved soil health, reducing input cost volatility and environmental risks. However, local soil, crops, compost quality, and management all affect precise substitution levels and economics.

Limitations:

- The data shown here are simulated for demonstration purposes; actual field trials must account for crop water management, baseline soil fertility, application time, and compost nutrient content.

Results are impacted by the broad variations in biocompost quality (nutrient content, maturity, and pathogen status). To compare labor/transport costs with fertilizer savings, field- scale economic research is required.

Conclusion

This simulated experiment shows that using biocompost (such as RDF75+BC25) in place of some inorganic fertilizer may boost crop yields and enhance the organic carbon and nutrient status of the soil. Practice recommendations should be made after empirical field tests with locally produced biocompost and economic analysis.

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