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Impact of Poultry Manure on the Growth and Yield of Three Tomato (*Solanum lycopersicum L.*) Cultivars Cultivated in Brazzaville

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Abstract

Tomato (*Solanum lycopersicum L.*) is widely cultivated worldwide for its fruit, which is rich in water, minerals, and proteins, and plays a role in disease prevention. However, in the Republic of Congo, low production levels fail to meet population needs, primarily due to inadequate agricultural practices, particularly in fertilization. This study aimed to evaluate the impact of organic fertilizer on tomato growth and yield. A completely randomized block design (CRBD) with two factors fertilizer and variety was used, including three replications and nine treatments. T0 served as the control, and T1 represented poultry manure application. Growth parameters were measured over 15 weeks post-transplanting, while yield parameters were assessed over 12 weeks. Statistical analysis involved the independent samples median test and ANOVA at the 5% significance level. Results showed that plants treated with poultry manure exhibited significantly enhanced growth and yield compared to unfertilized plants. Poultry manure markedly improves both the vegetative and reproductive performance of tomato plants.

Keywords

Poultry Manure, Tomato, Growth, Yield, Organic Fertilizer

1. Introduction

Tomato (*Solanum lycopersicum* Mill), a member of the Solanaceae family, is a globally cultivated fruit vegetable. Global production reaches approximately 150 million tons annually [1], and China is the world's leading producer of tomatoes, with an output of approximately 50 million tons and Africa contributing 11.37% of this output [2]. Although precise data for the Republic of Congo are limited, a growing interest in tomato cultivation is evident among local market gardeners.

Tomatoes are highly valued for their nutritional content, particularly their high levels of vitamins A, C, and E, phenolic antioxidants, and lycopene [3]. In Brazzaville, tomato farming supports both nutrition and the incomes of small-scale producers and vendors. However, production is frequently constrained by pests and diseases, which affect both yield and fruit quality.

To mitigate these issues, chemical fertilizers are commonly used to enhance growth and reduce disease incidence. However, these inputs carry significant environmental and health risks, including residual toxicity and soil degradation. Indeed, the use of poultry manure as an organic amendment has demonstrated its potential to enhance crop performance while supporting the sustainability of agricultural systems. Several recent studies have shown the effectiveness of organic fertilizers in improving tomato growth and yield, while also reducing environmental impact [4] [5]. The study conducted by [6] also highlighted the effectiveness of poultry manure in enhancing eggplant production.

This study aims to assess the impact of poultry manure on the growth and yield of three tomato varieties cultivated in Brazzaville, with the broader goal of addressing food insecurity in the Republic of Congo.

2. Materials and Methods

2.1. Study Site

The experimental site was located within the National Agency for the Valorization of Research and Innovation Results (ANVRI), situated in the premises of the former ORSTOM scientific campus. This site is located in the southern zone of Brazzaville, specifically in the 1st district, Makélékélé. The campus is part of the Patte d'Oie forest reserve, established on a plateau at an altitude of 309 meters in the southwest of Brazzaville (15˚14' East longitude and 4˚16' South latitude).

The area has a humid tropical climate, with an annual average temperature of 25˚C and a narrow temperature range (4˚C - 6˚C). The warmest months are March and April, while July and August are the coolest [7]. Annual rainfall averages 1200 mm, mainly from October to May, with a brief lull between January and February. Relative humidity exceeds 70% year-round, peaking between 88% and 94%. Evaporation is highest between February and March, with another peak in August and September. Sunshine averages 140 hours per month, with maximum values in April–May and November–December, and a minimum in July [8].

Geologically, the area is dominated by sandstone and sandy formations belonging to the Inkisi series, composed of arkoses and feldspathic sandstones [9].

The experiment was conducted from November 14, 2017, to February 8, 2024.

2.2. Plant Material and Organic Fertilizer

- V1: Ninja (packaged in France)

- V2: Cobra (packaged in Vietnam)
- V3: Caraibo (packaged in France)

Poultry manure was sourced from the National Institute of Agronomic Research. Delivered wet in 50 kg bags, it was sun-dried before application to enhance its effectiveness. Once dried, the manure was stored in bags until use (**Figure 1**).

Figure 1. Poultry droppings exposed to sunlight.

2.3. Experimental Design and Setup

Land preparation took place from April 20 to 26, 2024. The site was cleared, weeded, and ploughed to a depth of 25 cm. In total twenty-seven raised beds (2 m × 1.2 m; 2.4 m^2 each) were constructed, separated by 0.5 m furrows. Sowing in the nursery was carried out on April 3, 2024, and transplanting on May 8, 2024.

A completely randomized block design (completely randomly) with three replicates per treatment and two factors variety (V1, V2, V3) and fertilization (T0 = control, T1 = poultry manure) was employed, resulting in six treatments with three replicates each. Each plot consisted of twelve plants, from which five vigorous individuals were selected per treatment. With three replicates, this resulted in a total of 15 plants per treatment (**Figure 2**).

Figure 2. Experimental plot.

2.4. Fertilizer Application and Crop Maintenance

Before transplanting, poultry manure was applied at a rate of 0.5 kg per planting hole (pocket planting), and an additional 0.5 kg (or approximately 12.5 t/ha) was added after the appearance of flower buds. Control plants (T0) received no manure. Beds were watered after each application to encourage manure decomposition.

Standard practices such as watering, weeding, staking, and pruning were carried out regularly to ensure optimal plant development.

2.5. Data Collection

Growth Parameters

Measurements began one week after transplanting and continued weekly. Parameters included:

- Neck diameter (measured with a caliper),
- Stem height (measured with a 1-meter ruler from the collar to the apex),
- Number of leaves.

Yield Parameters

Starting 20 days after transplanting, the following were monitored:

- Number of flower buds and flowers,
- Number of fruits per plant,
- Fruit diameter and length (measured with calipers),
- Fruit weight (measured with precision scales).

2.6. Statistical Analysis

Data were processed using Microsoft Excel 2019 and SPSS v26. Normality was tested using Kolmogorov-Smirnov and Shapiro-Wilk tests. Based on these, either:

- One-way ANOVA (comparisons by Tukey test $p < 0.05$) or
- Independent samples median test (for non-normal data) was used, with a significance level of $p < 0.05$.

3. Results

3.1. Effects of Fertilizer on Agro-Morphological Traits

-Collar Diameter

The collar diameter of the plants from the three tomato cultivars, after fertilization with poultry manure, is shown in Figure 3. Plants treated with poultry manure exhibited greater collar diameter values across all three cultivars: 9.56 mm (V1), 8.01 mm (V2), and 10.45 mm (V3), compared to control plants with 9.39 mm, 6.33 mm, and 7.95 mm, respectively. The highest diameter was observed in V3T1.

Statistical analysis confirmed that poultry manure had a significant positive effect on collar diameter across all varieties ($P < 0.05$). Notably, V3 showed the most substantial increase.

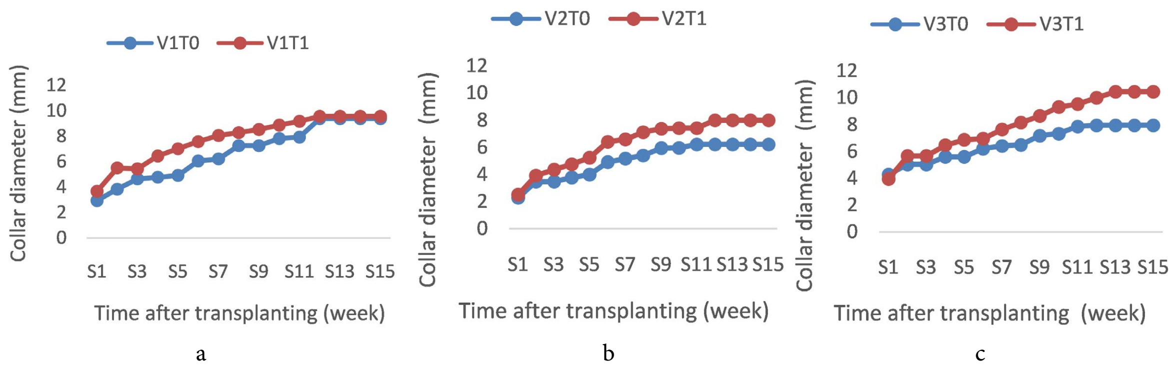


Figure 3. Evolution of Collar Diameter in Tomato Varieties V1, V2, and V3. Legend: a: Variety V1 (Ninja), b: Variety V2 (Cobra), c: Variety V3 (Caraibo). V1T0, V2T0, V3T0: Control treatments (no poultry manure); V1T1, V2T1, V3T1: Treatments with poultry manure application.

The results of the median test for independent samples on variety V1 showed a significant effect of poultry manure application on collar diameter ($P = 0.037 < 0.050$). Additionally, the one-way analysis of variance (ANOVA) for varieties V2 and V3 revealed a significant influence of poultry manure on the collar diameter of both tomato varieties ($P = 0.018 < 0.05$ for V2 and $P = 0.016 < 0.05$ for V3). The highest collar diameters were observed in plants of varieties V1 and V3 that received poultry manure (group b) (Table 1).

Table 1. Classification of collar diameter in tomato varieties by treatment.

Dependent variable (a)	Treatments	Medians	Dependent variable (b)	Treatments	Means
Collar Diameter	V1T0	8.90ab	Collar Diameter	V2T0	6.23a
	V1T1	10b		V2T1	8.01b
				V3T0	7.95a
				V3T1	10.45b

V1T0: control (non-fertilized), V1T1: fertilized with poultry manure, V2T0: control (non-fertilized), V2T1: fertilized with poultry manure, V3T0: control (non-fertilized), V3T1: fertilized with poultry manure.

3.2. Number of Leaves (Figure 4)

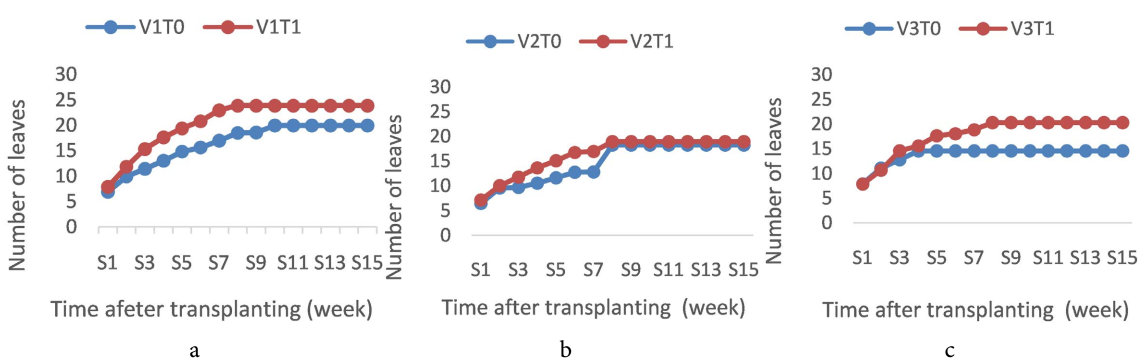


Figure 4. Evolution of the number of leaves per plant in three tomato varieties. Legend: a: Variety V1 (Ninja), b: Variety V2 (Cobra), c: Variety V3 (Caraibo). V1T0, V2T0, V3T0: Control treatments (no poultry manure); V1T1, V2T1, V3T1: Treatments with poultry manure application.

The median test for independent samples on varieties V1 and V2 did not indicate a significant effect of poultry manure application on the number of leaves (P = 0.071 > 0.05 for V1 and P = 0.063 > 0.05 for V2) (Table 2). However, the one-way analysis of variance (ANOVA) for variety V3 revealed a significant effect of poultry manure on the number of leaves (P = 0.00 < 0.05). The highest number of leaves was observed in plants of variety V1 fertilized with poultry manure (group a) (Table 2).

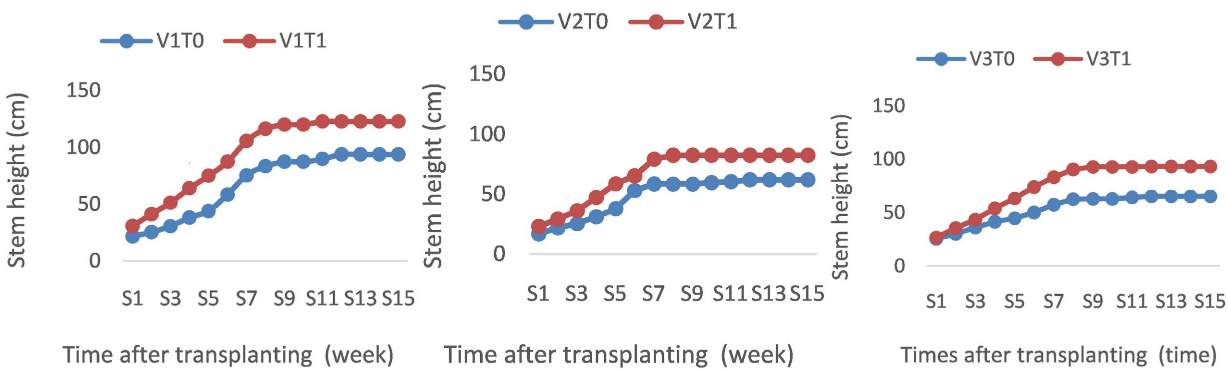
Table 2. Classification of leaf number in tomato varieties by treatment.

Dependent variable (a)	Treatments	Medians	Dependent variable (b)	Treatments	Means
Nbfeu	V1T0	21a	Nbfeu	V3T0	14.53a
	V1T1	24a		V2T1	20.27b
	V2T0	17a			
	V2T1	20a			

V1T0: control (non-fertilized), V1T1: fertilized with poultry manure, V2T0: control (non-fertilized), V2T1: fertilized with poultry manure, V3T0: control (non-fertilized), Nbfeu: number of leaves.

3.3. Stem Height

Figure 5 presents the statistical analysis results of stem height in the three tomato varieties, with or without fertilization using poultry manure. From the figure, it is evident that the main stem height was greater in tomato plants fertilized with poultry manure, with values of 122.77 cm, 82.27 cm, and 93.23 cm for varieties V1, V2, and V3 respectively. These values were higher than those measured in the unfertilized control plants, which reached 93.83 cm, 61.88 cm, and 65.46 cm respectively for V1, V2, and V3. The greatest stem height was recorded in treatment V1T1, while the lowest was observed in the control treatment of variety V2 (V2T0).



a b c

Figure 5. Evolution of stem Height in three tomato varieties. Legend: a: Variety V1 (Ninja), b: Variety V2 (Cobra), c: Variety V3 (Caraibo). V1T0, V2T0, V3T0: Control treatments (no poultry manure); V1T1, V2T1, V3T1: Treatments with poultry manure application.

The results of the median test for independent samples on varieties V2 and V3 showed a significant effect of poultry manure application on stem height (P = 0.037 < 0.05 for V2 and P = 0.013 < 0.05 for V3) (Table 3). However, the one-way analysis of variance (ANOVA) on variety V1 did not indicate a significant effect of poultry manure on stem height (P = 0.086 > 0.05) (Table 3). The greatest stem heights were observed in plants of variety V1 fertilized with poultry manure (group a) (Table 3).

Table 3. Effect of poultry manure application on the stem height in three tomato varieties.

Dependent variable (a)	Treatments	Medians	Dependent variable (b)	Treatments	Means
Stem Height	V2T0	69,8a	Stem Height	V1T0	93.8a
	V2T1	84b		V1T1	122.7a
	V3T0	70a			
	V3T1	90b			

V1T0: control (non-fertilized), V1T1: fertilized with poultry manure, V2T0: control (non-fertilized), V2T1: fertilized with poultry manure, V3T0: control (non-fertilized), V3T1: fertilized with poultry manure.

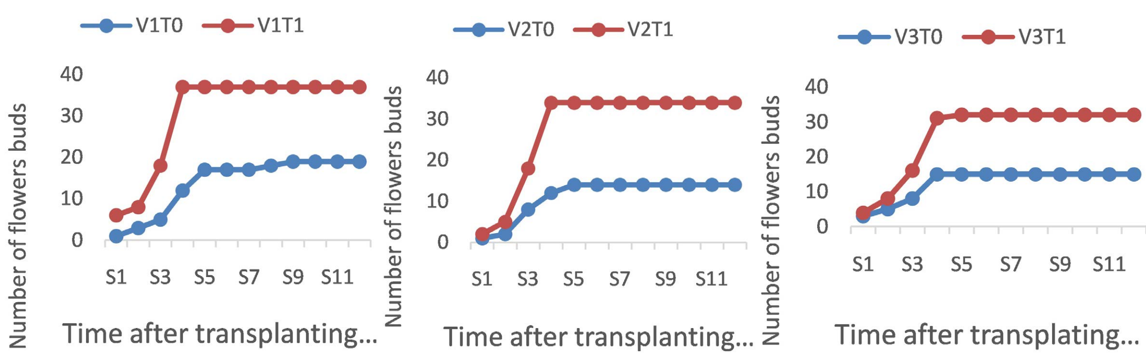
3.4. Number of Flower Buds

The number of flower buds observed in tomato plants of the three varieties (V1, V2, and V3), whether fertilized or not with poultry manure, is illustrated in Figure 6. The results show that all plants treated with poultry manure (treatment T1) produced a significantly higher number of flower buds compared to the unfertilized control plants (T0).

Specifically, the fertilized varieties V1, V2, and V3 (V1T1, V2T1, and V3T1) produced 37, 34, and 32 flower buds respectively more than twice the number observed in the control plants (V1T0, V2T0, and V3T0), which had 17 or fewer buds.

The highest number was recorded in V1T1 plants with 37 flower buds, while the lowest number was observed in the control V2T0.

These results clearly indicate the positive effect of poultry manure on flower induction in tomato plants, particularly in variety V1.



a b c

Figure 6. Evolution of the number of flower buds in three tomato varieties. Legend: a: Variety V1 (Ninja), b: Variety V2 (Cobra), c: Variety V3 (Caraibo). V1T0, V2T0, V3T0: Control treatments (no poultry manure); V1T1, V2T1, V3T1: Treatments with poultry manure application.

The median test for independent samples and the one-way analysis of variance (ANOVA) applied to the three tomato varieties revealed a significant effect of poultry manure application on the number of flower buds. The results were statistically significant for all three varieties, with P-values of 0.003, 0.002, and 0.016, respectively, all below the 0.05 threshold (Table 4).

Table 4. Classification of the number of flower buds in tomato varieties by treatment.

Dependent variable (a)	Treatments	Medians	Dependent variable (b)	Treatments	Means
Number flowers buds	V1T0	18b	Number flowers buds	V2T0	13.53a
	V1T1	35b		V2T1	34.40b
				V3T0	0
				V2T1	13b

V1T0: control (non-fertilized), V1T1: fertilized with poultry manure, V1T2: fertilized with termite mound soil, V2T0: control (non-fertilized), V2T1: fertilized with poultry manure, V3T0: control (non-fertilized).

3.5. Flower Number

The flower production of tomato plants from the three cultivars, following fertilization with poultry manure, is presented in Figure 7. In fertilized plants, the number of flowers per plant ranged from 16 to 18, whereas in unfertilized control plants, the range was from 5 to 8. This clearly indicates a substantial increase in floral initiation due to the organic amendment.

Specifically, the number of flowers recorded in the poultry manure-treated plants were: V1: 18 flowers, V2: 16 flowers and V3: 17 flowers.

In contrast, the control (non-fertilized) plants exhibited the following flower counts: V1: 6 flowers, V2: 8 flowers and V3: 5 flowers.

The highest flower count was recorded in cultivar V1 under fertilization treatment (V1T1), while the lowest was observed in the unfertilized control of cultivar V3 (V3T0).

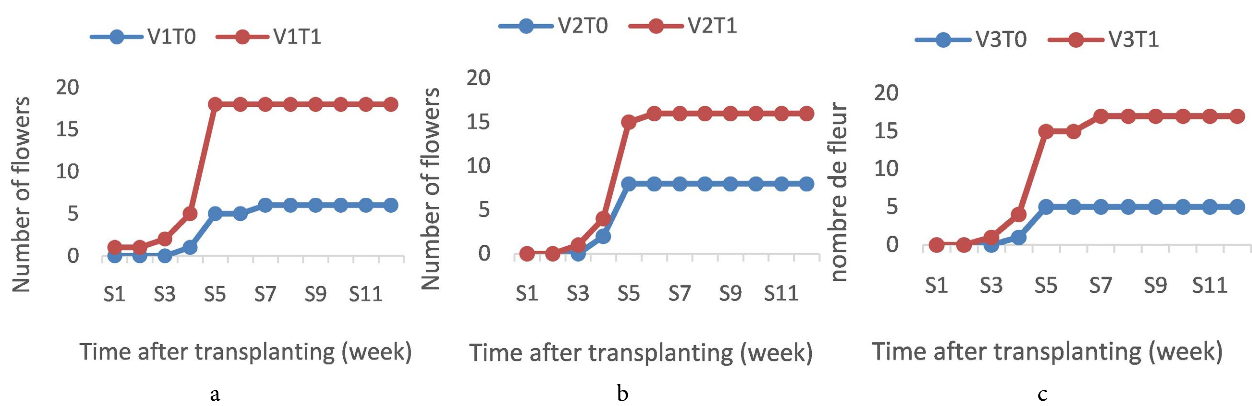


Figure 7. Evolution of flower number over time in three tomato cultivars (V1, V2, and V3) under fertilization with poultry manure and control conditions. Legend: a: Variety V1 (Ninja), b: Variety V2 (Cobra), c: Variety V3 (Caraibo). V1T0, V2T0, V3T0: Control treatments (no poultry manure); V1T1, V2T1, V3T1: Treatments with poultry manure application.

These findings highlight the effectiveness of poultry manure in enhancing floral development in tomato plants across different cultivars, suggesting its potential as a sustainable organic fertilizer to improve reproductive performance.

The results of the median test for independent samples and the one-way analysis of variance (ANOVA) for varieties V2 and V3 indicate a significant effect of poultry manure application on the number of flowers in the three tomato varieties ($P = 0.003 < 0.05$ and $P = 0.002 < 0.05$, respectively) (Table 5). However, no significant effect was observed for variety V1 ($P = 0.153 > 0.05$). The highest numbers of flowers were recorded in plants fertilized with poultry manure, particularly in varieties V1 and V2, which were classified in groups a and b, respectively (Table 5).

Table 5. Effect of poultry manure application on the number of flowers in three tomato varieties.

Dependent variable (a)	Treatments	Medians	Dependent variable (b)	Treatments	Means
Nbflowers	V1T0	1a	Nbflowers	V2T0	7.60a
	V1T1	16a		V2T1	16.27b
	V3T0	0a			
	V3T1	13b			

V1T0: control (non-fertilized), V1T1: fertilized with poultry manure, V2T0: control (non-fertilized), V2T1: fertilized with poultry manure, V3T0: control (non-fertilized), V3T1: fertilized with poultry manure, Nbflowers: number of flowers.

3.6. Number of Fruits

Regarding the number of fruits per plant, it ranged from 1 to 21, appearing from the 3rd week with a marked increase starting in the 5th week. The highest number of fruits was observed in the V2 variety, followed by V1 and V3, with 21, 16, and 15 fruits respectively. In contrast, the lowest number of fruits was recorded in the control plant of variety V3 (Figure 8).

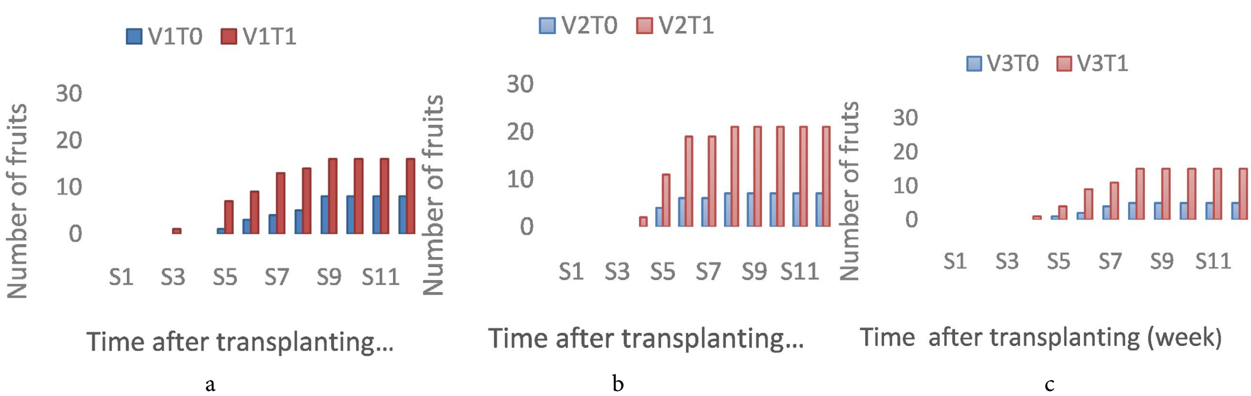


Figure 8. Evolution of fruit count over time in the three tomato varieties. Legend: a: Variety V1 (Ninja), b: Variety V2 (Cobra), c: Variety V3 (Caraibo). V1T0, V2T0, V3T0: Control treatments (no poultry manure); V1T1, V2T1, V3T1: Treatments with poultry manure application.

The median test for independent samples conducted on varieties V2 and V3 showed a significant effect of poultry manure application on the number of fruits in the three tomato varieties (P = 0.000 < 0.05 and P = 0.010 < 0.05, respectively). In contrast, the one-way analysis of variance (ANOVA) performed on variety V1 did not reveal a significant effect (P = 0.059 > 0.050). The highest fruit counts were recorded in plants fertilized with poultry manure in varieties V1 and V2, classified into groups a and b, respectively (Table 6).

Table 6. Classification of the number of fruits in tomato varieties according to treatments.

Dependent variable (a)	Treatments	Medians	Dependent variable (b)	Treatments	Means
Nbfrui	V2T0	8a	Nbfrui	V1T0	8a
	V2T1	21b		V1T1	18
	V3T0	5a			
	V3T1	14b			

V1T0: control (non-fertilized), V1T1: fertilized with poultry manure, V2T0: control (non-fertilized), V2T1: fertilized with poultry manure, V3T0: control (non-fertilized), V3T1: fertilized with poultry manure.

Fruit Diameter

Figure 9 shows the fruit diameter of plants from the three tomato varieties, either fertilized or not with poultry manure. The largest diameter was recorded in variety V1, with an average of 17.17 mm, followed by varieties V3 and V2, with average diameters of 14.92 mm and 14.01 mm, respectively. In contrast, the smallest diameters were observed in the control plants across all three varieties.

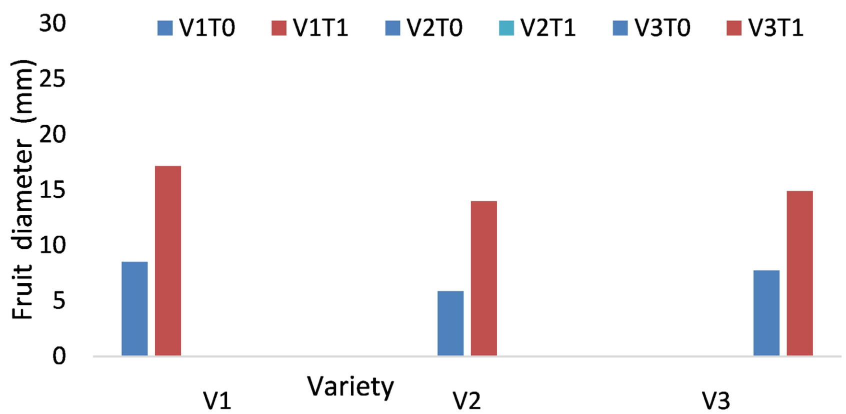


Figure 9. Evolution of fruit diameter over time in three tomato varieties. Legend: a: Variety V1 (Ninja), b: Variety V2 (Cobra), c: Variety V3 (Caraibo). V1T0, V2T0, V3T0: Control treatments (no poultry manure); V1T1, V2T1, V3T1: Treatments with poultry manure application.

The median test for independent samples revealed a statistically significant effect of poultry manure application on the fruit diameter of tomato plants (P = 0.027 < 0.05; P = 0.018 < 0.05; and P = 0.000 < 0.05). Among the tested varieties, V1 exhibited the largest fruit diameter (Table 7).

Table 7. Classification of fruit diameters in tomato varieties under different treatments.

Dependent variable (a)	Treatments	Medians
Diameter	V1T0	0
	V1T1	43.6a
	V2T0	0
	V2T1	10a
	V3T0	0
	V3T1	26a

V1T0: control (non-fertilized), V1T1: fertilized with poultry manure, V2T0: control (non-fertilized), V2T1: fertilized with poultry manure, V3T0: control (non-fertilized), V3T1: fertilized with poultry manure.

3.7. Fruit Mass

Figure 10 shows the fruit weight of plants from the three tomato varieties, either fertilized or not with poultry manure. It highlights a higher fruit weight in fertilized plants compared to control plants. In variety V1, fertilized plants reached an average fruit weight of 25.16 g, which was higher than that of varieties V2 (11.88 g) and V3 (11.34 g). Conversely, the lowest fruit weights were recorded in the unfertilized plants across all varieties.

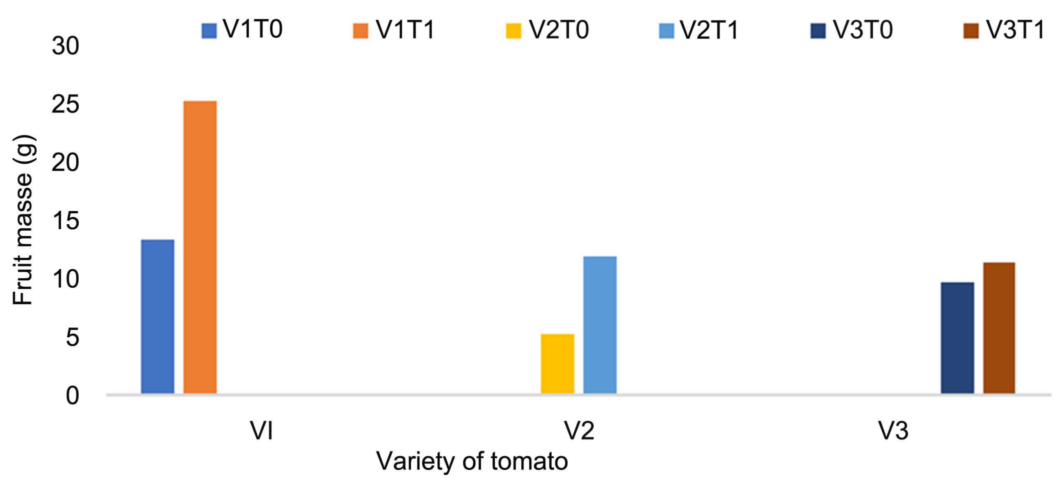


Figure 10. Evolution of fruit mass over time in three tomato varieties. Legend: a: Variety V1 (Ninja), b: Variety V2 (Cobra), c: Variety V3 (Caraibo). V1T0, V2T0, V3T0: Control treatments (no poultry manure); V1T1, V2T1, V3T1: Treatments with poultry manure application.

The results of the median test for independent samples show a highly significant effect of the combined application of poultry manure and termite mound soil on the fruit weight of tomato plants ($P = 0.027 < 0.05$; $P = 0.018 < 0.05$; and $P = 0.000 < 0.05$). The highest average fruit weight was recorded in variety V1 (Table 8).

Table 8. Classification of fruit mass in tomato varieties according to treatments.

Dependent variable (a)	Treatments	Medians
Fruits mass	V1T0	0
	V1T1	45.5a
	V2T0	0
	V2T1	3a
	V3T0	0
	V3T1	15a

V1T0: control (non-fertilized), V1T1: fertilized with poultry manure, V2T0: control (non-fertilized), V2T1: fertilized with poultry manure, V3T0: control (non-fertilized), V3T1: fertilized with poultry manure.

4. Discussion

4.1. Effect of Organic Fertilization on Growth Variables

Our results show that poultry manure significantly improves the growth variables of tomato plants, notably collar diameter, stem height, and number of leaves. This improvement is more pronounced than that observed in plants not amended with poultry manure. Although the chemical composition of the poultry manure was not locally analyzed, data from [1] indicate an average content of 2.8% N, 2.5% P_2O_5, and 1.6% K_2O. This nutrient composition of poultry manure may explain the significant improvement observed in the growth variables of the tomato plants in this study. Nitrogen, which constitutes 3.389 % of poultry manure [10], likely promoted this markedly greater growth compared to control plants. Indeed, the application of poultry manure resulted in increased collar diameter, stem height, and leaf count relative to unfertilized plants. These findings align with those of [11], who demonstrated that organic fertilizers particularly poultry manure significantly enhance plant height, collar diameter, and branching number in tomato plants. In addition, the findings of [5] demonstrated the effectiveness of using poultry manure on all growth parameters of tomato plants, compared to goat and cow manure. These authors concluded that organic fertilizers, particularly poultry manure, significantly enhance the growth parameters of tomato plants. Furthermore, [6] also reported substantial vegetative growth in eggplant seedlings following poultry manure application.

Beyond this aspect, poultry manure also improves the physico-chemical properties of the soil. [12] showed that the application of chicken manure significantly enhances these properties. Due to its rapid decomposition, it contributes to improving the physical, chemical, and biological fertility of the soil, thus providing better growth conditions for crops. These findings are consistent with those of [13], who demonstrated that soils amended with manure exhibited better physico-chemical properties, resulting in significant improvements in biometric parameters such as stem height, number of leaves, and collar diameter.

4.2. Effect of Organic Fertilizer on Yield Variables

Regarding yield variables, the results show that tomato plants fertilized with poultry manure produced more than the unfertilized control plants. This is primarily due to the mineral richness of poultry manure, which enhances soil fertility. According to [14], poultry manure has a high agronomic value, with 60% to 90% of its nitrogen content in mineral form, making it readily available for plant uptake.

Secondly, other mineral elements such as phosphorus and especially potassium play a crucial role in fruit production. Potassium, for instance, helps maintain the plant's water potential, which is essential for producing larger fruits. This explains the better growth of yield variables observed in plants fertilized with poultry manure compared to unfertilized control plants. These results clearly indicate that the composition of poultry manure is responsible for the improved production. Our findings align with those of [15], who revealed that chicken manure contains potassium and phosphorus, essential nutrients for flower bud initiation and fruit development. In addition to these two elements, the nitrogen contained in poultry manure is believed to play a key role in achieving high tomato yields [16].

Indeed, nitrogen stimulates photosynthetic activity [17], a vital process for the plant. Photosynthesis is the process by which light energy is converted into chemical energy at the level of the light-harvesting complexes and the reaction centers. This conversion then allows the storage of assimilates in specialized organs, such as fruits, which directly contributes to good yield at the end of the growth cycle. Thus, tomato plants amended with poultry manure showed better production. Our results are consistent with those of [18], who reported that poultry manure and plants fertilized with organic inputs produced a higher number of tomato fruits and greater yields compared to the control plots. Similar to those obtained by [19] in their study entitled Impact of Organic Fertilizers on Tomato Yields and the Density of Arbuscular Mycorrhizal Fungi in the Saguiya Region (Niger). The authors showed that tomato plants treated with poultry manure had a higher yield compared to those amended with cow or goat dung. Moreover, the chemical composition of poultry manures also promoted earlier appearance of the first flower buds, leading to faster flowering. These results are similar to those obtained by [6], who showed that eggplant plants treated with poultry manure exhibited earlier floral bud emergence and a higher number of blossomed flowers. The availability of nutrients provided by poultry manure also improved the production of tomato varieties. Indeed, since mineralization is a gradual process, cumulative residual effects can contribute to improving soil fertility, thereby promoting increased fruit yields over successive cropping cycles [20].

5. Conclusions

This study highlighted the agronomic potential of poultry manure in improving tomato production. The results showed that poultry manure had a positive effect on the agromorphological parameters of tomato plants, which is attributed to its rich mineral content. Based on these findings, the use of poultry manure could serve as an environmentally friendly and cost-effective alternative to synthetic fertilizers. This approach would help reduce production expenses for farmers.

However, since this study was conducted over a single season, further multi-year trials including biochemical and microbiological analyses of both the poultry manure and the soils are necessary to confirm these results and broaden their applicability. Such investigations would provide more comprehensive insights into the long-term effects and environmental sustainability of poultry manure in different agroecological conditions.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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