

## The Effect of Vermicompost and Liquid Organic Fertilizer (POC) Application on Soil Biological Properties, Growth, and Yield of Tomato (*Solanum Lycopersicum* L.)

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**ABSTRACT:** Tomato (*Solanum lycopersicum* L.) is one of the most important horticultural commodities with high economic value. However, its productivity has significantly declined due to land degradation, particularly in marginal soils such as Ultisols, which are characterized by low organic matter content and nitrogen deficiency. Improving soil fertility and enhancing tomato yield can be achieved through the application of solid organic fertilizer in the form of vermicompost (kascing) and liquid organic fertilizer (POC). This study aimed to: (1) determine the optimal dose of vermicompost to improve soil biological properties, growth, and tomato yield; (2) identify the best POC concentration to enhance tomato productivity; and (3) evaluate the interaction between vermicompost and POC on soil biological properties, growth, and yield of tomato. The experiment was arranged in a factorial Randomized Block Design (RBD) with two factors: vermicompost doses (0 g, 20 g, 40 g, and 60 g/plant) and POC concentrations (0 ml/L, 30 ml/L, and 60 ml/L), each replicated three times. The results showed that vermicompost application had a highly significant effect ( $P < 0.01$ ) on almost all parameters, including soil microbial population, plant height, number of leaves, number of flowers, number of fruits, fruit weight per plant, and yield per hectare. The application of 60 g/plant vermicompost produced optimal growth with the highest number of flowers (73.50), fruits (87.33), fruit weight per plant (1540.73 g), and yield (3.06 t/ha). Similarly, POC application had a highly significant effect on vegetative and generative growth, where a concentration of 60 ml/L accelerated flowering (38.83 days after transplanting) and increased the number of leaves and fruit weight. The interaction between vermicompost and POC also showed synergistic effects, with the best combination obtained at 60 g/plant vermicompost and 30 ml/L POC. These results demonstrate that the integrated use of vermicompost and POC is effective in improving soil biological properties and enhancing the growth and yield of tomato in a sustainable manner.

**KEYWORDS:** Tomato, Vermicompost, Liquid Organic Fertilizer, Soil Biology, Productivity.

### INTRODUCTION

Indonesia, as an agricultural country, has great potential in the agricultural sector, including horticulture, which provides high economic value commodities. One of the most important horticultural crops is tomato (*Solanum lycopersicum* Mill.), which is widely cultivated because it can be consumed fresh or processed, and is also used in the food, cosmetic, and pharmaceutical industries (Sari et al., 2020; Wahyurini, 2020).

Despite the increasing market demand, tomato production in Indonesia has declined. Data from the Central Statistics Agency (BPS, 2024) show that national production decreased by 2.14% in 2023, while in Bali it dropped drastically from 12,172 tons in 2021 to only 5,218 tons in 2023. One of the main causes is land degradation due to excessive use of chemical fertilizers and pesticides, particularly in marginal soils such as Ultisols, which are acidic and low in nutrients (Sumarniasih & Antara, 2021).

To address this problem, environmentally friendly cultivation systems are required through the use of organic fertilizers. Vermicompost (kascing), as a solid organic fertilizer, has been proven to improve soil fertility, nutrient availability, and soil microbial activity, thereby positively influencing plant growth and yield (Hartatik et al., 2015; Hanafi et al., 2023). Similarly, liquid organic fertilizer (LOF), particularly NASA LOF, enhances plant metabolism, improves soil structure, and supports both vegetative and generative growth (Dahlan et al., 2023).

Several studies have demonstrated that the combination of vermicompost and NASA LOF improves soil biological properties and provides the best results for the growth and yield of horticultural crops (Oktaviani et al, 2020). Soil biological

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properties, including microbial and enzymatic activities, are crucial indicators of soil health and nutrient availability for plants (Gadi et al., 2025).

Based on these considerations, research on the combined application of solid organic fertilizer (vermicompost) and liquid organic fertilizer (NASA LOF) is necessary to evaluate their effects on soil biological properties, growth, and tomato yield in a sustainable manner.

## RESEARCH METHOD

This study was an experimental research designed using a two-factorial Randomized Block Design (RBD). The first factor was the application of vermicompost (M) consisting of four levels:  $M_0$  = without vermicompost,  $M_1$  = 20 g/plant,  $M_2$  = 40 g/plant, and  $M_3$  = 60 g/plant. The second factor was the concentration of liquid organic fertilizer (POC) (Z) consisting of three levels:  $Z_0$  = 0 ml/L,  $Z_1$  = 30 ml/L, and  $Z_2$  = 60 ml/L. The combination of both factors resulted in 12 treatments, each repeated three times, so that a total of 36 experimental units were obtained. Each unit consisted of five tomato plants, of which three were used as samples.

The study was conducted from April to June 2025 at the experimental field in Br. Jelijih Pondoh, Megati Village, Selemadeg Timur District, Tabanan Regency, Bali, with an average field temperature of 27°C.

The implementation began with seed selection and nursery management, followed by land preparation through tillage, ridge formation, and the application of organic mulching. Tomato seedlings aged 15–20 days were transplanted at a spacing of 60 cm. Vermicompost was applied twice, during the vegetative and generative phases, by top-dressing, while liquid organic fertilizer (POC) was applied weekly at the root zone from 10 days after transplanting until one week before harvest. Plant maintenance included watering, weeding, replanting, staking, pruning, and environmentally friendly pest control. Harvesting was carried out five times when fruits reached physiological maturity at 62–65 days after planting.

The observed variables consisted of soil biological properties (microbial population and soil respiration), as well as tomato growth and yield parameters, including plant height, number of leaves, stem diameter, number of branches, flowering time, number of flowers, number of fruits, fruit weight per plant, and fruit yield per hectare. Supporting data were also collected from soil chemical analyses before and after the experiment.

Data were analyzed using analysis of variance (ANOVA) based on the two-way factorial RBD model. When significant effects were found, the analysis was followed by the Least Significant Difference (LSD) test at a 5% significance level. Correlation analysis was also performed to evaluate the relationships between treatments and observed variables.

## RESULTS

### Analysis of Soil Chemical Properties at the Research Site.

Prior to the application of treatments, an analysis of the soil chemical properties at the research site was conducted to determine the initial soil fertility status. The results of the soil chemical analysis are presented in Table 1.

**Table 1. Selected Soil Chemical Properties**

Parameter	Content	Category (*)
Total N (%)	0.140	Low
Available P	7.700	Very High
Available K	155.680	Moderate
CEC	6.920	—

**Source:** Soil and Environmental Science Laboratory, Faculty of Agriculture, Udayana University (2025).

**Note:** T = High, VH = Very High, M = Moderate.

The soil analysis at the research site indicated that the total nitrogen content was low (0.140%), which may inhibit vegetative growth of tomato plants, cause leaf chlorosis, and reduce productivity. In contrast, the available phosphorus content (7.700 ppm) was categorized as very high, supporting root development, accelerating flowering, and enhancing fruit setting and filling. The available potassium content (155.680 ppm) was in the moderate category, suggesting the need for improvement to support fruit size, sweetness, and overall quality. The base saturation value (6.920) reflected a fairly good soil capacity to retain and supply nutrients.

Overall, the soil at the research site demonstrated favorable conditions for tomato growth due to its high phosphorus content and adequate base saturation. However, the low nitrogen content remained a limiting factor. Therefore, the application

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of vermicompost and liquid organic fertilizer (POC) is expected to improve soil nutrient status, increase the availability of nitrogen and potassium, and support optimal growth and yield of tomato plants.

### Soil Biological Properties as Affected by Vermicompost and Liquid Organic Fertilizer (POC)

To evaluate the effects of vermicompost and liquid organic fertilizer (POC) treatments, two key indicators of soil biological properties were observed: soil microbial population (CFU/g soil) and soil respiration (mg CO<sub>2</sub>/kg soil/day).

#### 1. Soil Microbial Population (CFU/g soil)

Soil samples were collected from the rhizosphere of tomato plants under different combinations of vermicompost and POC treatments. The microbial population was determined using the Total Plate Count (TPC) method, and the results are presented in Table 2.

**Table 2. Soil Microbial Population under Vermicompost and POC Treatments**

Sample Code	Soil:Vermicompost Composition	POC Concentration (ml/L)	Total Microbes (CFU/g)
M <sub>0</sub> Z <sub>0</sub>	No Vermicompost	0	9.8 × 10 <sup>6</sup>
M <sub>0</sub> Z <sub>1</sub>	No Vermicompost	30	7.6 × 10 <sup>6</sup>
M <sub>0</sub> Z <sub>2</sub>	No Vermicompost	60	8.8 × 10 <sup>6</sup>
M <sub>1</sub> Z <sub>0</sub>	Vermicompost 20 g/plant	0	9.3 × 10 <sup>6</sup>
M <sub>1</sub> Z <sub>1</sub>	Vermicompost 20 g/plant	30	9.1 × 10 <sup>6</sup>
M <sub>1</sub> Z <sub>2</sub>	Vermicompost 20 g/plant	60	1.5 × 10 <sup>7</sup>
M <sub>2</sub> Z <sub>0</sub>	Vermicompost 40 g/plant	0	1.0 × 10 <sup>7</sup>
M <sub>2</sub> Z <sub>1</sub>	Vermicompost 40 g/plant	30	9.6 × 10 <sup>6</sup>
M <sub>2</sub> Z <sub>2</sub>	Vermicompost 40 g/plant	60	1.1 × 10 <sup>7</sup>
M <sub>3</sub> Z <sub>0</sub>	Vermicompost 60 g/plant	0	2.0 × 10 <sup>7</sup>
M <sub>3</sub> Z <sub>1</sub>	Vermicompost 60 g/plant	30	1.1 × 10 <sup>7</sup>
M <sub>3</sub> Z <sub>2</sub>	Vermicompost 60 g/plant	60	1.6 × 10 <sup>7</sup>

*Source: Soil Science and Environmental Laboratory, Faculty of Agriculture, Udayana University (2025).*

The microbial population varied across treatments, ranging from 7.6 × 10<sup>6</sup> to 2.0 × 10<sup>7</sup> CFU/g soil. The highest population was recorded in the treatment with 60 g vermicompost without POC (M<sub>3</sub>Z<sub>0</sub>), while the lowest was observed in the treatment without vermicompost and with 30 ml/L POC (M<sub>0</sub>Z<sub>1</sub>).

In general, vermicompost application increased microbial populations due to its rich organic matter content (C-organic, N, P, K) and the presence of native microbial communities that enhance organic matter decomposition. POC contributed soluble nutrients that stimulated microbial metabolism, particularly in combination with moderate vermicompost doses (20–40 g). Treatments such as 20 g vermicompost + 60 ml/L POC (M<sub>1</sub>Z<sub>2</sub>) and 40 g vermicompost + 60 ml/L POC (M<sub>2</sub>Z<sub>2</sub>) also resulted in high microbial populations, indicating synergistic effects between solid organic inputs and liquid nutrient sources.

However, certain combinations (e.g., M<sub>0</sub>Z<sub>1</sub> and M<sub>2</sub>Z<sub>1</sub>) showed relatively lower microbial populations, likely due to imbalances in the C/N ratio or suboptimal environmental conditions for specific microorganisms. Overall, vermicompost and POC treatments significantly influenced microbial populations, thereby enhancing soil biological activity, nutrient cycling, and the availability of essential elements for tomato growth.

#### 2. Soil Respiration (mg CO<sub>2</sub>/kg soil/day)

Soil respiration was used as an indicator of biological activity, reflecting microbial metabolism through CO<sub>2</sub> release. Higher respiration values indicate greater microbial activity in decomposing organic matter and recycling nutrients. Measurements were conducted using a closed incubation method with NaOH solution as a CO<sub>2</sub> trap. The results are presented in Table 3.

Soil respiration ranged between 6.00 and 8.74 mg CO<sub>2</sub>/kg soil/day. The highest value was recorded in the treatment without vermicompost + 30 ml/L POC (M<sub>0</sub>Z<sub>1</sub>), while the lowest was observed with 60 g vermicompost + 30 ml/L POC (M<sub>3</sub>Z<sub>1</sub>).

In general, moderate POC application (30 ml/L), either with or without vermicompost, tended to increase respiration activity, indicating that POC provided readily available energy sources for microbial metabolism. Conversely, relatively low respiration at high vermicompost doses (60 g) combined with 30 ml/L POC may be attributed to substrate saturation or imbalances

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in the C/N ratio that restricted the growth of certain microbial groups. However, respiration increased again under high vermicompost with 60 ml/L POC (M<sub>3</sub>Z<sub>2</sub>), suggesting that balanced nutrient availability can still support microbial activity.

These findings highlight that soil respiration is a valuable indicator of soil biological dynamics. Increases in respiration reflect enhanced microbial activity, which ultimately contributes to improved soil fertility, nutrient cycling, and tomato plant growth.

**Table 3. Soil Respiration under Vermicompost and POC Treatments**

Sample Code	Soil:Vermicompost Composition	POC Concentration (ml/L)	Respiration (mg CO <sub>2</sub> /kg soil/day)
M <sub>0</sub> Z <sub>0</sub>	No Vermicompost	0	7.03
M <sub>0</sub> Z <sub>1</sub>	No Vermicompost	30	8.74
M <sub>0</sub> Z <sub>2</sub>	No Vermicompost	60	6.86
M <sub>1</sub> Z <sub>0</sub>	Vermicompost 20 g/plant	0	6.86
M <sub>1</sub> Z <sub>1</sub>	Vermicompost 20 g/plant	30	8.06
M <sub>1</sub> Z <sub>2</sub>	Vermicompost 20 g/plant	60	6.51
M <sub>2</sub> Z <sub>0</sub>	Vermicompost 40 g/plant	0	7.89
M <sub>2</sub> Z <sub>1</sub>	Vermicompost 40 g/plant	30	6.34
M <sub>2</sub> Z <sub>2</sub>	Vermicompost 40 g/plant	60	8.06
M <sub>3</sub> Z <sub>0</sub>	Vermicompost 60 g/plant	0	8.23
M <sub>3</sub> Z <sub>1</sub>	Vermicompost 60 g/plant	30	6.00
M <sub>3</sub> Z <sub>2</sub>	Vermicompost 60 g/plant	60	8.23

**Source:** Soil Science and Environmental Laboratory, Faculty of Agriculture, Udayana University (2025).

### Significance of Treatment Effects on Observed Variables

The data presented in Table 4 indicate that the interaction between vermicompost (M) and liquid organic fertilizer (POC/Z) had a significant effect on several vegetative growth variables (number of leaves, stem diameter, and number of branches), as well as a highly significant effect on yield variables (fruit weight and yield per hectare). The single factor of vermicompost exerted a highly significant effect on nearly all observed variables, highlighting its role as a source of nutrients and beneficial microorganisms that improve soil fertility and support tomato growth. Meanwhile, the single factor of POC also demonstrated a highly significant effect on plant height, number of leaves, flowering time, and fruit weight, functioning as a readily available nutrient stimulant that promotes both vegetative and generative growth. Soil biological variables (microbial population and soil respiration) were analyzed descriptively to illustrate the biological dynamics resulting from organic treatments, rather than being subjected to statistical significance testing.

**Table 4. Significance of Vermicompost (M), Liquid Organic Fertilizer/POC (Z), and Their Interaction (M × Z) on Soil Biological Properties, Growth, and Yield of Tomato Plants**

No	Observed Variable	Treatments		
		G	P	G x P
1	Soil microbial population	na	na	na
2	Soil respiration	na	na	na
3	Plant height	**	**	ns
4	Number of leaves	**	**	**
5	Stem diameter	**	**	**
6	Number of branches	**	**	**
7	Flowering time	**	**	ns
8	Number of flowers	**	**	**
9	Fruit weight	**	**	*
10	Fruit yield per hectare	**	**	**

**Notes:**

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na : Not statistically analyzed

ns : Not significant ( $p > 0.05$ )

\* : Significant ( $p < 0.05$ )

\*\* : Highly significant ( $p < 0.01$ )

### Plant Height and Flowering Time

The analysis presented in Table 5 indicates that the interaction between vermicompost and liquid organic fertilizer (POC) had no significant effect ( $p > 0.05$ ) on either plant height or flowering time. However, as single factors, both treatments exhibited significant to highly significant effects ( $p < 0.05$ – $0.01$ ).

**Table 5. Effect of Vermicompost and POC on Plant Height and Flowering Time of Tomato**

Treatment	Plant Height (cm)		Flowering Time (days after planting/DAP)	
Without Vermicompost	76,50	a	45,78	d
Vermicompost 20 g/plant	89,11	b	42,00	c
Vermicompost 40 g/plant	91,78	b	38,33	b
Vermicompost 60 g/plant	94,11	b	35,44	a
LSD 5%	<b>5,96</b>		<b>1,21</b>	
Without POC (0 ml/L)	82,63	a	41,75	c
POC 30 ml/L per plant	89,46	b	40,58	b
POC 60 ml/L per plant	91,54	b	38,83	a
LSD 5%	<b>4,67</b>		<b>0,59</b>	
CV (%)	<b>3,10</b>		<b>1,38</b>	

**Note:** Values followed by the same letter in the same column are not significantly different according to the LSD test at the 5% level.

Based on Table 5, in terms of plant height, the treatment without vermicompost produced the lowest growth (76.50 cm), while the application of 60 g vermicompost per plant resulted in the highest plant height (94.11 cm). Similarly, plants without POC reached a height of 82.63 cm, whereas the application of 60 ml/L POC increased plant height to 91.54 cm. These findings demonstrate the role of vermicompost as a source of organic nutrients and beneficial soil microorganisms, while POC acts as a provider of readily available nutrients and natural growth regulators that stimulate vegetative development.

For flowering time, plants without vermicompost exhibited the latest flowering (45.78 DAP), whereas the application of 60 g vermicompost per plant accelerated flowering to 35.44 DAP. A similar pattern was observed with POC application, where the absence of POC resulted in delayed flowering (41.75 DAP), while the application of 60 ml/L POC accelerated the generative phase to 38.83 DAP. This acceleration is associated with the role of vermicompost in improving phosphorus availability and soil structure, as well as the function of POC in supplying readily absorbable nutrients and bioactive compounds that facilitate the transition from vegetative to generative growth. Thus, although the interaction between vermicompost and POC was not statistically significant, their individual applications positively contributed to both vegetative growth and generative development of tomato plants.

### **Number of Leaves, Stem Diameter, Number of Branches, Number of Flowers, Number of Fruits, Fruit Weight per Plant, and Fruit Yield per Hectare**

The results presented in Table 6 indicate that the interaction between vermicompost (kascing) and liquid organic fertilizer (POC) had a highly significant effect on the vegetative growth of tomato plants. The treatment without vermicompost and without POC ( $M_0Z_0$ ) produced 67.50 leaves, a stem diameter of 7.48 mm, and 4.00 branches, whereas the combination of 60 g vermicompost with 30 ml/L POC ( $M_3Z_1$ ) increased these parameters to 122.50 leaves, 11.23 mm stem diameter, and 13.00 branches. This improvement in vegetative parameters suggests that the combination of vermicompost and POC provides a balanced nutrient supply, enhances soil microbial activity, and supports the optimal formation of vegetative organs. A stronger vegetative condition contributes to increased photosynthetic surface area, stem robustness, and a better assimilate distribution to support the generative phase.

During the generative phase, the treatment without vermicompost and POC ( $M_0Z_0$ ) resulted in 20.17 flowers, 42.17 fruits, 656.40 g fruit weight per plant, and a productivity of 1.26 t/ha. In contrast, the application of 60 g vermicompost combined with

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30 ml/L POC (M<sub>3</sub>Z<sub>1</sub>) produced 73.50 flowers, 87.33 fruits, 1540.73 g fruit weight per plant, and a productivity of 3.06 t/ha. These results indicate that the combination of solid and liquid organic fertilizers can provide a stable and readily available nutrient supply, particularly during the critical stages of flowering and fruit filling, leading to a significant increase in tomato yield. Therefore, the application of 60 g vermicompost per plant in combination with 30 ml/L POC can be recommended as an effective and sustainable organic fertilization strategy to enhance tomato productivity.

**Table 6. Interaction Effects of Vermicompost and Liquid Organic Fertilizer (POC) on Tomato Growth and Yield**

Treatment	Number of Leaves (leaves)	Stem Diameter (mm)	Number of Branches	Number of Flowers	Number of Fruits	Fruit Weight per Plant (g/plant)	Fruit Weight per Hectare (t/ha)
M <sub>0</sub> Z <sub>0</sub>	67,50 a	7,48 a	4,00 a	20,17 a	42,17 a	656,40 a	1,26 a
M <sub>0</sub> Z <sub>1</sub>	75,33 ab	7,65 a	4,33 a	27,33 ab	48,83 ab	822,20 ab	1,59 ab
M <sub>0</sub> Z <sub>2</sub>	79,33 b	8,25 ab	5,00 a	34,17 b	52,50 bc	906,13 ab	1,80 ab
M <sub>1</sub> Z <sub>0</sub>	82,50 bc	8,40 ab	5,33 a	36,50 bc	55,33 bc	956,13 ab	1,96 ab
M <sub>1</sub> Z <sub>1</sub>	98,50 de	9,45 bc	8,00 b	50,00 cd	63,17 cd	1068,23 bc	2,16 bc
M <sub>1</sub> Z <sub>2</sub>	104,33 ef	9,88 cd	8,67 b	55,67 de	66,00 de	1120,73 bc	2,27 bc
M <sub>2</sub> Z <sub>0</sub>	87,50 cd	8,80 bc	6,00 a	40,33 cd	57,17 bc	1012,40 bc	2,03 ab
M <sub>2</sub> Z <sub>1</sub>	110,50 fg	10,25 cd	9,83 bc	60,83 de	70,50 cd	1184,87 cd	2,33 bc
M <sub>2</sub> Z <sub>2</sub>	115,50 g	10,65de	11,00 cd	65,00 ef	75,00 de	1315,23 de	2,62 cd
M <sub>3</sub> Z <sub>0</sub>	92,50 d	9,18 bc	7,83 ab	45,67 cd	61,67 cd	1056,83 bc	2,12 ab
M <sub>3</sub> Z <sub>1</sub>	122,50 h	11,23 e	13,00 d	73,50 f	87,33 f	1540,73 e	3,06 d
M <sub>3</sub> Z <sub>2</sub>	118,50 g	11,03 e	11,00 cd	71,50 f	80,33 f	1420,13 de	2,84 cd
<b>LSD 5%</b>	<b>4,66</b>	<b>0,48</b>	<b>1,32</b>	<b>10,59</b>	<b>9,46</b>	<b>281,19</b>	<b>0,13</b>
<b>CV (%)</b>	<b>0,98</b>	<b>1,04</b>	<b>3,42</b>	<b>4,40</b>	<b>3,02</b>	<b>5,91</b>	<b>1,24</b>

Note: Values followed by the same letter in the same column are not significantly different according to the LSD test at the 5% level.

### DISCUSSION

This study aimed to determine the effect of vermicompost and liquid organic fertilizer (LOF) application on the growth and yield of tomato plants (*Solanum lycopersicum L.*), with consideration of soil conditions and soil biological activity as key supporting factors. The growth and yield of tomato plants are strongly influenced by soil fertility, both chemical and biological properties, as these determine nutrient availability and rhizosphere microbial activity.

Soil analysis at the study site revealed that the total nitrogen (N) content was classified as low (0.140%), while available phosphorus (P) was very high (7.700 ppm), and available potassium (K) was within the medium category (155.680 ppm). The base saturation (KU) of 6.920 indicated a fairly good soil capacity to support nutrient supply (Table 5.1). This condition is consistent with the statement of Adekiya et al. (2022), who noted that nitrogen is an essential nutrient for vegetative growth, whereas phosphorus and potassium are important for root development, flowering, and fruit formation. Thus, although the high phosphorus content supports flowering and yield, the low nitrogen level becomes a limiting factor that needs to be addressed through the application of organic fertilizers such as vermicompost and LOF.

In addition to chemical properties, soil biological conditions were also observed through microbial population and soil respiration. Based on microbial population counts (Table 5.2), the number of microorganisms varied among treatments, ranging from  $7.6 \times 10^6$  to  $2.0 \times 10^7$  CFU/g soil. The highest population was found in the treatment with vermicompost 60 g/plant without LOF (M<sub>3</sub>Z<sub>0</sub>), whereas the lowest population occurred in the treatment without vermicompost but with LOF 30 ml/L (M<sub>0</sub>Z<sub>1</sub>). This indicates that vermicompost plays an important role in enhancing microbial populations due to its nutrient-rich organic matter and indigenous decomposer microbes. According to Sopha et al. (2020), solid organic fertilizer application can increase soil microbial diversity, which supports nutrient mineralization. LOF also contributes to providing readily available nutrients, and in combination with moderate doses of vermicompost (20–40 g), it was able to increase microbial populations to  $>10^7$  CFU/g soil.

Soil respiration observations (Table 5.3) showed values ranging from 6.00 to 8.74 mg CO<sub>2</sub>/kg soil/day. The highest respiration was found in the treatment without vermicompost but with LOF 30 ml/L (M<sub>0</sub>Z<sub>1</sub>), while the lowest value was recorded in the combination of vermicompost 60 g with LOF 30 ml/L (M<sub>3</sub>Z<sub>1</sub>). The increase in respiration under moderate LOF application indicates high microbial metabolic activity due to the availability of easily soluble energy sources. Conversely, lower values under

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high vermicompost with moderate LOF suggest the possibility of substrate saturation or an imbalance in the C/N ratio, although respiration values increased again when high vermicompost was combined with LOF 60 ml/L ( $M_3Z_2$ ). According to Amalia & Fathurrahman (2024), soil respiration is a sensitive indicator for assessing microbial activity dynamics and nutrient cycling.

Overall, the findings of this study confirm that relatively favorable soil chemical properties (high P and sufficient KU), together with improved biological properties through the application of vermicompost and LOF, enhance nutrient availability and microbial activity. The combination of high-dose vermicompost with moderate to high LOF proved effective in increasing microbial populations and soil respiration, ultimately supporting both vegetative and generative growth of tomato plants optimally.

Based on Table 5.5, the application of vermicompost had a significant effect on the plant height of tomato. The treatment without vermicompost produced the lowest average height of 76.50 cm, whereas the application of 60 g vermicompost per plant increased plant height to 94.11 cm. This trend indicates that the higher the dose of vermicompost applied, the greater the increase in plant height. This result is consistent with the characteristics of vermicompost as a solid organic fertilizer rich in macro-nutrients (N, P, K) and essential micronutrients, accompanied by the activity of microorganisms that improve soil structure and enhance nutrient availability (Riski et al., 2024). Nitrogen in vermicompost plays a role in chlorophyll formation and protein synthesis, thereby accelerating vegetative growth through increased photosynthetic activity (Sanda & Syam, 2018).

Meanwhile, the application of Nasa liquid organic fertilizer (LOF) also showed a significant effect on tomato plant height. Plants without LOF reached only an average height of 82.63 cm, whereas the application of 60 ml/L Nasa LOF per plant increased plant height to 91.54 cm. This increase was due to the liquid nature of Nasa LOF, which makes it more readily absorbed by roots, as well as its content of essential nutrients, humic acids, and natural growth regulators that stimulate cell division and elongation (Harahap et al., 2020). The natural hormones contained in Nasa LOF, such as auxins, cytokinins, and gibberellins, further support stem and leaf growth by enhancing meristematic activity (Dahlan et al., 2023).

The findings of this study confirm that vermicompost serves as a source of organic nutrients capable of improving soil biological properties through enhanced microbial populations and nutrient mineralization, while Nasa LOF acts as a source of readily available nutrients that strengthens vegetative growth. Although the interaction between the two treatments did not show a significant effect on plant height, their combined use still provided positive impacts in supporting optimal tomato growth.

The mechanism of action of vermicompost and LOF in combination can be explained through the synergy of improved soil biology and nutrient availability. Vermicompost enhances soil aggregation, organic carbon content, and soil enzyme activity, thereby strengthening the rhizosphere environment (Sanda & Syam, 2018). Meanwhile, Nasa LOF accelerates nutrient absorption by providing nutrients in soluble form and supplying natural hormones that stimulate cell division. Thus, the combined use of both inputs supports improved vegetative growth, as reflected in increased plant height.

These findings are consistent with the report of Sutejo et al. (2024), who stated that the combination of solid and liquid organic fertilizers can enhance nutrient uptake efficiency and stimulate the vegetative growth of horticultural crops. Therefore, it can be concluded that the application of 60 g vermicompost per plant and 60 ml/L Nasa LOF represents the most effective treatment in supporting tomato plant height growth in this study.

Unlike single applications, the combination of 60 g vermicompost per plant and 30 ml/L Nasa liquid organic fertilizer (LOF) resulted in the highest number of leaves, stem diameter, and number of branches, indicating a significant synergistic effect on tomato vegetative growth. In this combination, vermicompost functions as a source of organic matter and macro-nutrients (N, P, K, Ca, Mg) as well as micro-nutrients (Fe, Zn, Mn, Cu), which are gradually released through microbial decomposition processes in the soil (Hasalsyah et al., 2025). This process not only improves nutrient availability but also enhances soil structure, increases porosity, and enriches microbial populations that support organic matter decomposition and nutrient cycling (Budiyanto et al., 2019). Thus, vermicompost creates stable edaphic conditions to support tomato vegetative growth.

On the other hand, Nasa LOF supplies nutrients in soluble form, particularly nitrogen, phosphorus, and potassium, along with bioactive compounds such as amino acids, vitamins, natural hormones (auxins, cytokinins, gibberellins), and enzymes. These readily available nutrients accelerate plant metabolism, stimulate cell division and elongation, and enhance photosynthetic activity (Gadi et al., 2025). The natural hormones in Nasa LOF also regulate plant hormonal pathways—for instance, cytokinins promote lateral shoot formation, thereby increasing branch number, while auxins influence stem tissue differentiation, enhancing stem diameter.

The synergy between vermicompost and Nasa LOF lies in the mechanism of nutrient availability and uptake. Vermicompost releases nutrients gradually through soil microbial activity, whereas Nasa LOF provides readily available nutrients that are directly utilized by the plant. This combination establishes a balance between short-term and long-term nutrient supply. Furthermore, the microorganisms enriched by vermicompost can utilize organic compounds and substances from Nasa LOF as substrates, thereby accelerating mineralization and increasing the availability of essential nutrients (Sutejo et al., 2024).

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Physiologically, an increase in leaf number enhances the photosynthetic surface area, while greater stem diameter strengthens the transport of water and photosynthates from leaves to other organs. A higher number of branches expands the canopy, improving light interception efficiency. These factors directly contribute to greater accumulation of vegetative biomass, which ultimately supports flower and fruit formation. Thus, the synergistic effect of vermicompost and Nasa LOF not only promotes vegetative growth but also has the potential to increase tomato generative yield.

In addition to enhancing vegetative growth, vermicompost application also had a significant effect in accelerating the generative phase. The time to flowering decreased from 45.78 days after planting (DAP) in the treatment without vermicompost to 35.44 DAP with 60 g vermicompost per plant. This acceleration mechanism is closely related to the availability of macro-nutrients (particularly N, P, and K) and micro-nutrients gradually released by vermicompost. Phosphorus plays a crucial role in ATP synthesis and enzyme regulation in energy metabolism pathways, which are required for floral initiation (Hidayat et al., 2023). Additionally, microbial activity in vermicompost enhances the mineralization of organic phosphates through phosphatase enzyme production, thereby increasing phosphorus availability in the rhizosphere (Hanafi et al., 2023). Potassium in vermicompost also acts as an osmotic regulator, maintaining photosynthetic efficiency and photosynthate transport to the generative meristem, thereby accelerating flower development.

Similarly, the application of Nasa LOF reduced the time to flowering from 41.75 DAP without LOF to 38.83 DAP at 60 ml/L dosage. This effect can be explained by its readily available nutrients (N, P, K, Mg, Ca) as well as bioactive compounds such as amino acids, vitamins, and natural hormones (auxins, cytokinins, gibberellins). Gibberellins in LOF stimulate the expression of genes related to the vegetative-to-generative phase transition by suppressing floral repressor proteins (DELLA) and activating the florigen pathway (FT gene), thus accelerating flower induction (Herman et al., 2023). Meanwhile, cytokinins enhance apical meristem activity and generative shoot differentiation, while auxins regulate flower primordia formation through modulation of sugar and assimilate distribution to the growing points (Kamilia, 2022).

Although the interaction between vermicompost and Nasa LOF did not show a statistically significant effect, they still complement each other. Vermicompost improves soil structure and biology, supporting sustainable nutrient availability, while Nasa LOF provides readily available nutrients and bioactive compounds that directly stimulate hormonal pathways for flowering. The combined mechanisms of soil improvement, nutrient availability, and hormonal stimulation explain the acceleration of the generative phase in tomato plants. Thus, the application of vermicompost and Nasa LOF not only supports vegetative growth but also optimizes the transition to flowering, which ultimately determines the yield potential of tomato plants.

Unlike single applications, the combination of 60 g vermicompost per plant and 30 ml/L LOF produced the highest flower number, reaching 73.50 flowers per plant. This increase demonstrates a significant synergistic effect in supporting the generative initiation phase. Vermicompost provides macro-nutrients, particularly phosphorus and potassium, which are essential for flower development and energy transfer during the generative stage. Phosphorus supports generative tissue differentiation, while potassium promotes ATP production required for flowering. Meanwhile, LOF supplies readily available nutrients and bioactive compounds such as amino acids and natural hormones (auxins, cytokinins, and gibberellins) that accelerate flower primordia formation. The synergy between nutrient availability from vermicompost and the bioactive stimulants in LOF creates optimal physiological conditions that enhance flower number in tomato plants (Oktaviani et al., 2020). This is consistent with the findings of Hartatik et al. (2017), who reported that the combination of solid and liquid organic fertilizers increased flower and fruit numbers in horticultural crops through improvements in soil biological conditions and photosynthetic activity.

Furthermore, the higher number of flowers was followed by an increase in the number of fruits formed. The combination treatment of 60 g vermicompost per plant and 30 ml/L Nasa liquid organic fertilizer (LOF) produced the highest fruit number, namely 87.33 fruits per plant. This indicates that, in addition to supporting flower initiation, the combined treatment also enhanced fruit set. Vermicompost improved nitrogen availability to support the development of fertile flowers, while LOF provided natural hormones that enhanced synchronization of pollination and fruit formation. In addition, the stable nutrient supply from vermicompost ensured long-term nutrient availability, whereas the soluble nutrients in LOF provided rapid support during the fruit-setting phase. According to Wang et al. (2017), vermicompost not only increases nutrient availability but also enriches enzymatic and hormonal activities in the soil, which can improve both flowering and fruit set. This reinforces the notion that the combined application of vermicompost and LOF produces a greater number of high-quality fruits.

This condition subsequently impacted fruit weight per plant. The combination of 60 g vermicompost per plant with 30 ml/L LOF produced the highest fruit weight, reaching 1540.73 g per plant. The increase in fruit weight demonstrates that the treatment influenced not only fruit number but also fruit filling and enlargement. Vermicompost played a role in gradually supplying macro-nutrients (N, P, K) and micro-nutrients (Ca, Mg, Zn, Cu), which are essential for photosynthate transport to fruits, while LOF enriched the availability of readily absorbed nutrients and bioactive compounds that support fruit enlargement

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metabolism. The natural hormones in LOF, particularly gibberellins and cytokinins, stimulated fruit cell division and enlargement, thereby significantly increasing fruit weight. These findings are consistent with Amalia & Fathurrahman (2024), who reported that the combination of solid and liquid organic fertilizers increased tomato fruit weight by 30–40% compared with single applications. This confirms that the synergy of solid–liquid organic fertilization contributes substantially to improving harvest quality.

The increase in fruit weight per plant was also reflected at the field scale through the parameter of fruit yield per hectare. The combination treatment of 60 g vermicompost per plant with 30 ml/L LOF produced the highest productivity, namely 3.06 t/ha. This result was considerably higher compared with the unfertilized treatment, which produced only 1.26 t/ha. Agronomically, this demonstrates that the combination of vermicompost and LOF can increase land-use efficiency by simultaneously enhancing both fruit number and fruit weight. Vermicompost created stable edaphic conditions through improvements in soil physical, chemical, and biological properties, whereas LOF ensured the rapid availability of nutrients during critical growth phases. According to Truong & Wang (2015), liquid organic fertilizers can rapidly increase the availability of essential nutrients, while solid organic fertilizers ensure long-term nutrient supply; thus, their combination produces a synergistic effect in improving crop productivity.

Therefore, the synergistic effect between vermicompost and LOF not only increased flower number as an early indicator of the generative phase but also had a significant impact on fruit number, fruit weight per plant, and overall productivity per hectare. The combined treatment proved effective in creating an optimal nutrient balance, accelerating metabolism, and enhancing plant physiological efficiency. This makes the application of 60 g vermicompost per plant with 30 ml/L LOF an effective and sustainable organic fertilization strategy to improve tomato productivity, as also supported by the findings of Liu et al. (2022).

### CONCLUSION

Based on the results of this study, it can be concluded that the application of vermicompost had a highly significant effect ( $p < 0.01$ ) on almost all observed variables, including vegetative growth (plant height, number of leaves, stem diameter, and number of branches), generative phase (time to flowering, number of flowers, and number of fruits), as well as yield (fruit weight per plant and fruit yield per hectare). The best treatment was the application of 60 g/plant vermicompost, which enhanced vegetative growth, accelerated flowering, and resulted in the highest fruit number and weight. Similarly, the application of liquid organic fertilizer (LOF) also had a highly significant effect ( $p < 0.01$ ) on tomato growth and yield. The application of 60 ml/L LOF accelerated flowering, increased the number of leaves, flowers, and fruits, and improved yield. However, the combination of 60 g/plant vermicompost with 30 ml/L LOF ( $M_3Z_1$ ) was the most effective treatment, producing optimal vegetative growth, the highest number of flowers and fruits, and the greatest land productivity, reaching 3.06 tons/ha. These findings suggest that the integrated application of vermicompost and liquid organic fertilizer is a promising strategy to enhance the growth and productivity of tomato plants.

### ADVICE

1. The use of vermicompost at a dose of 60 g/plant in combination with liquid organic fertilizer (LOF) at 30 ml/L is highly recommended to optimize the growth and yield of tomato plants, as this combination has proven to provide the best results for most observed variables.
2. The application of vermicompost and LOF can be adopted as a sustainable cultivation strategy, since it not only improves tomato growth and yield but also enhances soil biological properties through increased microbial activity and nutrient availability.
3. Further research is recommended to evaluate the effectiveness of vermicompost and LOF combinations across different tomato varieties and agroecosystem conditions, in order to develop more practical and cost-effective organic fertilization recommendations for farmers.

### ACKNOWLEDGMENTS

Thank you to the agroecotechnology master program, Faculty of Agriculture, Udayana University and friends and supervisors who have provided criticism and suggestions, assistance, facilities and equipment so that this research can run.

### REFERENCES

- 1) Afrinaldi, L. A., Sari, R. P., & Yulianti, Y. (2020). Utilization of chicken eggshell powder and vermicompost in Ultisol soil on the growth and yield of purple eggplant (*Solanum melongena L.*). *Jurnal Agroteknologi Tropika*, 8(2).

## The Effect of Vermicompost and Liquid Organic Fertilizer (POC) Application on Soil Biological Properties, Growth, and Yield of Tomato (*Solanum Lycopersicum L.*)

- 2) Amalia, R. F., & Fathurrahman, F. (2024). Evaluation of liquid organic fertilizers (POC) from several legumes and organic NPK on the growth and yield of tomato (*Lycopersicum esculentum L.*). *Dinamika Pertanian*, 40(1), 41–52. [https://doi.org/10.25299/dp.2024.vol40\(1\).18866](https://doi.org/10.25299/dp.2024.vol40(1).18866)
- 3) Badan Pusat Statistik. (2024). *Horticultural statistics 2023*. [https://www.bps.go.id/publication/2024/06/10/790c957ba8892f9771aeefb7/statistik-hortikultura-2023.html?utm\\_source=chatgpt.com](https://www.bps.go.id/publication/2024/06/10/790c957ba8892f9771aeefb7/statistik-hortikultura-2023.html?utm_source=chatgpt.com)
- 4) Badan Pusat Statistik Provinsi Bali. (2024). *Tomato production in Bali Province by regency/city (tons), 2021–2023*. [https://bali.bps.go.id/id/statistics-table/2/MzQzIzI%3D/produksi-tomat-provinsi-bali-menurut-kabupaten-kota.html?utm\\_source=chatgpt.com](https://bali.bps.go.id/id/statistics-table/2/MzQzIzI%3D/produksi-tomat-provinsi-bali-menurut-kabupaten-kota.html?utm_source=chatgpt.com)
- 5) Budiyanto, A., Juarsah, I., & Handayani, E. P. (2019). Soil quality improvement using organic fertilizer for sustainable agriculture. *Jurnal Wacana Pertanian*, 14(2).
- 6) Dahlan, F. I., Suriyanti, & Ralle, A. (2023). Effect of concentration and interval of NASA liquid organic fertilizer (POC) on the growth and yield of eggplant (*Solanum melongena L.*). *Jurnal AgrotekMAS*, 4(2). <https://jurnal.fp.umi.ac.id/index.php/agrotekmas>
- 7) Gadi, F. R. B., Bunyani, N. A., & Roman, M. F. (2025). Effect of different doses of NASA liquid organic fertilizer (POC NASA) on the growth of water spinach (*Ipomoea reptans Poir.*). *HUMANITIS: Journal of Humanities, Social and Business*, 3(2), 396–402.
- 8) Hanafi, M., Rasyid, A., & Indriyani, S. (2023). Effect of vermicompost application on nitrogen availability in different soils and nitrogen uptake by pakcoy (*Brassica rapa L.*). *Jurnal Ilmu Pertanian*, 10(3).
- 9) Harahap, F. S., Rahmaniah, R., Oesman, R., & Arman, I. (n.d.). Effect of supplying NASA liquid organic fertilizer and rice husk ash on the chemical properties of soil for tomato cultivation. *International Journal of Science, Technology & Management*. <http://ijstm.inarah.co.id>
- 10) Hartatik, W., Husnain, & Rachman, A. (2015). Role of organic fertilizer in improving soil and crop productivity. Balai Penelitian Tanah, Badan Litbang Pertanian. <http://balittanah.litbang.pertanian.go.id>
- 11) Hasalsyah, W., Midranisiah, Aryani, I., & Akbar, R. A. (2025). Effect of vermicompost and rice-washed water liquid organic fertilizer on growth and yield of tomato (*Lycopersicum esculentum Mill.*) in polybags. *Agriwana: Journal of Agriculture and Forestry*, 3(1), 9–20.
- 12) Herman, H., Satna, A., & Messa, J. (2023). Effectiveness of liquid organic fertilizer on growth and yield of curly tomato. *Journal Agroecotech Indonesia (JAI)*, 2(1).
- 13) Hidayat, R., Mustofa, A., & Lestari, D. (2023). Effect of liquid organic fertilizer on horticultural crop growth. *Jurnal Agroteknologi Tropika*, 11(2), 88–95.
- 14) Kamilia, W. K. (2022). Effect of liquid organic fertilizer from fermented Maja fruit and NASA liquid organic fertilizer on tomato growth. *Jurnal Agroekoteknologi*, 10(3).
- 15) Liu, X., Zhang, J., Wang, Q., Chang, T., Shaghaleh, H., & Alhaj Hamoud, Y. (2022). Improvement of photosynthesis by biochar and vermicompost to enhance tomato (*Solanum lycopersicum L.*) yield under greenhouse conditions. *Plants*, 11(3214). <https://doi.org/10.3390/plants11233214>
- 16) Oktaviani, R., Nurhidayati, S., & Putri, D. A. (2020). Effect of NASA liquid organic fertilizer on water spinach growth in hydroponic systems. *Jurnal Agronomi Indonesia*, 48(2), 123–130.
- 17) Riski, A. W., Widjajani, B. W., & Mindari, W. (2024). Effectiveness of vermicompost and Black Soldier Fly compost on nutrient uptake (N, P), growth, and yield of cherry tomato (*Solanum lycopersicum var. cerasiforme*) on saline soil. *Agro Bali: Agricultural Journal*, 7(2), 616–627. <https://doi.org/10.37637/ab.v7i2.1355>
- 18) Sanda, N., & Syam, N. (2018). Effectiveness of vermicompost and liquid organic fertilizer on the growth and yield of tomato (*Lycopersicum esculentum Mill.*). *Jurnal Agrotek*, 2(1).
- 19) Sari, S. R., Umarie, I., & Wijaya, I. (2023). Response of lettuce (*Lactuca sativa L.*) varieties to different concentrations of NASA POC in NFT hydroponic systems. *Proceedings of the National Seminar on Agrotechnology, Universitas Muhammadiyah Jember*.
- 20) Sari, L. D. A., Kurniawati, E., Ningrum, R. S., & Ramadani, A. H. (2021). Vitamin C content of tomato (*Lycopersicum esculentum Mill.*) fruit at different maturation stages based on days after planting. *Jurnal Farmasi dan Ilmu Kefarmasian Indonesia*, 8(1).
- 21) Sumarniasih, M. S., & Antara, N. S. (2021). Characteristics of Ultisol soils and their impact on crop productivity. *Jurnal Agroekologi Tropika*, 9(1), 45–55. <https://jurnal-agroekologi-tropika.org>

## The Effect of Vermicompost and Liquid Organic Fertilizer (POC) Application on Soil Biological Properties, Growth, and Yield of Tomato (*Solanum Lycopersicum* L.)

- 22) Sutejo, H., Napitupulu, M., Mantika, D., Rahmi, A., & Fatah, A. (2024). Growth and yield of tomato (*Solanum lycopersicum* Mill) Gustavi variety applied with varying levels of cow manure vermicompost and NASA liquid organic fertilizer. *Journal of Agriculture and Ecology Research International*, 25(3), 205–213. <https://doi.org/10.9734/jaeri/2024/v25i3607>
- 23) Truong, H. D., & Wang, C. H. (2015). Effects of different combinations of vermicompost on growth, yield, and fruit quality of two tomato varieties under greenhouse conditions. *Journal of Agricultural Science*, 7(11), 216–227. <http://dx.doi.org/10.5539/jas.v7n11p216>
- 24) Wang, X.-X., Zhao, F., Zhang, G., Zhang, Y., & Yang, L. (2017). Vermicompost improves tomato yield and quality and the biochemical properties of soils with different tomato planting history in a greenhouse study. *Frontiers in Plant Science*, 8, 1978. <https://doi.org/10.3389/fpls.2017.01978>
- 25) Wahyurini, L. (2020). *Tomato cultivation techniques and crop recovery*. UPN “Veteran” Yogyakarta Research and Community Service Institute.



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