

Comparative Effects of Traditional Compost, Cattle Manure, and Mineral Fertilizers on the Growth and Yield of *Solanum nigrum* L. in the Peri-Urban Area of Ouagadougou, Burkina Faso

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Abstract

Solanum nigrum L., commonly known as black nightshade, is a leafy vegetable with high nutritional and medicinal value, widely consumed in West Africa. In Burkina Faso, it contributes to food security and traditional medicine, but its production remains constrained by low soil fertility and suboptimal cultural practices. The use of organic and mineral amendments appears as a promising strategy to sustainably enhance productivity. A field trial was conducted in the peri-urban area of Ouagadougou on sandy-clay soils with slightly acidic pH. Three types of amendments (compost, cattle manure, and NPK 15-15-15 fertilizer) were applied at three different doses representative of local practices. The experimental design was a randomized complete block with three replications. Measured parameters included plant height, leaf number, fresh biomass, and dry biomass. Statistical analyses were performed using R software with a two-way ANOVA followed by Tukey's test for mean separation. The results revealed significant differences among morphotypes and treatments. The black-fruited morphotype exhibited the best performance in terms of growth and biomass, particularly under manure and NPK fertilization. Compost improved growth but with less pronounced effects. The green-fruited morphotype recorded the lowest values, while the purple-fruited morphotype showed intermediate performance. Increasing amendment doses enhanced growth parameters up to a threshold, beyond which a plateau effect was observed. This study highlights the effectiveness of manure and NPK at medium doses (200 kg/ha) as the most suitable options to optimize the yield of *S. nigrum*. These findings provide a basis for developing recommendations adapted to peri-urban farming systems in Burkina Faso.

Keywords: *Solanum nigrum*, fertilization, productivity, nutrition, Burkina Faso, food security

INTRODUCTION

Solanum nigrum L., commonly known as black nightshade, is a leafy vegetable widely consumed in several regions of Africa, particularly in Burkina Faso. Its leaves are an important source of essential nutrients such as vitamins A and C, calcium, iron, and dietary fiber, making it a valuable component of local diets (Uusiku et al., 2010 ; Thakur et al., 2022). Beyond its nutritional value, the plant is recognized for its medicinal properties, including antioxidant, anti-inflammatory, and antimicrobial effects (Ugbogu et al., 2021). Thus, *S. nigrum* contributes both to household food security and to traditional medicine practices in many communities (Sangija et al., 2021). Despite its importance, the production of *S. nigrum* in peri-urban areas of Burkina Faso is constrained by several challenges. Low soil fertility,

nutrient depletion, and suboptimal agronomic practices often limit vegetative growth and biomass accumulation, resulting in fewer harvestable leaves and reduced overall yields (Awio et al., 2021). These constraints directly affect household food availability as well as the income of smallholder farmers (Tapsoba et al., 2023). The use of organic and mineral amendments appears to be a promising strategy to improve the productivity of this crop.

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Organic inputs such as compost and farmyard manure enrich the soil with organic matter and enhance its capacity to retain water and nutrients, thereby promoting vegetative growth and improving soil health (Ho et al., 2022). Mineral fertilizers, particularly nitrogen-rich formulations, can stimulate rapid growth and biomass production, though their effects often depend on application rates and soil conditions (Thomas et al., 2019). Studies conducted in West Africa have shown that organic amendments generally enhance growth and the nutritional quality of leafy vegetables, while mineral fertilizers tend to maximize yield (Adjogboto et al., 2023). However, very few studies have simultaneously compared the effects of different amendment types applied at multiple doses on the growth and yield of *S. nigrum* under peri-urban conditions in Burkina Faso. This lack of data hampers the development of locally adapted recommendations and limits the potential for sustainable production of this important species (Manka'abusi et al., 2024). The objective of the present study is therefore to fill this gap by evaluating the effects of three types of amendments (compost, manure, and mineral fertilizer) applied at three different rates on the growth and yield of *S. nigrum* L. Specifically, the study aims to: compare plant growth responses according to the type and dose of amendment; evaluate yield performance under the same conditions; and identify the most effective amendment and dose for sustainable production adapted to peri-urban soils and agroecological conditions. The expected outcomes will not only help improve cultivation practices for black nightshade but will also contribute to household food security and the valorization of this nutritious and medicinal plant in the peri-urban zones of Burkina Faso (Traore et al., 2018).

Table 1. Application Rates of Different Amendments.

Type of amendment	Dose 1	Dose 2	Dose 3
Traditional compost	5 t/ha	10 t/ha	15 t/ha
Cattle manure	5 t/ha	10 t/ha	15 t/ha
Mineral fertilizer (NPK 15-15-15)	100 kg/ha	200 kg/ha	300 kg/ha

Experimental Design

The experiment was set up using a completely randomized block design with three repetitions. Each plot measured 2 m × 2 m and contained 120 plants, evenly distributed according to the morphotypes and treatments. The treatments and doses were randomly assigned within each block to minimize biases related to soil heterogeneity and environmental conditions. This design allowed for the detection of the main effects of the amendments and doses, as well as their interactions with the morphotypes of *Solanum nigrum* L.

MATERIALS AND METHODS

Study Site

The experiment was conducted in a suburban area of Ouagadougou. The soil in the study area had a clayey-sandy texture with a slightly acidic pH ranging from 6.2 to 6.8, and exhibited a low to moderate organic matter content. The region's climate is classified as Sudano-Sahelian, characterized by a dry season and a rainy season. The average annual precipitation ranges from 800 to 1000 mm. These conditions are representative of those encountered in peri-urban vegetable farming and directly influence the growth of *Solanum nigrum* L.

Plant Under Investigation

The plant investigated in this study is *Solanum nigrum* L., a local variety well adapted to the agroecological conditions of Burkina Faso. The seeds were initially sown in a nursery to ensure optimal germination rates and uniformity in seedling development. The seedlings were transplanted into the field when they had developed four to five true leaves, ensuring proper root establishment and uniform growth on the experimental site.

Amendments and Application Rates

Three types of amendments were assessed in this study: traditional compost, derived from the decomposition of plant organic matter; cattle manure, sourced from local livestock farms; and the mineral fertilizer NPK 15-15-15, which provides readily available nutrients to stimulate growth. Each amendment was applied at three different rates, representative of local agricultural practices, spanning a range from low to high doses (Table 1).

Measured Parameters

The parameters considered in this study were selected for their simplicity, reliability, and relevance for field evaluation. They are grouped into two categories (Table 2).

Statistical Analysis

All statistical analyses were performed using R software (version 4.3.3). Treatment effects were evaluated with a two-way ANOVA (morphotype × fertilizer dose) to assess the interactions between morphotype type and the different doses of compost, manure, or NPK. When

Table 2. Measured parameters for vegetative growth and yield evaluation

Category	Parameter	Description / Unit
Vegetative growth	Plant height	Distance from the base to the apex of the main stem (cm).
Vegetative growth	Number of leaves	Total number of healthy leaves per plant (count).
Yield	Fresh mass	Weight of the aboveground biomass immediately after harvest (kg/plant).
Yield	Dry mass	Weight of the biomass after oven-drying at 60 °C until constant mass (kg/plant).

significant differences were detected, Tukey's HSD test was applied for multiple comparisons in order to separate the means. Finally, bar plots were generated to illustrate the data distribution and highlight the differences observed among morphotypes and fertilization treatments.

RÉSULTS

Effects of fertilization treatments on growth and biomass production

Growth and Yield Performance Under Control Conditions

The results from the control treatment indicate significant

differences among morphotypes for plant height ($p < 0.001$), fresh mass ($p = 0.0288$), and dry mass ($p = 0.0156$), whereas the number of leaves did not differ significantly ($p = 0.519$). The black-fruited morphotype recorded the highest values, with a plant height of 29.99 cm, 4.43 leaves, a fresh mass of 0.0502 kg/plant, and a dry mass of 0.01985 kg/plant. The green-fruited morphotype exhibited the lowest performance, with a height of 23.98 cm, 4.00 leaves, a fresh mass of 0.0428 kg/plant, and a dry mass of 0.01583 kg/plant. The purple-fruited morphotype occupied an intermediate position, with a height of 27.01 cm, 3.83 leaves, a fresh mass of 0.0465 kg/plant, and a dry mass of 0.01828 kg/plant (Table 3).

Table 3. Growth parameters of fruit morphotypes under control treatment

Morphotype	Height (cm)	Leaves	Fresh_mass (g)	Dry_mass (g)
Black fruits	29.99 a	4.43 a	0.0502 a	0.01985 a
Green fruits	23.98 c	4.00 a	0.0428 b	0.01583 b
Purple fruits	27.01 b	3.83 a	0.0465 ab	0.01828 ab
p-value	<0.001	0.519	0.0288	0.0156

Effect of Morphotype and Compost Dose on Growth Parameters

The analyses revealed significant differences among morphotypes for all parameters ($p < 0.001$). The black-fruited morphotype recorded the best performances, with an average height of 39.19 cm, 9.60 leaves, a fresh mass of 0.0949 kg/plant and a dry mass of 0.0393 kg/plant, without notable variation across doses. The green-fruited

morphotype showed the lowest values for biomass, with 0.0760 and 0.0305 kg/plant for fresh and dry mass respectively, although its height increased progressively with dose, from 31.36 cm to 38.14 cm. The purple-fruited morphotype occupied an intermediate position, with height increasing slightly with dose, from 35.49 cm to 38.14 cm, while biomass remained stable, with values of 0.0856 and 0.0341 kg/plant (Table 4).

Table 4. Effect of compost dose on growth and biomass parameters across fruit morphotypes.

Morphotype	Dose	Height (cm)	Leaves	Fresh Mass (kg/plant)	Dry Mass (kg/plant)
Black fruits	5 t/ha	39.19 a	9.60 a	0.0949 a	0.0393 a
Black fruits	10 t/ha	39.19 a	9.60 a	0.0949 a	0.0393 a
Black fruits	15 t/ha	39.19 a	9.60 a	0.0949 a	0.0393 a
Green fruits	5 t/ha	31.36 c	8.60 ab	0.0760 c	0.0305 c
Green fruits	10 t/ha	36.32 b	8.60 ab	0.0760 c	0.0305 c
Green fruits	15 t/ha	38.14 ab	8.60 ab	0.0760 c	0.0305 c
Purple fruits	5 t/ha	35.49 b	7.80 b	0.0856 b	0.0341 b
Purple fruits	10 t/ha	35.49 b	7.80 b	0.0856 b	0.0341 b
Purple fruits	15 t/ha	38.14 ab	7.80 b	0.0856 b	0.0341 b
p-value		<2e-16	1.21e-05	1.17e-15	4.51e-12

Effect of Manure on Growth and Biomass

The results obtained with manure show significant differences among morphotypes for plant height ($p = 0.011$), while no significant differences were observed for the number of leaves, fresh mass, and dry mass ($p > 0.05$). The black fruit morphotype exhibited the best overall performance, with a stable height of 38.52 cm, an average of 10.27 leaves, a fresh mass of 0.0955 kg/plant, and a

dry mass of 0.0388 kg/plant, with no variation across the applied doses. The green fruit morphotype recorded the lowest values, particularly for biomass (0.0742 and 0.0304 kg/plant), although plant height increased progressively from 31.27 cm at 5 t/ha to 38.81 cm at 15 t/ha. The purple fruit morphotype showed intermediate results, with a constant height of 34.66 cm, an average of 8.67 leaves, a fresh mass of 0.0834 kg/plant, and a dry mass of 0.0332 kg/plant, regardless of the dose applied (Table 5).

Table 5. Growth and biomass of three fruit morphotypes under manure application.

Morphotype	Dose	Height (cm)	Leaves (no.)	Fresh Mass (kg/plant)	Dry Mass (kg/plant)
Black fruits	5 t/ha	38.52 a	10.27 a	0.0955 a	0.0388 a
Black fruits	10 t/ha	38.52 a	10.27 a	0.0955 a	0.0388 a
Black fruits	15 t/ha	38.52 a	10.27 a	0.0955 a	0.0388 a
Green fruits	5 t/ha	31.27 c	7.63 b	0.0742 c	0.0304 b
Green fruits	10 t/ha	35.11 b	7.63 b	0.0742 c	0.0304 b
Green fruits	15 t/ha	38.81 a	7.63 b	0.0742 c	0.0304 b
Purple fruits	5 t/ha	34.66 b	8.67 ab	0.0834 b	0.0332 b
Purple fruits	10 t/ha	34.66 b	8.67 ab	0.0834 b	0.0332 b
Purple fruits	15 t/ha	34.66 b	8.67 ab	0.0834 b	0.0332 b
p-value		0.011	0.5769	0.413	0.105

Effect of Fertilizers on Growth and Biomass of Different Morphotypes

The results obtained with NPK show significant differences among morphotypes for plant height ($p = 0.0145$), fresh mass ($p = 0.0237$) and dry mass ($p = 0.0476$), whereas the number of leaves did not vary significantly ($p = 0.518$). The black-fruited morphotype recorded the best performances, with a stable height of 37.82 cm, 7.40 leaves,

a fresh mass of 0.107 kg/plant, and a dry mass of 0.0428 kg/plant, regardless of the applied dose. The green-fruited morphotype showed the lowest values, with a height of 30.30 cm, 5.37 leaves, a fresh mass of 0.084 kg/plant, and a dry mass of 0.0345 kg/plant, without any variation across doses. The purple-fruited morphotype occupied an intermediate position, with a constant height of 34.24 cm, 6.17 leaves, a fresh mass of 0.093 kg/plant, and a dry mass of 0.0388 kg/plant (Table 6).

Table 6. Growth and biomass parameters of morphotypes under NPK fertilization

Morphotype	Dose	Height (cm)	Leaves	Fresh_mass (g)	Dry_mass (g)
Black fruits	100 kg/ha	37.82 a	7.40 a	0.107 a	0.0428 a
Black fruits	200 kg/ha	37.82 a	7.40 a	0.107 a	0.0428 a
Black fruits	300 kg/ha	37.82 a	7.40 a	0.107 a	0.0428 a
Green fruits	100 kg/ha	30.30 c	5.37 b	0.084 c	0.0345 c
Green fruits	200 kg/ha	30.30 c	5.37 b	0.084 c	0.0345 c
Green fruits	300 kg/ha	30.30 c	5.37 b	0.084 c	0.0345 c
Purple fruits	100 kg/ha	34.24 b	6.17 ab	0.093 b	0.0388 b
Purple fruits	200 kg/ha	34.24 b	6.17 ab	0.093 b	0.0388 b
Purple fruits	300 kg/ha	34.24 b	6.17 ab	0.093 b	0.0388 b
p-value		0.0145	0.518	0.0237	0.0476

Growth and Biomass Responses of Fruit Morphotypes to Different Fertilization Treatments

Black fruits

In black fruits, leaf production responded strongly to fertilization. Manure and NPK treatments induced the highest leaf numbers, with maximum values reached at 200

and 300 kg/ha. The increase was particularly pronounced between 100 and 200 kg/ha, whereas a plateau effect was observed beyond 200 kg/ha. Compost improved leaf development compared to the control, but its effect was less pronounced than that of organic and mineral fertilizers. The control consistently recorded the lowest

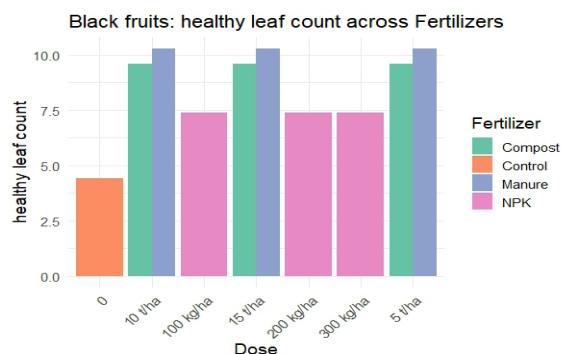


Figure 1. Number of leaves in black fruits under different fertilizers and doses.

values, confirming the importance of nutrient supply for this morphotype (Figure 1).

Fresh mass in black fruits was also markedly influenced by fertilization. The highest values were obtained under NPK

and manure, with a significant increase from 100 to 200 kg/ha, followed by stabilization at 300 kg/ha. Compost contributed to an improvement compared to the control, though less effective than the other treatments. These findings highlight the high capacity of black fruits to utilize

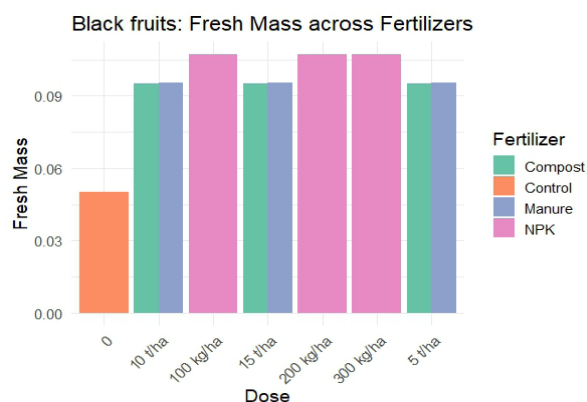


Figure 2. Fresh mass of black fruits under different fertilizers and doses.

nutrient inputs efficiently, resulting in enhanced biomass accumulation (Figure 2).

Dry mass followed a trend similar to fresh mass. Under

NPK and manure treatments, black fruits achieved the highest values, with an optimum at 200 kg/ha. Compost induced a significant increase compared to the control, but remained less effective than the other fertilization

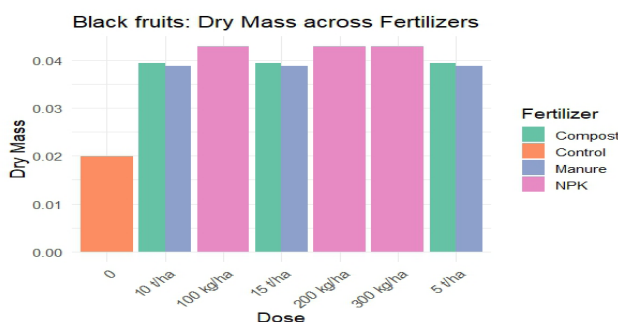


Figure 3. Dry mass of black fruits under different fertilizers and doses.

strategies. Overall, this morphotype displayed a strong capacity for dry matter accumulation in response to nutrient application (Figure 3).

Green fruits

In green fruits, leaf number also increased with fertilization,

though the response was less pronounced than in black fruits. Manure and NPK significantly enhanced foliar development, while compost had only a modest effect. As expected, the control recorded the lowest values, underlining the dependence of this morphotype on fertilization for sustaining leaf production (Figure 4).

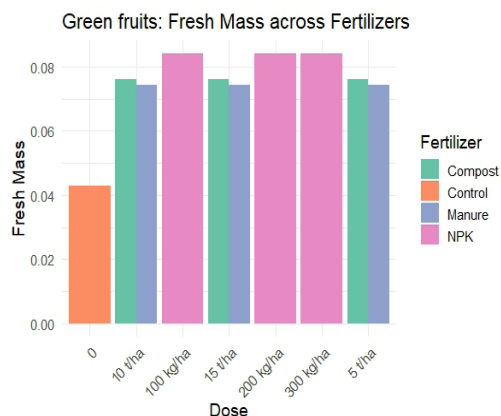


Figure 4 . Number of leaves in green fruits under different fertilizers and doses.

Fresh mass in green fruits increased under fertilization but remained consistently lower than in black fruits. Manure and NPK produced the greatest improvements, especially at 200 kg/ha. Compost led to a moderate increase,

indicating a positive but limited contribution compared with other treatments. These results suggest a lower efficiency of green fruits in converting nutrient inputs into biomass (Figure 5).

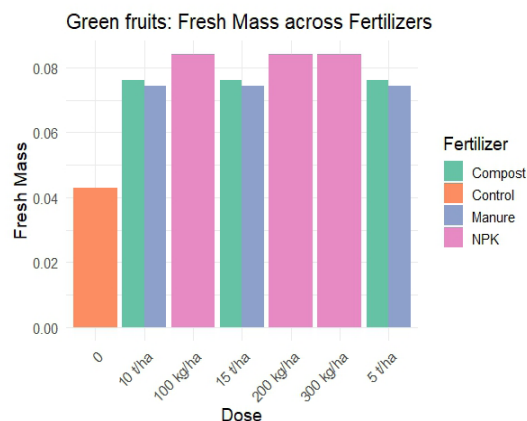


Figure 5. Fresh mass of green fruits under different fertilizers and doses.

Dry mass in green fruits followed the same pattern as fresh mass. NPK and manure significantly stimulated biomass accumulation, but maximum values remained lower than those of black fruits. Compost induced a measurable

improvement relative to the control, though less effective than the other fertilizers. This behavior indicates that green fruits possess a reduced capacity to convert nutrient inputs into dry matter (Figure 6).

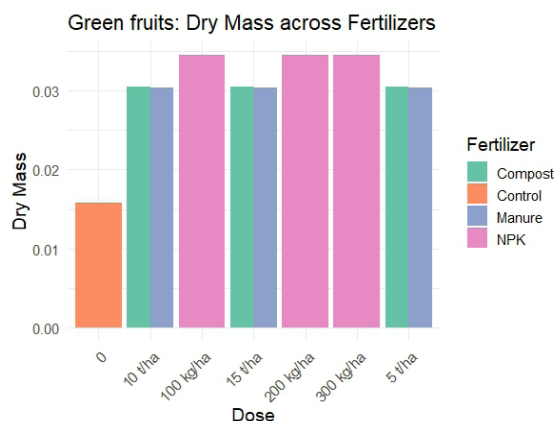


Figure 6. Dry mass of green fruits under different fertilizers and doses.

Purple fruits

In purple fruits, fertilization positively influenced leaf production, with manure and NPK inducing the strongest increases. The response was particularly notable

between 100 and 200 kg/ha, but a plateau effect was observed at 300 kg/ha, suggesting diminishing returns at higher doses. Compost contributed to an increase compared with the control, though less effectively than other treatments (Figure 7).

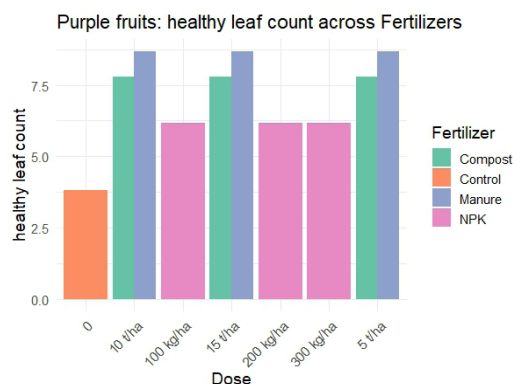


Figure 7. Number of leaves in purple fruits under different fertilizers and doses.

Fresh mass in purple fruits reached intermediate levels compared with black and green fruits. Manure and NPK resulted in the highest values, with a significant rise up to 200 kg/ha and stabilization thereafter. Compost exerted a

positive effect relative to the control, but its efficiency was lower than that of manure and NPK. These observations confirm that purple fruits benefit from fertilization, though less intensively than black fruits (Figure 8).

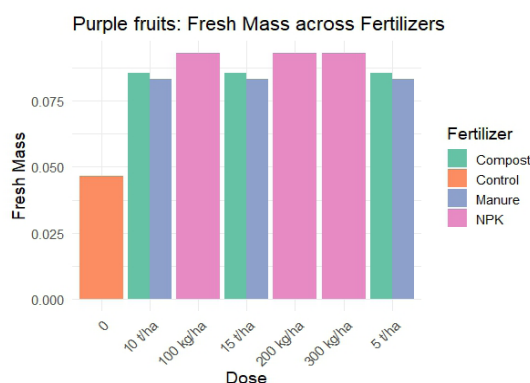


Figure 8. Fresh mass of purple fruits under different fertilizers and doses.

Dry mass in purple fruits showed a trend comparable to fresh mass. Manure and NPK significantly enhanced dry biomass accumulation, especially at 200 kg/ha, but the effect leveled off at higher doses. Compost produced

a modest improvement, while the control consistently recorded the lowest values. This indicates that the response of purple fruits to fertilization is intermediate between that of black and green fruits (Figure 9).

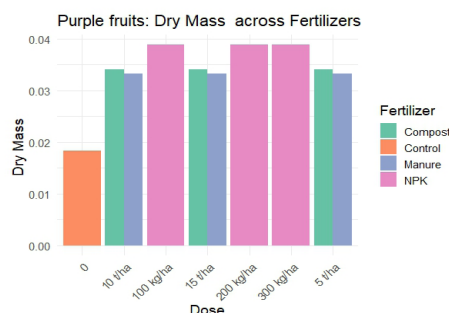


Figure 9. Dry mass of purple fruits under different fertilizers and doses.

DISCUSSION

The results show that fertilization significantly enhances growth and biomass accumulation, with marked differences among morphotypes, which confirms the central role of nutrient inputs in crop performance (Canatoy & Daquiado, 2021). The black-fruited morphotype consistently exhibits the best performance in terms of height, leaf number, fresh and dry biomass, followed by the purple-fruited morphotype, while the green-fruited morphotype remains the least productive. This hierarchy highlights the strong genetic determinism underlying nutrient uptake and utilization efficiency (Génard & Lescourret, 2004). Compost improves growth compared to the control, but its effects are less pronounced than those of manure and NPK fertilizers, which is consistent with observations in other vegetable crops where organic amendments release nutrients more slowly (Basir et al., 2025). In green and purple morphotypes, dose effects are mainly visible in plant height, while the black morphotype reaches its maximum potential even at the lowest dose, confirming its higher physiological efficiency and rapid nutrient use (Bajomo et al., 2022). Manure strongly stimulates growth and biomass, particularly in the black morphotype, which maintains stable performance regardless of the dose, a behavior also reported in other nutrient-efficient species (Holatko et al., 2022). Green-fruited plants respond with gradual height increases, while purple-fruited plants occupy an intermediate position with less variation, illustrating physiological differences in the conversion of nutrients into biomass (Lambers & Poorter, 2004). NPK induces a rapid and strong response even at the lowest application rate, reflecting the high nutrient availability of mineral fertilizers (Arbačauskas et al., 2023). However, a plateau occurs at 300 kg/ha, suggesting nutritional saturation or metabolic competition, a phenomenon widely documented in the literature as diminishing returns from excessive fertilizer use (Tan et al., 2005). This finding indicates that increasing application beyond 200 kg/ha provides no additional benefits and may reduce nutrient use efficiency (Zhu et al., 2024). In all cases, the hierarchy among morphotypes remains unchanged, with black-fruited plants outperforming the others, demonstrating that genetic factors predominate over the type or dose of fertilization. In the absence of fertilization, growth and biomass are strongly reduced, but the black morphotype still maintains its superiority, highlighting its genetic advantage under limiting conditions. The analysis of fertilizer doses reveals a clear dose-response relationship between 100 and 200 kg/ha, with progressive improvements in growth parameters, but a plateau at 300 kg/ha that reflects

diminishing returns. This phenomenon is well known and is attributed to nutrient saturation, increased nutrient losses, and possible physiological imbalances (Ismail et al., 2024). When comparing morphotypes, black-fruited plants stand out for their physiological efficiency and ability to rapidly utilize available nutrients, making them the most suitable for intensive production systems (El-Sharkawy & De Tafur, 2010). Purple-fruited plants show a positive but weaker response, confirming their intermediate status, while green-fruited plants, although stimulated by fertilization, remain limited due to low efficiency in converting nutrients into biomass (Simonutti et al., 2025). Overall, the results confirm that fertilization is essential to optimize growth and biomass, that manure and NPK are the most effective treatments while compost, although beneficial, remains less competitive, and that the optimal dose is around 200 kg/ha, providing a balance between productivity, physiological efficiency, and long-term soil fertility management (Howe et al., 2024) ; Liu et al., 2020).

CONCLUSION

This study highlights the significant effect of fertilization treatments on the growth and biomass production of the three morphotypes. Overall, manure and NPK applications proved to be the most effective, markedly improving plant height, leaf number, and both fresh and dry biomass, with optimal responses observed around 200 kg/ha for NPK and 10 t/ha for manure. Compost also had a positive effect compared with the control, but its impact remained more limited. A clear hierarchy among morphotypes was observed: the black-fruited morphotype consistently outperformed the others, showing a superior ability to utilize nutrient inputs and accumulate biomass. The purple-fruited morphotype displayed intermediate responses, while the green-fruited morphotype showed the lowest performance, reflecting a reduced efficiency in nutrient use. These findings confirm not only the importance of nutrient supply in enhancing growth and productivity but also the decisive role of morphotype selection. In particular, the black-fruited morphotype, combined with adequate organic or mineral fertilization, appears to be the most promising option for optimizing plant production.

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