Hindawi
Advances in Agriculture
Volume 2023, Article ID 4599133, 9 pages
https://doi.org/10.1155/2023/4599133

*Research Article*

# Influences of NPSB and Vermicompost Application Rates on Yields of Tomato (*Lycopersicon esculentum* Mill) at Jimma Ganati Research Site of Wallaga University, Western Ethiopia

**Fayera Asefa Bebayehu, Alemayehu Wagari Irge, Abdela Tufa Woticha, and Adugna Hunduma Dabalo**

*Wallaga University, Shambu Campus, Agricultural Faculty, Plant Science Department, Shambu, Western Ethiopia*

Correspondence should be addressed to Fayera Asefa Bebayehu; fayeraasefa@gmail.com

Received 29 September 2022; Revised 13 March 2023; Accepted 8 April 2023; Published 14 April 2023

Academic Editor: Othmane Merah

Copyright © 2023 Fayera Asefa Bebayehu et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

The tomato (*Lycopersicon esculentum* Mill) is an important vegetable crop in Ethiopia and is produced and eaten in large quantities throughout the nation. However, the tomato production is quite low (10 $tons{\cdot}ha^{-1}$) compared to the global average yield of 34 $tons{\cdot}ha^{-1}$ due to the repetitive use of chemical fertilizers alone, growing intensive crops that are absorbing significant amounts of the soil nutrients, and the lack of application of organic fertilizers. Therefore, it is crucial to take accurate measurements when using fertilizers in order to solve issues and boost crop yield. The study's objective was to find out how NPSB and vermicompost fertilizers together influenced tomato growth, yield characteristics, and yield at the Wallaga University Research Site for two consecutive years (2021 and 2022). The experiment used a factorial randomized block design with two components: four levels of NPSB and four levels of vermicompost. The tomato fruit production and all of its components were strongly impacted by the primary and interaction effects of NPSB and vermicompost treatment rates. The highest fruit length was 6.26 cm, the largest fruit diameter was 5.94 cm, the shoot fresh weight was 48.25 $g{\cdot}plant^{-1}$, the shoot dry weight was 4.50 $g{\cdot}plant^{-1}$, the marketable fresh fruit per plant was 5.54 kg, and the fruit yield was 24.36 $ton{\cdot}ha^{-1}$ after the application of 125 $kg{\cdot}ha^{-1}$ NPSB plus 8 $ton{\cdot}ha^{-1}$ vermicompost. Application of 125 $kg{\cdot}ha^{-1}$ of NPSB fertilizer along with 8 $tons{\cdot}ha^{-1}$ of vermicompost increases net benefits by 115922.5 $ETB{\cdot}ha^{-1}$ as compared to a control. Therefore, in order to enhance tomato yield, it may be suggested that farmers utilize the combination of 125 $kg{\cdot}ha^{-1}$ of NPSB and 8 $tons{\cdot}ha^{-1}$ of vermicompost rather than applying any inorganic fertilizers alone.

## 1. Introduction

The tomato (*Lycopersicon esculentum* Mill.) is a *solanaceae* family, annual herb, farmed for its fleshy berry fruit [1]. It is a berry, with a pulpy exterior and one or more seeds inside [2]. One of the most common crops in home gardens is the tomato, which is delicious and adaptable, easy to grow, and yields a lot of fruit for the amount of area they take up [3]. It provides minerals, vitamins, and antioxidants [4]. It is one of the most significant vegetable crops in Ethiopia and one of the organic veggies. Both small-scale farmers and commercial producers grow this crucial cash crop for the fresh market and processing sector.

The Jimma Ganati district in Ethiopia, Oromia Regional State is distinguished by a diverse agroecology [5] that is ideal for growing high-value commodities, especially tomato varieties. The overall yield of this crop has increased significantly in Ethiopia [6]. Although the world average tomato output was 34 tons per year [7, 8], the national and regional yields have remained below 10 tons per year [9]. This may be the outcome of the constant use of chemical fertilizers and low soil fertility.

Production of highland crops is most severely constrained by soil fertility [10]. Moreover, poor agronomic methods and insufficient soil fertility are to blame for Ethiopia's low tomato productivity [11]. As a result, continuous application of chemical fertilization alone degrades the physical, chemical, and biological qualities of the soil [12] and lowers the crop's protein content and carbohydrate quality [13].

New farming techniques have been created in the so-called organic agriculture to solve the issues [14]. Application of organic fertilizer has been shown to enhance crop growth through the provision of plant nutrients, including micronutrients, as well as the enhancement of the physical, chemical, and biological characteristics of the soil [15, 16]. Vermicompost, for instance, is a good source of several critical nutrients, and using it to grow vegetables can help with waste disposal and the shortage of organic manure. Composting is the focus of the second green revolution, which is now being promoted globally through the use of vermicompost. One of the distinguishing features of vermicompost is the high concentration of plant-available nutrients it contains, such as ammonium nitrogen, exchangeable phosphorus, and soluble potassium, calcium, and magnesium derived from organic wastes [17].

As a result, using organic or inorganic fertilizers alone did not result in a production gain that was sustainable [18]. A method to address the nutrient needs of crops is to combine a tiny amount of inorganic fertilizer with the organic resources present on farms [19]. It was suggested that by using a combination of chemical and organic fertilizers, productivity might be improved while simultaneously reducing the amount of chemical fertilizers needed, which had detrimental effects on production costs and the environment. The objective of the current study was to determine how the combined effects of NPSB and vermicompost on tomato development, yield characteristics, and fruit yield.

## 2. Materials and Methods

*2.1. An Explanation of the Research Area.* The experiment was conducted at the Wallaga University Research location Jimma Ganati Western Ethiopia throughout the 2021-2022 growing seasons. From Addis Ababa, the location is 334 kilometers away. Sand and loam make up the local soil type. The area is 2560 meters above sea level on average. The daily temperature ranges from 16 to 23°C. The region receives between 1900 and 2400 mm of rain on average per year, with July and August being the wettest months. Crop production is ideal for the region's climate and geography. The main crops farmed in the region are pulses, vegetables, and cereals [20]. In the study area, smallholder farmers have received extensive training on the use of organic fertilizers like vermicompost from regional governments and NGO partners working together, but some farmers do not prepare vermicompost due to a lack of knowledge. For this reason, teams were created to prepare and sell vermicompost in districts during crop season at a fair price to the literate farmers. Institutions at the district level also hire professionals who instruct farmers in the usage of fertilizer and crop planting.

*2.2. Analysis of Samples of Soil.* The soil at the experimental site was inspected prior to planting. Using an auger to drill through the experimental units in a zigzag manner, composite surface soil samples (0–30 cm depth) were collected from sixteen plots before the experimental site was planted. These samples were bulked into one sample. The extracted sample, which weighed 1.0 kg and was made from the bulked earth, was then air dried and ground in a mortar and pestle. Several chemical and physical soil parameters, such as soil texture, pH, cation exchangeable capacity, organic carbon, total nitrogen, accessible phosphorus, and sulfur were screened for in the sample using a 2-mm sieve prior to analysis. Soil tests were performed by the Nekemte Soil Research Center. The hydrometer method was used to measure the distribution of soil particle sizes [21], and a pH meter set to a 1 : 2.5 soil-to-water ratio was used to determine the pH of the soil [22]. The availability of phosphorus was assessed using the Bray-I [23] method, total nitrogen by the Kjeldahl [24] method, and soil organic carbon by the Walkley–Black Oxidation [25] method. Before using vermicompost as a fertilizer treatment, its chemical qualities were examined (Table 1).

*2.3. Field Planning and Preparation.* Before the ground was physically leveled, broken up into clods, and weed control was carried out as per suggested for the crop, oxen were employed to prepare the trial field. Finally, the unit plots were prepared for sowing using spades. The Roma VF tomato variety was sown in mid-July 2021 and 2022 as a test crop. In the nursery, seedlings were well-established before being carefully transferred to the test plots. The size of the plots determined by researchers in the study area as advised and practiced for specific tomato types. Each plot measured 8.1 $m^2$ (1.8 m × 4.5 m), and the distances between rows, plants, plots, and adjacent blocks were, respectively, 75 cm, 30 cm, 0.5 m, and 1 m. The total experimental area was 795.15 $m^2$ (51.3 m × 15.5 m). Each plot was used, and it was 4.5 meters long, with 5 rows and 30 centimeters between plants. From a net plot size of 3.6 $m^2$, data was gathered on the three middle rows to minimize the boundary effect (3 m × 1.2 m).

*2.4. Treatments and Experimental Design.* The treatments were composed of four levels of blended NPSB (0, 75, 100, and 125 $kg \cdot ha^{-1}$) and four amounts of vermicompost (0, 4, 6, and 8 tons per $ha^{-1}$) (Table 2). Five rows (the number of treatments allotted for each plot) were evenly divided between each fertilizer application, and it was applied using band placement (application of fertilizers into the soil close to the seed). In some regions of Ethiopia, NPSB 100 $kg \cdot ha^{-1}$ was utilized as a suggested fertilizer for the production of tomato fruit and as a standard for NPSB levels arrangement. For the experiment, a factorial with a Randomized Completely Block Design was used. NPSB fertilizer is composed of 19%N, 38%P, 7%S, and B1%. While vermicompost was incorporated into the soil plots one week prior to planting by keeping the treatments as they were assigned for each plot, the entire blended NPSB fertilizer was administered as per the treatments at a full dose at sowing.

Table 1: Chemical composition of vermicompost.

| Year | Type of composts | Soil pH | Organic carbon (%) | Organic matter (g·kg$^{-1}$) | Electric conductivity (meq/100 g) | Cation exchange capacity (meq/100 g) | Total nitrogen (g·kg$^{-1}$) | Total phosphorus ($P_2O_5$) (g·kg$^{-1}$) | Total sulfur (g·kg$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| 2021 | Vermicompost | 7.25 | 9.10 | 380.74 | 1.20 | 29.00 | 35.62 | 28.25 | 9.33 |
| 2022 | Vermicompost | 7.25 | 8.92 | 354.55 | 1.10 | 27.00 | 37.05 | 26.31 | 9.11 |

*2.5. Data Collected*

*2.5.1. Plant Height (cm).* Ten plants were randomly chosen from each plot, tagged from the soil line to the growing point, and measured on a centimeter scale. The mean height of each plant was then represented in centimeters.

*2.5.2. Number of Leaves, Branches, and Flowers per Plant.* From the transplanting date until 5 weeks after transplantation, the number of leaves, branches, and flowers per plant were counted at intervals of 7 days, and an average was calculated.

*2.5.3. Fruit Dimensions (in Centimeters).* Five fruits were used to measure fruit length and diameter (in centimeters). Using a vernier caliper, the length and diameter of the fruit were measured at its center. Fruit averages were calculated and expressed in centimeters for length and diameter.

*2.5.4. Shoot Weight (kg·ha$^{-1}$) When Fresh and Dry.* When the above-ground portion reached physiological maturity, it was collected, the shoot's fresh weight was measured, it was also dried in an oven, and the shoot's dry weight was estimated.

*2.5.5. Fruit That Is Completely Marketable and Unmarketable (ton·ha$^{-1}$).* Randomly chosen ten plants each plot, with ten fruits per plant, was weighted for unmarketable and marketable fruit per plant.

*2.5.6. Fruit Production (ton·ha$^{-1}$).* Each plot's middle three rows were taken, weighed in kilos, and their tons were converted for yield analysis.

*2.6. Data Evaluation.* After SAS software version 9.3 verified the homogeneity of the error variance, the data were subjected to a combined analysis of variance. Following the steps in [26], the treatment means were compared using the least significant differences test at the 0.05 probability level.

*2.7. Budget Analysis in Part.* As explained by [27], a partial financial analysis was conducted. Using a partial budget analysis, the financial benefits of applied blended NPSB and vermicompost fertilizers were determined. In this experiment, the variable costs were derived by multiplying the fertilizer and labor costs by the number of fertilizer applications. Other managerial and fixed costs, however, were left out of the estimate because it was thought they would all be equal. Blended NPSB was priced at 15 ETB per kilogram. In the local market of the research area, the tomato fruit yield was valued at an average open market price was 10 ETB·kg$^{-1}$ between 2021 and 2022. To account for the difference between the experimental fruit yield and the fruit yield that farmers can expect from the same treatment, subtract 10% from the original output. Vermicompost and blended NPSB application were projected to cost 0.5 ETB·kg$^{-1}$ in labor. Total variable costs, gross benefits, and net benefits were computed in accordance with the CIMMYT partial budget analysis technique. On non-dominated treatments, marginal analysis was done to determine the treatments that would yield the highest return on the farmer's investment.

Table 2: Description of the various treatment options.

| Treatment combinations | Blended NPSB levels (kg·ha$^{-1}$) | Vermicompost levels (tons·ha$^{-1}$) |
|---|---|---|
| $NPSB_1VC_1$ | 0 | 0 |
| $NPSB_1VC_2$ | 0 | 4 |
| $NPSB_1VC_3$ | 0 | 6 |
| $NPSB_1VC_4$ | 0 | 8 |
| $NPSb_2VC_1$ | 75 | 0 |
| $NPSB_2VC_2$ | 75 | 4 |
| $NPSB_2VC_3$ | 75 | 6 |
| $NPSB_2VC_4$ | 75 | 8 |
| $NPSB_3VC_1$ | 100 | 0 |
| $NPSB_3VC_2$ | 100 | 4 |
| $NPSB_3VC_3$ | 100 | 6 |
| $NPSB_3VC_4$ | 100 | 8 |
| $NPSB_4VC_1$ | 125 | 0 |
| $NPSB_4VC_2$ | 125 | 4 |
| $NPSB_4VC_3$ | 125 | 6 |
| $NPSB_4VC_4$ | 125 | 8 |

NPSB stands for nitrogen, phosphorus, sulfur, and boron; VC stands for vermicompost.

## 3. Results and Discussion

*3.1. Physicochemical Characteristics of Soil.* Prior to the administration of the treatments, experimental field soils were assessed for a number of physicochemical characteristics using the approach described in [28] (Table 3). The experimental site's mean soil pH was 4.99, which was strongly acidic [29] and ideal for the growth of various vegetable crops. In the years 2021 and 2022, the total nitrogen in the soil increased from 2.8 g·ha$^{-1}$ to 3.10 g·ha$^{-1}$, which was suitable for crop growth and increased crop yield. While soil phosphorus availability was 10.21 g·ha$^{-1}$ in 2022 compared to 9.84 g·ha$^{-1}$ in 2021, 8 mg·ha$^{-1}$ of accessible

Table 3: Before applying any fertilizer, the physical and chemical characteristics of the soil in the study area were examined.

| S/N | Year | Soil pH | Organic carbon (%) | Soil organic matter ($g \cdot kg^{-1}$) | Cation exchange capacity (meq/100 g soil) | Total nitrogen ($g \cdot kg^{-1}$) | Available phosphorus ($P_2O_5$) ($g \cdot kg^{-1}$) | Available sulfur ($g \cdot kg^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| 1 | 2021 | 5.07 | 3.02 | 33.36 | 18.67 | 1.8 | 9.84 | 12.91 |
| 2 | 2022 | 4.90 | 4.02 | 46.21 | 23.10 | 1.10 | 10.21 | 14.52 |
| Method of analysis | | 1 : 2.5 ratio water method of bray II method kjeldahl method | | | | | | |

phosphorus is a crucial quantity for the majority of field crops [30]. In 2021, the soil's organic carbon content was 3.02%, and in 2022, it was 4.02% (Table 3). In comparison to 2021, this showed 12.91 $mg \cdot ha^{-1}$ of accessible sulfur, while 2022 showed 14.52 $mg \cdot ha^{-1}$.

*3.2. Growth Parameters.* Tomato plant height and leaf count are crucial yield characteristics because tall plants with green leaves promote photosynthetic activity, which increases tomato fruit yield. When NPSB and vermicompost were applied at the same time and at different rates, the height and quantity of tomato leaves (*Solanum lycopersicum* L.) dramatically increased in comparison to the control (Table 4). $NPSB_4VC_4$ (150 $kg \cdot NPSB \cdot ha^{-1}$ plus 8 $kg \cdot VC \cdot ha^{-1}$) recorded the tallest tomato plant height (40.42 cm) and the most leaves (23.54), whereas the control plot recorded the smallest plant height (30.25 cm) and the fewest leaves (14.58) (Table 4). According to these results, the plant's height and number of leaves likewise increased when NPSB and vermicompost rates rose (Table 4). The application of sufficient and stable nutrients of blended NPSB and vermicompost, which promoted cell elongation and consequently leads to higher vegetative growth of tomatoes, may be responsible for the rise in plant height and number of leaves in tomatoes. In comparison to the 100% recommended dose of NPSB and control, respectively, the combined application of 125 $kg \cdot NPSB \cdot ha^{-1}$ plus 8 $kg \cdot VC \cdot ha^{-1}$ enhanced plant height by 7.93% and 30.62% and the number of leaves by 30.49% and 61.45%.

The combined application of blended NPSB and vermicompost had a significant effect on the number of branches per plant, the number of flowers per plant, and a number of fruits per plant tomato. The highest values of the number of branches per plant (5.17), number of flowers per plant (21.75), and number of fruits per plant (23.13) of tomato were obtained from the application of 150 $kg \cdot ha^{-1}$ NPSB fertilizer with 8 $kg \cdot ha^{-1}$ vermicompost. Significantly, the lowest values of the number of branches per plant (1.66), number of flowers per plant (12.20), and number of fruits per plant (11.71) of tomato were obtained from the control. When $NPSB_4VC_4$ (125 $kg \cdot NPSB \cdot ha^{-1}$ plus 8 $kg \cdot VC \cdot ha^{-1}$) was applied, there were 211.45% more branches, 78.28% more blooms, and 97.52% more fruits per plant than there were under control conditions. The improved impact of amendments on the soil's physicochemical qualities and nutrient status, which promotes plant growth, may be the cause of the tomatoes' maximum growth parameters after the application of vermicompost and NPSB fertilizer compared to the unfertilized plot. Similar results were reported by [17] who said that applying 8 tons of vermicompost per acre along with 150 kg of NPS and 150 kg of urea per acre considerably enhanced tomato growth indices. Vermicompost was applied to the tomato plant to increase growth, flower and fruit development, and yield, according to [31, 32], who also confirmed the findings. Among the most often cited benefits of vermicompost treatment are increased plant growth and development and, occasionally, changes in plant morphology [17, 33, 34].

*3.3. Yield and Yield Parameters.* Table 5 provides information on tomato yield and yield factors as they relate to the use of combined NPSB and vermicompost. In light of this, $NPSB_4VC_4$ yielded the significant and highest values of tomato fruit length (6.26 cm), fruit diameter (5.94 cm), shoot fresh weight (48.25 $g \cdot plant^{-1}$), and shoot dry weight (4.50 g $plant^{-1}$) (Table 5). An unfertilized plot (control) of tomatoes produced the smallest measurements of fruit length (4.90 cm), fruit diameter (4.69 cm), shoot fresh weight (15.00 $g \cdot plant^{-1}$), and shoot dry weight (2.78 $g \cdot plant^{-1}$) (Table 5). Additionally, there were notable impacts of combined NPSB and vermicompost fertilizers on tomato fruit yield and marketable fresh fruit per plant (Table 5). The combined application of 125 kg blended NPSB with 8 tons of vermicompost per hectare resulted in the highest values of marketable fresh fruit per plant (5.54 kg) and fruit yield (10.82 $tons \cdot ha^{-1}$) while the control application resulted in the lowest values of marketable fresh fruit per plant (2.12 kg) and fruit yield (10.82 $tons \cdot ha^{-1}$).

The primary issue with tomatoes is fruit deterioration, which leads to a rise of fresh fruits that can't be sold. Treatments $NPSB_2VC_1$ (75 $kg \cdot NPSB \cdot ha^{-1}$), $NPSB_3VC_1$ (100 $kg \cdot NPSB \cdot ha^{-1}$), and $NPSB_4VC_1$ (125 $kg \cdot NPSB \cdot ha^{-1}$) significantly increased the amount of unmarketable fresh fruit per plant to 0.77 kg, 0.77 kg, and 0.78 kg, respectively, while $NPSB_2VC_3$ (75 $kg \cdot NPSB \cdot ha^{-1}$ plus 8 $ton \cdot ha^{-1}$) produced the least amount of unmarketable fresh fruit per plant (0.36) (Table 5). As shown in Table 5, the unmarketable fresh fruit grew when the NPSB application rates increased, but it dropped as the vermicompost application rates climbed. This demonstrates how crucial vermicompost is in preventing tomato fruit degradation.

Applying blended $NPSB_4VC_4$ (150 $kg \cdot NPSB \cdot ha^{-1}$ with 8 $kg \cdot VC \cdot ha^{-1}$) improved tomato output, marketable fresh fruit per plant, fruit length, fruit diameter, shoot fresh weight, and shoot dry weight by 1.16 cm, 0.55 cm, 37.25 $g \cdot plant^{-1}$, 1.22 $g \cdot plant^{-1}$, and 2.15 kg $plant^{-1}$,

Table 4: The over years (2021 and 2022) mean value of the studied parameters under the effects of NPSB and vermicompost fertilizers rates.

| Treatments | | Plant height (cm) | Number of leaf per plant | Number of branch per plant | Number of flower per plant | Number of fruit per plant |
|---|---|---|---|---|---|---|
| NPS ($kg{\cdot}ha^{-1}$) | VC ($kg{\cdot}ha^{-1}$) | | | | | |
| 0 | 0 | $30.25^{i}$ | $14.58^{h}$ | $1.66^{g}$ | $12.20^{d}$ | $11.71^{e}$ |
| 0 | 4 | $31.79^{h}$ | $14.90^{h}$ | $1.67^{g}$ | $12.32^{d}$ | $11.79^{e}$ |
| 0 | 6 | $32.46^{g}$ | $14.92^{h}$ | $2.23^{g}$ | $12.34^{d}$ | $12.38^{e}$ |
| 0 | 8 | $33.59^{f}$ | $16.00^{g}$ | $2.50^{f}$ | $13.50^{c}$ | $16.11^{d}$ |
| 75 | 0 | $33.59^{f}$ | $16.22^{g}$ | $2.50^{f}$ | $13.54^{d}$ | $16.21^{d}$ |
| 75 | 4 | $36.92^{e}$ | $16.21^{g}$ | $3.13^{e}$ | $16.31^{bc}$ | $17.50^{c}$ |
| 75 | 6 | $37.46^{d}$ | $16.96^{f}$ | $3.36^{d}$ | $17.87^{b}$ | $17.51^{c}$ |
| 75 | 8 | $37.71^{d}$ | $18.55^{d}$ | $3.42^{d}$ | $17.97^{b}$ | $20.31^{b}$ |
| 100 | 0 | $37.45^{d}$ | $18.04^{e}$ | $3.08^{e}$ | $12.35^{d}$ | $15.22^{d}$ |
| 100 | 4 | $38.46^{c}$ | $20.63^{c}$ | $3.75^{c}$ | $18.00^{b}$ | $18.45^{bc}$ |
| 100 | 6 | $38.88^{b}$ | $23.01^{b}$ | $4.83^{b}$ | $18.22^{b}$ | $20.08^{b}$ |
| 100 | 8 | $38.47^{c}$ | $23.14^{b}$ | $4.85^{b}$ | $17.89^{b}$ | $17.04^{cd}$ |
| 125 | 0 | $37.46^{d}$ | $18.53^{d}$ | $3.11^{e}$ | $12.33^{d}$ | $15.20^{b}$ |
| 125 | 4 | $38.45^{c}$ | $20.60^{c}$ | $3.76^{c}$ | $17.88^{b}$ | $18.46^{bc}$ |
| 125 | 6 | $38.46^{c}$ | $23.02^{b}$ | $4.84^{b}$ | $17.96^{b}$ | $17.96^{bc}$ |
| 125 | 8 | $40.42^{a}$ | $23.54^{a}$ | $5.17^{a}$ | $21.75^{a}$ | $23.13^{a}$ |
| LSD | | 0.32 | 1.13 | 0.51 | 1.32 | 0.60 |
| CV | | 4.11 | 4.34 | 2.1 | 3.04 | 5.20 |

At a $P = 0.05$ probability level, similar letters don't appear to be statistically different from one another. NPSB stands for nitrogen, phosphorus, sulfur, and boron; VC stands for vermicompost; LSD stands for least significant difference; and CV stands for coefficient of variation.

respectively, above the control. The application of a high rate of blended NPSB and vermicompost, which makes nutrients adequate and easily delivered to the tomato plant, results in these increases in yield and yield metrics. It is believed that additional factors, such as the existence of advantageous microorganisms or biologically active compounds that influence plant growth, such as phytohormone, are released by advantageous microorganisms in the vermicompost-rich soil, which increases yield [33, 34]. The [35–37] report states that higher soil pH, accessible phosphorus, and total nitrogen, as well as potential additions of other macronutrients and micronutrients, were responsible for the improved tomato yields brought on by the application of vermicompost and mineral amendments together. The findings also support [38] who found that spraying 8 tons of vermicompost per hectare along with 150 kilograms of NPS and 150 kilograms of urea per hectare greatly increased tomato yield and yield components. The findings of [35, 39], who had previously reported that the application of vermicompost in addition to mineral fertilizer that contains nitrogen, phosphorus, and boron tends to increase the yield of tomato, potato, mulberry, and marigold when compared to fertilizer applied alone, were corroborated by these researchers. The application of the greatest vermicompost and NPSP rates resulted in higher yields [35].

Generally, the tomato output was strongly influenced by the types of applied fertilizers. The reason for the high tomato output and the nutrients it retained using organic fertilizer may be because the materials not only contained enough nutrients but also delivered them gradually to the plants. This reduces nutrient loss and leaching while also increasing nutrient usage effectiveness, which increases production. The more the vermicompost with NPSB content treatments, the better the tomato plants appeared in terms of yield and yield components. This is due to the better nutritional value of organically grown tomato plants compared to those grown in inorganic soil, and this study has demonstrated that utilizing both vermicompost and inorganic fertilizers combined is preferable to using either one separately.

*3.4. Economic Evaluation.* The combined application of NPSB and vermicompost fertilizer at 125 $kg{\cdot}ha^{-1}$ plus 8 $tons{\cdot}ha^{-1}$ had the highest net benefit (213302.50 $ETB{\cdot}ha^{-1}$) and marginal rate of return (1934%), followed by net benefit (198400 $ETB{\cdot}ha^{-1}$) reported from 100 $kg{\cdot}ha^{-1}$ to 6 $tons{\cdot}ha^{-1}$ with marginal rate of return of 899% (Table 6). Application of vermicompost at a rate of 4 tons per hectare produced a marginal rate of return of 1601% and a minimum net benefit of 129400 ETB per hectare (Table 6). Plots treated with vermicompost fertilizer at 8 tons per hectare without NPSB, as well as plots treated with 6 tons per hectare plus 75 kilograms of NPS and 8 tons per hectare plus 100 kilograms, were dominant (Table 6). Application of 125 $kg{\cdot}ha^{-1}$ of NPSB fertilizer along with 8 $tons{\cdot}ha^{-1}$ of vermicompost enhanced net benefits by 115922.5 $ETB{\cdot}ha^{-1}$ as compared to a control. Because it provided the highest adjusted fruit output (21.92 $tons{\cdot}ha^{-1}$) and was more affordable, farmers in the research area decided to apply 125 $kg{\cdot}ha^{-1}$ of NPSB combined with 8 $tons{\cdot}ha^{-1}$ of vermicompost fertilizer rates.

Table 5: The over years (2021 and 2022) mean value of the studied parameters under the effect of NPSB and vermicompost fertilizers rates.

| Treatments | | Fruit length (cm) | Fruit diameter (cm) | Shoot fresh weight ($g{\cdot}plant^{-1}$) | Shoot dry weight ($g{\cdot}plant^{-1}$) | Unmarketable fresh fruit per plant (kg) | Marketable fresh fruit per plant (kg) | Yield ($ton{\cdot}ha^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| NPS ($kg{\cdot}ha^{-1}$) | VC ($kg{\cdot}ha^{-1}$) | | | | | | | |
| 0 | 0 | $4.90^{d}$ | $4.69^{d}$ | $15.00^{e}$ | $2.78^{e}$ | $0.45^{f}$ | $2.12^{g}$ | $10.82^{f}$ |
| 0 | 4 | $4.99^{d}$ | $4.70^{d}$ | $15.10^{e}$ | $3.25^{e}$ | $0.45^{f}$ | $2.35^{e}$ | $14.60^{e}$ |
| 0 | 6 | $5.01^{c}$ | $5.22^{c}$ | $15.30^{e}$ | $3.30^{e}$ | $0.44^{f}$ | $3.25^{c}$ | $15.32^{d}$ |
| 0 | 8 | $5.05^{c}$ | $5.26^{c}$ | $15.35^{e}$ | $3.45^{e}$ | $0.44^{f}$ | $3.36^{c}$ | $15.43^{d}$ |
| 75 | 0 | $5.16^{cd}$ | $5.26^{c}$ | $20.00^{d}$ | $3.50^{d}$ | $0.77^{a}$ | $4.27^{b}$ | $15.60^{d}$ |
| 75 | 4 | $5.31^{c}$ | $5.32^{c}$ | $24.00^{c}$ | $3.59^{cd}$ | $0.45^{f}$ | $2.27^{ef}$ | $18.40^{c}$ |
| 75 | 6 | $5.82^{b}$ | $5.26^{c}$ | $30.00^{e}$ | $3.72^{c}$ | $0.44^{f}$ | $2.28^{ef}$ | $18.42^{c}$ |
| 75 | 8 | $5.83^{b}$ | $5.40^{b}$ | $38.12^{b}$ | $3.80^{c}$ | $0.36^{g}$ | $2.38^{de}$ | $20.65^{b}$ |
| 100 | 0 | $5.86^{b}$ | $5.31^{c}$ | $28.00^{c}$ | $3.51^{d}$ | $0.77^{a}$ | $2.51^{d}$ | $18.73^{c}$ |
| 100 | 4 | $5.99^{b}$ | $5.47^{b}$ | $29.20^{c}$ | $3.80^{c}$ | $0.56^{d}$ | $2.25^{fg}$ | $21.44^{b}$ |
| 100 | 6 | $6.07^{b}$ | $5.58^{b}$ | $29.11^{c}$ | $4.15^{b}$ | $0.56^{d}$ | $4.27^{b}$ | $22.55^{b}$ |
| 100 | 8 | $6.06^{b}$ | $5.63^{b}$ | $42.00^{ab}$ | $4.170^{b}$ | $0.55^{d}$ | $4.27^{b}$ | $22.00^{b}$ |
| 125 | 0 | $5.87^{b}$ | $5.25^{c}$ | $38.35^{b}$ | $4.16^{b}$ | $0.78^{a}$ | $2.13^{g}$ | $18.87^{c}$ |
| 125 | 4 | $6.04^{b}$ | $5.51^{b}$ | $42.51^{ab}$ | $4.05^{b}$ | $0.67^{c}$ | $4.26^{b}$ | $21.45^{b}$ |
| 125 | 6 | $6.05^{b}$ | $5.56^{b}$ | $42.55^{ab}$ | $4.05^{b}$ | $0.65^{c}$ | $4.26^{b}$ | $22.10^{b}$ |
| 125 | 8 | $6.26^{a}$ | $5.94^{a}$ | $48.25^{a}$ | $4.50^{a}$ | $0.66^{c}$ | $5.54^{a}$ | $24.36^{a}$ |
| LSD (5%) | | 1.42 | 0.45 | 2.63 | 1.74 | 0.41 | 1.64 | 11.23 |
| CV (%) | | 2.71 | 3.85 | 6.74 | 4.12 | 0.43 | 3.90 | 8.24 |

At a $P = 0.05$ probability level, similar letters don't appear to be statistically different from one another. VC stands for vermicompost, LSD stands for least significant difference, and CV stands for coefficient of variation. NPSB stands for nitrogen, phosphorus, sulfur, and boron.

Table 6: The over years (2021 and 2022) economic evaluation of fruit yield under the effect of NPSB and vermicompost fertilizers rates.

| Treatments | NPSB (kg·ha$^{-1}$) | VC (kg·ha$^{-1}$) | Fruit yield (ton·ha$^{-1}$) | Adjusted fruit yield (ton·ha$^{-1}$) | Gross benefit (ETB·ha$^{-1}$) | TVC (ETB·ha$^{-1}$) | Net benefit (ETB·ha$^{-1}$) | MRR (%) |
|---|---|---|---|---|---|---|---|---|
| *T*1 | 0 | 0 | 10.82 | 9.74 | 97380 | 0.00 | 97380.00 | — |
| *T*2 | 0 | 4 | 14.60 | 13.14 | 131400 | 2000.00 | 129400.00 | 1601 |
| *T*3 | 0 | 6 | 15.32 | 13.79 | 137880 | 3000.00 | 134880.00 | 548 |
| *T*4 | 0 | 8 | 15.43 | 13.89 | 138870 | 4000.00 | 134870.00 | *D* |
| *T*5 | 75 | 0 | 15.60 | 14.04 | 140400 | 1162.50 | 139237.50 | — |
| *T*6 | 75 | 4 | 18.40 | 16.56 | 165600 | 3162.50 | 162437.50 | 1160 |
| *T*7 | 75 | 6 | 18.42 | 16.58 | 165780 | 4162.50 | 161617.50 | *D* |
| *T*8 | 75 | 8 | 20.65 | 18.59 | 185850 | 5162.50 | 180687.50 | 1907 |
| *T*9 | 100 | 0 | 18.73 | 16.86 | 168570 | 1550.00 | 167020.00 | — |
| *T*10 | 100 | 4 | 21.44 | 19.30 | 192960 | 3550.00 | 189410.00 | 1119.5 |
| *T*11 | 100 | 6 | 22.55 | 20.30 | 202950 | 4550.00 | 198400.00 | 899 |
| *T*12 | 100 | 8 | 22.00 | 19.80 | 198000 | 5550.00 | 192450.00 | *D* |
| *T*13 | 125 | 0 | 18.87 | 16.98 | 169830 | 1937.50 | 167892.50 | — |
| *T*14 | 125 | 4 | 21.45 | 19.31 | 193050 | 3937.50 | 189112.50 | 1061 |
| *T*15 | 125 | 6 | 22.10 | 19.89 | 198900 | 4937.50 | 193962.50 | 485 |
| *T*16 | 125 | 8 | 24.36 | 21.92 | 219240 | 5937.50 | 213302.50 | 1934 |

At the $P = 0.05$ probability level, similar letters do not statistically vary from one another. Nitrogen, phosphorus, sulfur, and boron are combined to form NPSB. Vermicompost is VC. NPSB cost ha$^{-1}$ = 15 ETB; cost of application of both fertilizers (NPSB and vermicompost) ha$^{-1}$ = 0.5 EYB; Selling price of tomato fruit per kg = 10 ETB.

## 4. Conclusions

The current study's findings suggested that NPSB and vermicompost application together in to the soil affected tomato development, yield characteristics, and fruit production. The highest plant height, number of leaves, branches, flowers, fruits, fruit length, fruit diameter, shoot fresh weight, shoot dry weight, marketable fresh fruit yield, and fruit yield were attained at a combined application of 125 kg·ha$^{-1}$ NPSB with 8 ton·ha$^{-1}$. The highest amounts of unmarketable fresh fruit from treated plots were detected, and they only included NPSB fertilizer at rates of 75 kg, 100 kg, and 125 kg per hectare. The economic analysis revealed that the control treatment gave the lowest net benefit, whereas the application of 125 kg NPSB and 8 tons VC per hectare together produced the highest net benefit/return (93022.49 ETB per hectare) and marginal rate return (1010.61%) (45000.90 ETB ha$^{-1}$). To increase tomato production and farmer income, it is advised to combine the usage of 125 kg NPSB and 8 tons vermicompost fertilizers per hectare. Future research on the application of combinations biochar, vermiwash, and NPSB to these crops in the study area is crucial for all interested parties.

## Data Availability

Data are available upon reasonable request.

## Conflicts of Interest

The authors declare there are no conflicts of interest.

## Acknowledgments

The authors gratefully acknowledge the authorities of Wallaga University for financing and facilitating the full research expenses. This study was funded by the Wallaga University.

## References

[1] S. Grandillo, D. Zamir, and S. D. Tanksley, "Genetic improvement of processing tomatoes: a 20 years perspective," *Euphytica*, vol. 110, no. 2, pp. 85–97, 1999.

[2] W. A. Gould, *Tomato, Production, Processing and Technology*, CTI productions Inc, Baltimore, MD, USA, 1992.

[3] L. D. Robertson and J. A. Labate, "Genetic resources of tomato (lycopersicon esculentum Var. Esculentum) and wild relatives," in *Genetic Improvement of Solanaceous Crops*, M. K. Razdan and A. K. mattoo, Eds., CRC Press, Boca Raton, FL, USA, 2007.

[4] M. Y. Khan, M. M. Haque, A. H. Molla, M. M. Rahman, and M. Z. Alam, "Antioxidant compounds and minerals in tomatoes by *Trichodermaenriched biofertilizer* and their relationship with the soil environments," *Journal of Integrative Agriculture*, vol. 16, no. 3, pp. 691–703, 2017.

[5] G. Demlie, "Evaluation of deficit irrigation for potato production at secota, wag himra," in *Proceeding of the 4th Annual Regional Conference on Completed Research Activities*, B. Wondimu, Ed., Amara Regional Agricultural Research Institute, Bahir Dar, Ethiopia, 2012.

[6] D. Lemma, Z. Yayeh, and E. Herath, "Varietals development on vegetable," in *Proceeding of the Second Workshop of Horticultural Development in Ethiopia*, E. Herath and D. Lemma, Eds., IAR, Addis Ababa, Ethiopia, 1992.

[7] Faostat, *Food and Agricultural Commodities Production 2015*, Food and Agricultural Organization Statistics, Rome, Italy, 2015.

[8] FAO, *Production Year Book*, vol. 55, Basic Data Unit, Statistics Division, FAO, Rome, Italy, 2006.

[9] CSA, *Report on Area and Production of Major Crops in Ethiopia*, Centeral Statics Agency, Addis Ababa, Ethiopia, 2017.

[10] C. Y. Woldeyesus and R. Fisehaye, "On-farm fertilizer trial on food barley in Wolemera area," in *Proceedings of a Client-Oriented Research Evaluation Workshop on towards Farmer Participatory Research: Attempts and Achievements in the Central Highlands of Ethiopia,* Holetta Agricultural Research Centre, Holetta, Ethiopia, 2002.

[11] G. Agegnehu and T. Amede, "Integrated soil fertility and plant nutrient management in tropical agroecosystems: a review," *Pedosphere*, vol. 27, no. 4, pp. 662–680, 2017.

[12] S. Shimbo, T. Watanabe, Z. W. Zhang, and M. Ikeda, "Cadmium and lead contents in rice and other cereal products in Japan in 1998–2000," *Science of The Total Environment*, vol. 17, 2001.

[13] H. A. Marzouk and H. A. Kassem, "Improving fruit quality, nutritional value and yield of Zaghloul dates by the application of organic and/or mineral fertilizers," *Scientia Horticulturae*, vol. 127, no. 3, pp. 249–254, 2011.

[14] R. Chowdhury, "Effects of chemical fertilizers on the surrounding environment and the alternative to the chemical fertilizers," *Ies- Envis Newsletter*, vol. 7, no. 3, pp. 4-5, 2004.

[15] B. Liu, M. L. Gumpertz, S. Hu, and J. B. Ristaino, "Long-term effects of organic and synthetic soil fertility amendments on soil microbial communities and the development of southern blight," *Soil Biology and Biochemistry*, vol. 39, no. 9, pp. 2302–2316, 2007.

[16] L. B. Tonfack, A. Bernadac, E. Youmbi, V. P. Mbouapouognigni, M. Ngueguim, and A. Akoa, "Impact of organic and inorganic fertilizers on tomato vigor, yield and fruit composition under tropical andosol soil conditions," *Fruits*, vol. 64, no. 3, pp. 167–177, 2009.

[17] T. Mengistu, H. Gebrekidan, K. Kibret, K. Woldetsadik, B. Shimelis, and H. Yadav, "The integrated use of excreta-based vermicompost and NP fertilizer on tomato (*Solanumlycopersicum* L.) fruit yield, quality and soil fertility," *International Journal of Recycling of Organic Waste in Agriculture*, vol. 6, no. 1, pp. 63–77, 2017.

[18] G. Agegnehu, B. Lakew, and P. N. Nelson, "Cropping sequence and nitrogen fertilizer effects on the productivity and quality of malting barley and soil fertility in the Ethiopian highlands," *Archives of Agronomy and Soil Science*, vol. 60, no. 9, pp. 1261–1275, 2014.

[19] S. M. Shata, A. Mahmoud, and S. Siam, "Improving calcareous soil productivity by integrated effect of intercropping and fertilizer," *Research Journal of Agriculture and Biological Sciences*, vol. 3, no. 6, pp. 733–739, 2007.

[20] Csa (Central Statistical Agency), *Agricultural Sample Survey: Report on Area and Production of Major Crops (Private Peasant Holdings, Meher Season),* Central Statistical Agency (CSA), Addis Ababa, Ethiopia, 2019.

[21] S. Hunduma and G. Kebede, "Measurement of soil particle size distribution using hydrometer analysis," *American-Eurasian Journal of Agricultural & Environmental Sciences*, vol. 20, no. 4, pp. 243–254, 2020.

[22] S. Sahilemedhin and B. Taye, *Procedures for Soil and Plant Analysis*, National Soil Research Center Ethiopian Agricultural Research Organization, Addis Ababa, Ethiopia, 2000.

[23] D. L. Spark, A. L. Page, and P. A. Helmke, "Methods of soil analysis," *Chemical Methods*, Soil Science Society of America, Madison, WI, USA, 1996.

[24] J. M. Bremner and C. S. Mulvaney, ""Nitrogen-total" in methods of soil analysis," in *Chemical and Microbiological Properties*, A. L. Page, R. H. Miller, and D. R. Keeney, Eds., pp. 595–624, American Society of Agronomy, Madison, WI, USA, 1982.

[25] M. Schnitzer, "Total carbon, organic matter and carbon," in *Methods of Soil Analysis*, P. A. Kamara, A. Kamara, M. M. Mansaray, and P. A. Sawyerr, Eds., American Society of Agronomy, Madison, WI, USA, 1982.

[26] R. G. Steel and J. H. Torrie, *Principles and Procedures of Statistics. A Biometrical Approach*, McGraw Hill Book Co, New York, NY, USA, 1980.

[27] CIMMYT (International Maize and Wheat Improvement Center), "From agronomic data to farmer recommendations: an economics training manual (Completely revised.)," *Solely CIMMYT*, 1988.

[28] D. Ekero, W. Haile, L. Alemu, and M. Bibiso, "Effects of different land use types on soil physico-chemical properties in wolaita zone, Ethiopia," *Polish Journal of Soil Science*, vol. 55, no. 1, pp. 19–35, 2022.

[29] N. H. Batjes, "A global data set of soil pH Properties," International Soil Reference and Information Centre (ISRIC), Wageningen, Netherlands, Technical Paper 27, 1995.

[30] M. Tekalign and I. Haque, "Phosphorus status of some Ethiopian soils, II. Forms and distribution of inorganic phosphates and their relation to available phosphorus," *Tropical Agriculture*, vol. 68, pp. 2–8, 1991.

[31] S. Adhikary, "Vermicompost, the story of organic gold: a review," *Agricultural Sciences*, vol. 3, no. 7, pp. 905–917, 2012.

[32] J. Mistry, "Vermicompost, a best superlative for organic farming: a review," *Journal of Advanced Studies in Agricultural, Biological and Environmen-tal Sciences*, vol. 2, no. 3, pp. 38–46, 2015.

[33] M. Ceritoğlu, S. Şahin, and M. Erman, "Effects of vermicompost on plant growth and soil structure," *Selcuk Journal of Agricultural and Food Sciences*, vol. 32, no. 3, pp. 607–615, 2018.

[34] N. Ahmed and K. A. Al-Mutairi, "Earthworms effect on microbial population and soil fertility as well as their interaction with agriculture practices," *Sustainability*, vol. 14, p. 7803, 2022.

[35] G. Agegnehu, P. N. Nelson, and M. I. Bird, "Crop yield, plant nutrient uptake and soil physicochemical properties under organic soil amendments and nitrogen fertilization on Nitisols," *Soil and Tillage Research*, vol. 160, pp. 1–13, 2016.

[36] K. Tadesse, A. Mekonnen, A. Admasu et al., "Malting barley response to integrated organic and mineral nutrient sources in Nitisol," *International Journal of Recycling of Organic Waste in Agriculture*, vol. 7, no. 2, pp. 125–134, 2018.

[37] A. Mahajan, R. M. Bhagat, and R. D. Gupta, "Integrated nutrient management in sustainable rice wheat cropping

system for food security in India," *SAARC Journal of Agriculture*, vol. 6, no. 2, pp. 29–32, 2008.

[38] T. Tesfay, M. Gebremariam, K. Gebretsadik, M. Hagazi, and S. Girmay, "Tomato yield and economic performance under vermicompost and mineral fertilizer applications," *The Open Agriculture Journal*, vol. 12, no. 1, pp. 262–269, 2018.

[39] P. Kováčik, V. Šimanský, S. Smoleń, J. Neupauer, and K. Olšovská, "The effect of vermicompost and earthworms (Eisenia fetida) application on phytomass and macroelement concentration and tetanic ratio in carrot," *Agronomy*, vol. 12, no. 11, p. 2770, 2022.