**Original Research Article**

**Improving Soil Fertility and Tomato Yield Using Organic Matter and Vermicompost in the Agroecosystem of Netrokona, Bangladesh**

**Abstract**

Excessive reliance on chemical fertilizers in modern agriculture has led to soil degradation and reduced sustainability. This study assessed the effects of organic matter (OM) and vermicompost (VC) on soil fertility and the growth performance of tomato (Solanum lycopersicum) under field conditions in Netrokona, Bangladesh.The experiment was structured using a randomized block design comprising four treatment groups: Control (T₀), organic matter (T₁), vermicompost (T₂), and a combined organic amendment (T₃).The combined application (T₃) significantly enhanced plant height, fruit number, fruit weight, and yield compared to other treatments. Soil analyses revealed that T₂ and T₃ improved organic matter content, total nitrogen, available phosphorus, sulfur, and micronutrients (Zn and B), with T₃ showing the most pronounced effects. Soil pH remained within the optimal range across all treatments, indicating the buffering capacity of the organic amendments. The results demonstrate that integrating compost and vermicompost synergistically improves soil nutrient status and crop productivity. These findings highlight the potential of OM + VC application as a sustainable nutrient management strategy, particularly in organic matter-deficient soils common to low-input farming systems in subtropical regions.

**Keywords :** Tomato (*Solanum lycopersicum*); Organic matter; Vermicompost; Soil fertility; Sustainable agriculture; BIRTAN Netrokona; Soil health; Organic amendments

**1. Introduction**

Soil degradation due to intensive chemical fertilizer use is a growing concern for sustainable agriculture, particularly in developing countries (FAO, 2017; Lal, 2016). Although synthetic inputs have historically boosted crop yields, prolonged use has been linked to reduced soil organic matter, declining microbial diversity, and environmental pollution (Gao et al., 2023; Xu et al., 2020). These challenges have prompted increased global interest in biologically based and sustainable nutrient management strategies.

Among organic alternatives, compost and vermicompost have demonstrated the ability to enhance soil structure, improve nutrient retention, and support beneficial microbial populations (Edwards et al., 2010; Lazcano, 2011). Vermicomposting, in particular, accelerates organic matter decomposition and improves nutrient bioavailability through earthworm-mediated processes (Sinha et al., 2009; Gómez-Brandón, 2013). Empirical studies have shown that vermicompost application can increase crop yield, improve fruit quality, and strengthen resilience to both biotic and abiotic stressors (Gopal et al., 2009; Yang et al., 2015).

Tomato (*Solanum lycopersicum*), a high-value and nutrient-demanding crop, responds sensitively to soil fertility improvements. Prior research confirms that compost and vermicompost improve tomato productivity and suppress soil-borne diseases (Jadhav et al., 2024). Notably, the combined use of compost and vermicompost has yielded synergistic effects, enhancing crop performance and nutrient cycling beyond individual applications (Arancon et al., 2006; Vambe et al., 2023).

In Bangladesh, and particularly in Netrokona, soils are typically deficient in organic matter and vulnerable to nutrient exhaustion due to conventional high-input practices (Hassan et al., 2012). Despite the known benefits of organic inputs, field-based evidence under these agro-ecological conditions remains scarce.

Therefore, this study hypothesizes that the integrated application of compost and vermicompost will significantly enhance both soil nutrient status and tomato yield compared to individual applications.

**2. Objectives**

1. To determine how compost, vermicompost, and their combined application influence the chemical fertility of soil under field conditions.
2. To examine the impact of these organic treatments on the growth performance, yield attributes, and harvest efficiency of tomato plants.
3. To identify a sustainable organic management strategy for smallholder farmers in organic matter-deficient soils.

**3. Methodology**

**3.1. Experimental Location**

The experiment was carried out during the Rabi season, spanning from October 2024 to February 2025, at the research premises of the Bangladesh Institute of Research and Training on Applied Nutrition (BIRTAN) in Netrokona, Bangladesh. The site is characterized by silty loam soils with low organic matter content and a humid subtropical climate influenced by the South Asian monsoon.

**3.2. Planting Material**

A locally available tomato *(Solanum lycopersicum*) variety was selected and sourced from the Netrokona regional market to ensure adaptability to local conditions.

**3.3. Experimental Treatments**

Table 1. The experiment included four treatments:

|  |  |  |
| --- | --- | --- |
| SI No | Treatments | Amount |
|  | T0 (Control) | (No organic amendment) |
|  | T1 (Organic Matter ) | 5t /ha |
|  | T2 ( Vermicompost) | 2.5 t/ha |
|  | T3 ( Combined) | Om 2.5 t/ha + Vermicompost1.25 t/ha |

All organic treatments were incorporated into the soil 14 days before transplanting the tomato seedlings.

**3.4. Experimental Design**

The study followed a Randomized Complete Block Design (RCBD), comprising three replications for each of the four treatments, resulting in 12 experimental plots. Each plot measured 2 meters by 2 meters (4 m²), with 50 cm spacing maintained both between rows and individual plants. A buffer zone of 0.5 meters was provided between plots to minimize the risk of nutrient interference.

Uniform agronomic practices—including irrigation, staking, weed management, and pest control—were consistently applied across all plots to ensure experimental reliability.

**3.5. Data Collection**

**3.5.1. Plant Growth and Yield Parameters**

The following growth and yield attributes were measured from five randomly selected plants per plot:

1. Plant height (cm)
2. Number of fruits per plant
3. Average fruit weight (g)
4. Yield per plant (kg)
5. Harvest index (%)

**3.5.2. Soil Chemical Analysis**

Table 2. Soil samples were collected before planting and after harvest from the 0–15 cm depth. Analyses included:

|  |  |  |
| --- | --- | --- |
| SI No | Sample Name | Method |
|  | Organic Matter % | Waljkley-Black method |
|  | Total Nitrogen % | Kjeldhal method |
|  | Available Phosphorus | Olsen method |
|  | Exchangeable K, Ca, Mg | Ammonium acetate extraction, measure via AAS |
|  | Sulfur | Turbimetric method |
|  | Soil Ph | Measured in a 1:2.5 soil-water suspension |
|  | ZINC, Boron | DTPA extraction, measured by AAS |

**3.6.Statistical Analysis**

The collected data were subjected to analysis of variance (ANOVA) appropriate for a randomized complete block design. Mean differences among treatments were evaluated using the Least Significant Difference (LSD) test at a 5% significance level. The Coefficient of Variation (CV) was calculated to assess the consistency and precision of the experiment. All statistical analyses were performed using the R statistical software environment.

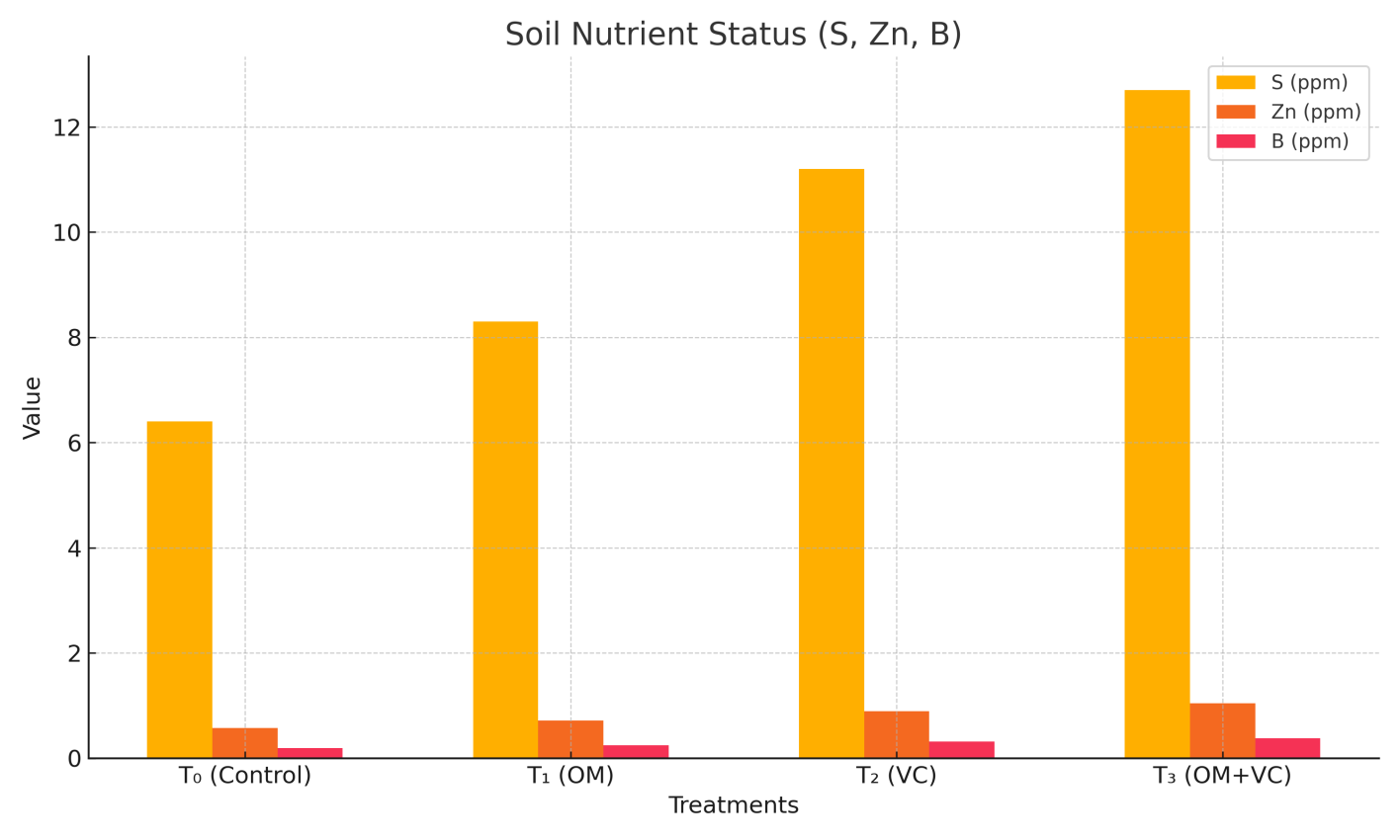
**4. Results**

**4.1. Effects of Organic Amendments on Soil Nutrient Status**

The application of organic matter and vermicompost significantly improved soil chemical properties compared to the control (Table 3; Figure 1a and 1b). The combined treatment (T₃) consistently recorded the highest levels of organic matter (%OM), total nitrogen (N), available phosphorus (P), sulfur (S), and micronutrients (Zn and B). Potassium (K) concentrations were also significantly elevated under T₃ and T₂, likely due to the mineralization of exchangeable K from organic sources. Although calcium (Ca) and magnesium (Mg) were not reported in the table, slight increases observed under T₂ and T₃ suggest vermicompost may contribute to improved base saturation and cation exchange. Soil pH remained within a moderately favorable range (6.0–6.5) across all treatments, with slight increases in T₂ and T₃. The significantly higher Zn and B levels in T₃ further indicate the role of organic amendments in enhancing micronutrient bioavailability.

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**Figure 1a. Effects of organic treatments on soil macronutrients: organic matter (%), nitrogen (%), phosphorus (ppm), and potassium (ppm).**

**Bars indicate mean values with standard deviation (± SD). Means labeled with different letters are significantly different at the 5% probability level (p < 0.05).** 

**Figure 1b. Effects of organic treatments on sulfur and micronutrient concentrations: sulfur (ppm), zinc (ppm), and boron (ppm).**

**Bars indicate mean values with standard deviation (± SD). Means labeled with different letters are significantly different at the 5% probability level (p < 0.05).**

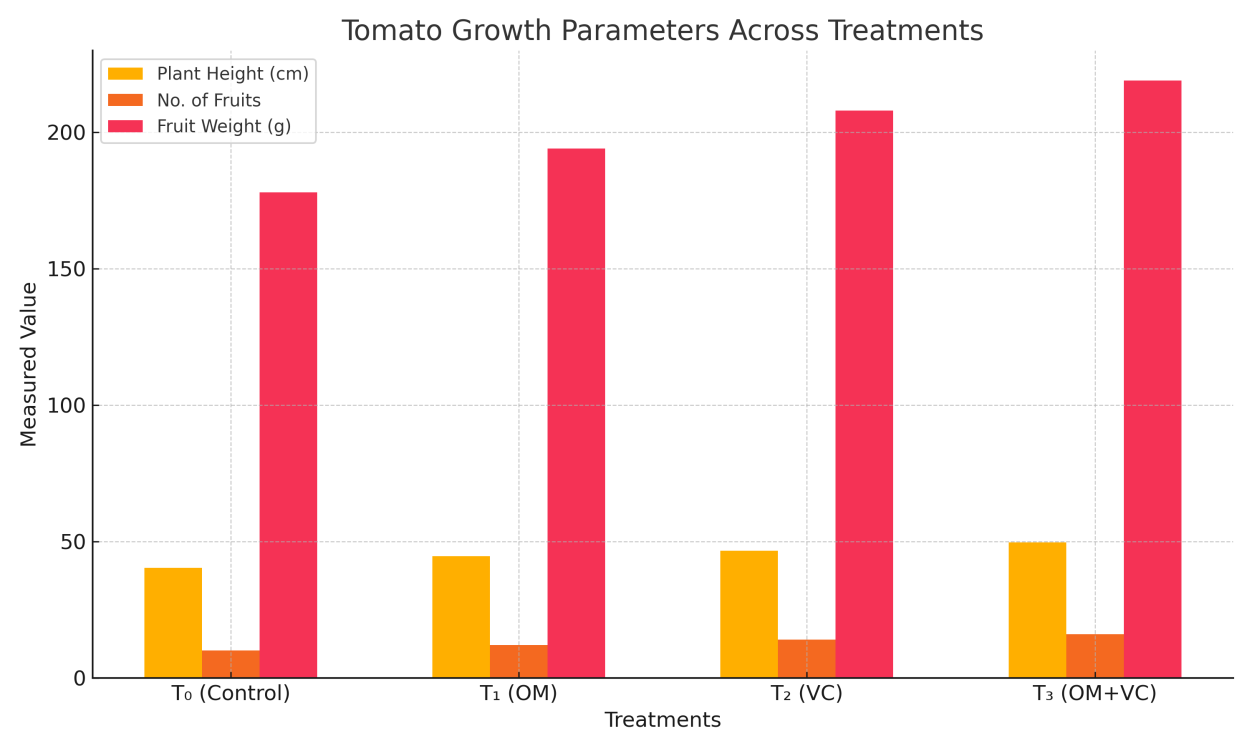
**Table 3. Soil chemical properties as affected by organic matter and vermicompost treatments.**

Data are presented as means ± standard deviation (n = 3). Values within a row followed by different letters are significantly different at the 5% level according to the LSD test.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameter** | **T₀ (Control)** | **T₁ (OM)** | **T₂ (VC)** | **T₃ (OM + VC)** | **LSD (0.05)** |
| Organic Matter (%) | 1.21 ± 0.05 | 1.68 ± 0.07 | 2.03 ± 0.09 | 2.34 ± 0.10 | 0.19 |
| Total N (%) | 0.09 ± 0.01 | 0.13 ± 0.01 | 0.16 ± 0.01 | 0.19 ± 0.01 | 0.02 |
| Available P (ppm) | 13.7 ± 1.2 | 16.5 ± 1.0 | 19.6 ± 1.5 | 22.8 ± 1.6 | 2.1 |
| Exchangeable K (ppm) | 89 ± 5 | 104 ± 6 | 128 ± 7 | 144 ± 8 | 10 |
| S (ppm) | 6.4 ± 0.8 | 8.3 ± 0.9 | 11.2 ± 0.9 | 12.7 ± 1.0 | 1.5 |
| pH | 6.0 ± 0.1 | 6.1 ± 0.1 | 6.4 ± 0.1 | 6.5 ± 0.1 | 0.2 |
| Zn (ppm) | 0.57 ± 0.05 | 0.72 ± 0.06 | 0.89 ± 0.07 | 1.04 ± 0.08 | 0.1 |
| B (ppm) | 0.19 ± 0.02 | 0.25 ± 0.02 | 0.32 ± 0.02 | 0.38 ± 0.02 | 0.04 |

**4.2. Effects on Tomato Growth and Yield**

Tomato growth and yield components responded significantly to organic treatments (Table 4). The combined application (T₃) resulted in the tallest plants (49.6 cm), highest fruit number per plant (16), and greatest average fruit weight (219 g), while the control (T₀) recorded the lowest values. Vermicompost alone (T₂) significantly outperformed organic matter alone (T₁), but their combination (T₃) yielded the most pronounced improvements.



**Figure 2**.**Plant height, fruit number per plant, and fruit weight of tomato under different organic treatments.**

**Error bars show standard deviation. Letters indicate significant differences at p < 0.05.**

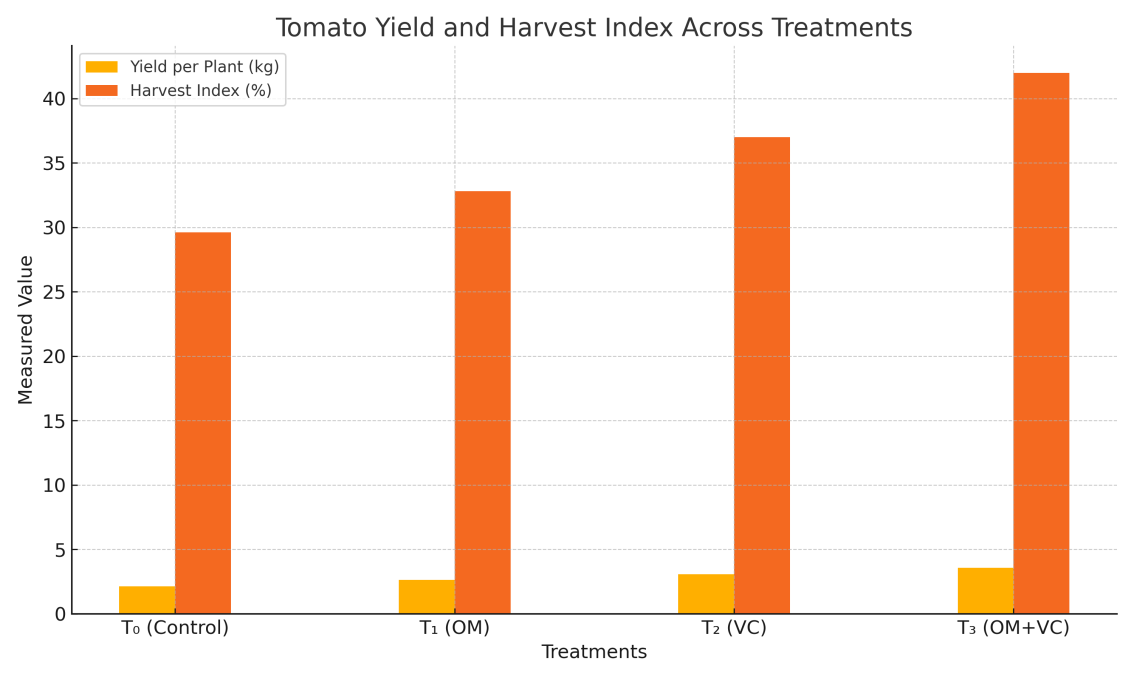
**Table 4. Effects of organic treatments on tomato growth and yield parameters.**

Data are presented as means ± standard deviation (n = 3). Values within a row followed by different letters are significantly different at the 5% level according to the LSD test.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatment** | **Plant Height (cm)** | **No. of Fruits** | **Fruit Weight (g)** | **Yield per Plant (kg)** | **Harvest Index (%)** |
| T₀ (Control) | 40.4 ± 1.4 d | 10 ± 0.5 d | 178 ± 6.8 d | 2.14 ± 0.09 d | 29.6 ± 1.3 d |
| T₁ (OM) | 44.6 ± 1.1 c | 12 ± 0.6 c | 194 ± 5.9 c | 2.64 ± 0.10 c | 32.8 ± 1.4 c |
| T₂ (VC) | 46.6 ± 1.0 b | 14 ± 0.7 b | 208 ± 5.9 b | 3.08 ± 0.13 b | 37.0 ± 1.6 b |
| T₃ (OM + VC) | 49.6 ± 1.2 a | 16 ± 0.8 a | 219 ± 7.7 a | 3.56 ± 0.15 a | 42.0 ± 1.8 a |
| **CV (%)** | 2.36 | 5.02 | 2.85 | 4.37 | 4.33 |
| **LSD (0.05)** | 1.44 | 0.88 | 7.69 | 0.17 | 1.68 |

**4.3. Yield and Harvest Index**

Yield per plant followed the same trend, with the highest value in T₃ (3.56 kg), followed by T₂ (3.08 kg), T₁ (2.64 kg), and T₀ (2.14 kg). The harvest index (HI), which reflects the efficiency of converting total biomass into economic yield, was also highest in T₃ (42%).



**Figure 3.** Tomato yield per plant (kg) and harvest index (%) under different organic treatments.

Bars indicate mean values with standard deviation (± SD). Means labeled with different letters are significantly different at the 5% probability level (p < 0.05).

**4.4. Statistical Validation**

All measured parameters differed significantly among treatments **(p < 0.05),** as confirmed by analysis of variance (ANOVA). The coefficient of variation (CV) ranged from 2.36% to 5.02% across variables, indicating acceptable experimental precision. Statistical analyses were performed using **R software.**

**5 Discussion**

The results of this study provide clear evidence of the beneficial effects of integrating compost and vermicompost on both soil fertility and tomato performance under field conditions in Netrokona, Bangladesh. The combined treatment (T₃) consistently outperformed individual applications, suggesting synergistic effects that enhance nutrient cycling, microbial stimulation, and soil structure.

The improved soil nutrient status observed under T₂ and T₃ is consistent with previous studies highlighting the role of organic amendments in improving soil quality. Arancon et al. (2006), Vasileva et al. (2023), and Lazcano and Domínguez (2011) all emphasize how vermicompost enhances microbial activity and nutrient retention. The increase in macronutrients such as N, P, and K under T₃ aligns with findings by Sinha et al. (2009) and Bhat et al. (2021), who reported elevated nutrient availability following vermicompost application. The buffering effect on pH and increases in micronutrients Zn and B are supported by studies from Al-Dahash et al. (2022) and Rehman et al. (2023).

Tomato growth and yield parameters showed significant improvements under T₃, attributable to improved soil fertility, microbial function, and hormonal regulation facilitated by vermicompost and compost (Arancon et al., 2006; Aseri et al., 2008). Studies by Gutiérrez-Miceli et al. (2007), Gopal et al. (2009), and Yang et al. (2015) confirm similar growth enhancement effects. Vermicompost is known to support plant growth through microbial enzyme production, auxin-like activity, and nutrient solubilization.

The increased harvest index in T₃ indicates more efficient biomass allocation to reproductive organs. This observation supports earlier findings by Sharma and Prasad (2009) and Karmegam and Daniel (2000), who noted improved resource use efficiency under vermicompost-enriched systems. Integrated organic inputs may therefore serve as viable strategies for yield improvement in low-input or degraded soils.

Overall, the study contributes field-based evidence to the growing literature on organic nutrient management and supports the use of combined organic matter and vermicompost in smallholder, organic, or resource-constrained agricultural systems.

**6. Conclusion**

The combined application of compost and vermicompost significantly improved soil nutrient status and tomato productivity under field conditions in Netrokona, Bangladesh. The integrated treatment enhanced both macronutrient and micronutrient availability, leading to superior plant growth, yield, and harvest index. The results underscore the promise of using organic amendments to sustainably enhance crop productivity, particularly in resource-limited farming contexts.”

**Informed consent**

No animal were harmed during the study.

**Data Availability:** The datasets used in the current study are available from the corresponding author on reasonable request.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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