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REGULAR ARTICLE

Growth and Yield Performance of High-Yielding Sweet Potato (*Ipomoea batatas* L.) Varieties Applied with Biofertilizers

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Abstract: Sweet potato *(Ipomoea batatas* L.) is an important root crop valued for its adaptability, nutritional content, and economic significance, especially in developing countries. However, optimal yield and quality are often constrained by poor soil conditions and excessive reliance on chemical fertilizers. This study investigated the growth and yield performance of high-yielding sweet potato varieties under different biofertilizer applications. A total of 864 slips were planted across 72 plots (1.70 × 2.60 m² each) in a 6 × 3 factorial experiment arranged in a Randomized Complete Block Design (RCBD). Treatments included six fertilizer options: negative control (no biofertilizer), Indigenous Microorganisms (IMO), Lactic Acid Bacteria Serum (LABS), Seaweed Extract, Bokashi, and positive control (complete fertilizer), combined with three sweet potato varieties: NSIC SP 25, NSIC SP 30, and NSIC SP 35. Results revealed that both fertilizer treatments and varieties had significant effects ($p < 0.05$) on vine length, tuber length, and tuber yield. However, their interaction showed no significant effect on the parameters tested. Among the fertilizer treatments, the complete fertilizer exhibited the highest performance, while Bokashi and LABS produced comparable results. Among the varieties, NSIC SP 35 consistently performed best in tuber size, weight, and overall yield, achieving 14.24 tons/ha, while NSIC SP 25 and NSIC SP 30 produced 8.32 tons/ha and 6.95 tons/ha, respectively. Among the fertilizer treatments, complete fertilizer produced the highest vine length and tuber yield, while seaweed extract also enhanced performance. Bokashi and IMO showed potential as sustainable alternatives, though their effects varied numerically across varieties without significant interaction. Cost and return analysis indicated that NSIC SP 35 applied with LABS was the most profitable combination, yielding the highest return on investment (ROI) at 248.93%. The study concluded that combining a high-performing variety such as NSIC SP 35 with a suitable fertilizer source can result in notable gains in productivity and profitability.

Keywords: biofertilizer; growth and yield performance; sustainable agriculture; sweet potato (*Ipomoea batatas*); variety evaluation

1. Introduction

Sweet potato (*Ipomoea batatas* L.), a member of the morning-glory family, is a globally significant food crop. It ranks sixth in importance after rice, wheat, potatoes, maize, and cassava, and fifth in developing countries. Unlike true tubers such as potatoes, sweet potatoes are storage roots that grow from sea level to elevations of up to 2,500 meters. They require minimal inputs and thrive in marginal environments, including poor soils and dry conditions (International Potato Center, 2017). Nutritionally, sweet potatoes are rich in vitamins B, C, and E, and contain moderate iron and zinc. Recent studies also highlight the cancer-preventive potential of anthocyanins found in purple varieties (Clt, 2024).

Highly versatile, sweet potatoes are consumed as food, used as animal feed, and friendly animal feed, as they help reduce methane emissions compared with conventional feed sources (Varalakshmi et al., 2022). In the Philippines, sweet potato farming is economically promising. Farmers can earn up to a 144% return per hectare, with an estimated net income of around Php 48,400.00 (Lirag, 2019; ISP Platform, n.d.).

Despite these benefits, several environmental and agronomic challenges limit the crop's full potential. Sweet potatoes grow best in warm climates with temperatures between 24°C and 29°C. Yield can be reduced by extreme temperatures, inconsistent rainfall, waterlogging, root rot, and drought stress. Pest and disease pressures, particularly during the rainy season, further constrain production. The availability of healthy planting material, especially during the dry season, is also crucial and can be ensured through methods such as sand storage (Abram et al., 2020; Sapakhova et al., 2023).

While sweet potatoes are recognized for their adaptability and resilience, optimizing their yield, especially in areas with limited access to synthetic fertilizers, remains a challenge. Growing interest in sustainable and cost-effective farming practices has brought attention to biofertilizers as alternatives to chemical fertilizers (Ibrahim et al., 2024; Li et al., 2022). Biofertilizers enhance soil fertility and promote plant growth by improving nutrient availability through microbial activity (Wei et al., 2024). However, limited research has examined the combined effects of high-yielding sweet potato varieties and biofertilizer application under localized farming conditions.

Most existing studies focus on either high-yielding varieties or biofertilizers in isolation, often under controlled conditions. Little is known about how these components interact under varying environmental and resource settings, particularly in regions such as Masbate. Moreover, the economic implications of adopting biofertilizer-based cultivation methods remain underexplored.

From April to June 2023, the Bicol Region, including Masbate, produced approximately 43.87 thousand metric tons of sweet potato, representing 28.9% of the national output. The harvested area from January to June 2023 totaled 38.33 thousand hectares, reflecting a slight increase compared with the previous year (Philippine Statistics Authority, 2023).

Despite this notable production, a research gap remains in identifying cultivation strategies that enhance both agronomic performance and profitability. This study addresses these gaps by evaluating the growth and yield performance of selected high-yielding sweet potato varieties with various biofertilizers. It also includes a cost and return analysis to assess the profitability and practical viability of biofertilizer use under local farming conditions at DEBESMSCAT. The findings are expected to provide insights for sustainable sweet potato production, improved land-use efficiency, and enhanced food security in Masbate province.

This study aims to evaluate the vegetative performance of high-yielding sweet potato varieties applied with different biofertilizers, specifically in terms of vine length. It also seeks to assess the yield performance based on several parameters, including the number of tubers per hill, the total weight of tubers per hill, the average weight of each tuber, and the diameter and length of each tuber. In addition, the study conducts a cost and return analysis to determine the economic viability of the treatment combinations.

2. Materials and Methods

2.1 Experimental Design

This study employed a Randomized Complete Block Design (RCBD) in a 6 x 3 factorial arrangement with 4 replications. The first factor was the biofertilizer treatments: F1 – Negative control (no Biofertilizer); F2 - Indigenous microorganism (IMO), F3 - Lactic Acid Bacteria Serum (LABS), F4 - Seaweed Extract, F5 - Bokashi, and F6 - Positive Control (Complete fertilizer). The second factor was the sweet potato variety: V1 - NSIC SP 25, V2 - NSIC SP 30, and V3 - NSIC SP 35. All experimental plots were amended with Carbonized Rice Hull (CRH) and planted with six experimental plants each.

2.2 Production Practices Employed

The experiment was conducted in a well-drained, sandy loam soil area with ample sunlight (6–8 hours/day). A total of 72 plots were established, each properly spaced to ensure drainage and ease of management. Three high-yielding sweet potato varieties (NSIC SP 25, SP 30, SP 35) were sourced from Visayas State University (VSU), Baybay, Leyte, and propagated at DEBESMSCAT. Planting materials were trimmed to 30cm in length and planted using the L-shape method, with a spacing of 75 cm between hills and 50 cm between rows.

Biofertilizers were applied at recommended rates. IMO, LABS and seaweed extract were applied at 106 L/ha through drench application at two-week intervals (Keliikuli et al., 2019). Bokashi was applied at 3 t/ha and was incorporated with CRH to improve soil structure and aeration. The complete fertilizer was prepared in a 1:10 dilution and applied biweekly at the recommended NPK rates for sweet potato (40 kg N, 50 kg P, and 70 kg K per hectare) to support vegetative growth, root development, and tuber quality (NPK Fertilizer Calculator, n.d).

Irrigation was provided manually using water from a nearby deep well, and weeding was done regularly. Standard Cultural practices were employed to minimize pest and disease incidence. Harvesting took place 90 days after planting, as indicated by leaf yellowing. Tubers were harvested manually using hand tools.

2.3 Data Gathering Procedure

Vine length was measured monthly from planting until the flowering stage using a tape measure, with three samples taken per plot. Only the main vine of each sampled plant was measured to minimize disturbance. Yield was assessed by recording the number of tubers per hill, the total weight of tubers per hill, the average weight per tuber, and the diameter and length of tubers.

2.4 Cost and Return analysis

Cost and return analysis was conducted using formulas adapted from the Department of Agriculture (2012). Total expenses were calculated as the sum of fixed and variable costs. Net income was obtained by subtracting total expenses from gross income. Return on investment (ROI) was computed by dividing the net income by the total expenses and multiplying the result by 100.

2.5 Data Analysis

Data were subjected to normality and homogeneity tests using the Shapiro-Wilk and Bartlett's tests, respectively. When assumptions were met, a two-factor RCBD ANOVA was performed to determine treatment effects. Significant means were further separated using Tukey's test. All statistical analyses were carried out using the Statistical Tool for Agricultural Research (STAR), Version 2.0.1, developed by the International Rice Research Institute.

3. Results and Discussion

3.1 Length of Vines

Table 2 presents the mean vine length of sweet potato varieties under different biofertilizer treatments. Analysis showed no significant interaction between variety and biofertilizer, but the main effects of both factors were statistically significant.

Table 2. Average length of vines (cm) of high-yielding sweet potato varieties applied with biofertilizers at 30 and 60 days after planting

Factors		Length of vines (cm)	
		30 days	60 days
Variety	NSIC SP 25	56.71[b]	117.00[b]
	NSIC SP 30	93.35[a]	185.42[a]
	NSIC SP 35	84.00[a]	172.17[a]
Fertilizer	No Biofertilizer	73.59[abc]	148.75[b]
	IMO	63.63[c]	147.69[b]
	LABS	75.59[abc]	154.11[b]
	Seaweed Extract	66.50[bc]	157.33[ab]
	Bokashi	85.78[ab]	155.28[ab]
	Complete Fertilizer	103.03[a]	186.00[a]
Interaction	Variety × Fertilizer	ns	ns

Means in a column for a given factor with the same letter are not significantly different ($p > 0.05$).

Among fertilizer treatments, the complete fertilizer (F6) recorded the longest vine length of 103.03 cm at 30 days and 186.00 cm at 60 days, significantly outperforming the other treatments. This indicates that balanced NPK inputs enhance vegetative growth, as nitrogen supports vine development, phosphorus promotes root and tuber initiation, and potassium contributes to disease resistance and tuber quality (Jagdish, 2023). Similar findings were reported by Oycha et al. (2023), who noted that complete fertilizers improve vine length through readily available nutrients that stimulate photosynthesis and vigor.

Among the varieties, NSIC SP 30 (V2) exhibited significantly longer vines at both 30 and 60 days (93.35 cm and 185.42 cm, respectively) compared with V1 (NSIC SP 25), which had the shortest vines. This performance is likely due to the favorable genetic traits of V2 that promote vigorous vegetative growth and adaptability (Quindara et al., 2020).

3.2 Yield Response

Table 3 presents the effects of different sweet potato varieties and fertilizer treatments on key yield parameters, including tuber length, diameter, number, and weight per hill. Significant differences were observed among varieties, with NSIC SP 35 showing the highest yield performance. The effects of fertilizer treatments and their interactions with variety were not significant.

3.2.1 Length of tubers

Fertilizer type significantly influenced tuber length, while no interaction effects were observed (Table 3). The complete fertilizer produced the longest tubers (10.55 cm), followed by Bokashi. This suggests that balanced mineral nutrition, particularly phosphorus and potassium, promotes root elongation and tuber development (Jagdish, 2023).

Table 3. Yield parameters of sweet potato as influenced by variety and fertilizer treatments.

	Factors	Length of tubers (cm)	Diameter of tubers (cm)	Number of tubers per hill	Weight of tuber per hill	Weight of each tuber (g)
Variety	NSIC SP 25	10.41^{a}	4.19^{b}	2.97^{b}	308.68^{b}	92.57^{a}
	NSIC SP 30	9.34^{b}	3.98^{b}	3.53^{b}	260.59^{b}	71.12^{b}
	NSIC SP 35	9.34^{b}	4.67^{a}	5.09^{a}	533.99^{a}	97.36^{a}
Fertilizer	No Biofertilizer	9.17^{b}	4.22	3.29	300.45^{b}	84.27
	IMO	9.66^{ab}	4.19	3.47	301.01^{b}	86.16
	LABS	9.41^{ab}	4.28	3.73	362.32^{ab}	86.89
	Seaweed Extract	9.37^{b}	4.23	3.56	314.05ab	79.88
	Bokashi	10.01^{ab}	4.36	4.19	407.17^{ab}	87.07
	Complete Fertilizer	10.55^{a}	4.39	4.93	521.52^{a}	97.82
Interaction	Variety × Fertilizer	ns	ns	ns	ns	ns

Means in a column for a given factor with the same letter are not significantly different ($p > 0.05$).

Similarly, Oycha et al. (2023) reported that balanced fertilization enhances tuber growth by improving nutrient uptake and root system expansion, which supports greater tuber elongation. Bokashi's effectiveness may be attributed to its microbial content, which improves nutrient cycling and root expansion (Christel, 2017).

NSIC SP 25 produced the longest tubers among the varieties tested, whereas NSIC SP 30 and NSIC SP 35 did not differ significantly and exhibited shorter tuber lengths. This may reflect genetic differences in assimilate allocation, where NSIC SP 25 favors tuber elongation (Oni & Olaniyi, 2025). Although NSIC SP 30 excelled in vine length, NSIC SP 25 appears to possess traits that promote tuber development. These results support the view that genetic makeup determines how nutrients are partitioned between vegetative and storage organs in sweet potatoes, with some varieties allocating more to tuber growth than vine elongation (Hammes & Belehu, 2005).

3.2.2 Diameter of tubers

Among the fertilizer treatments, complete fertilizer produced the highest mean tuber diameter (4.39 cm), followed closely by Bokashi (4.36 cm) and LABS (4.28 cm). However, the differences were not statistically significant ($P > 0.05$), indicating that although biofertilizer application visibly affected tuber diameter, the variations were not strong enough to establish treatment superiority at the 5% level.

In terms of variety, NSIC SP 35 consistently produced the widest tubers, significantly outperforming NSIC SP 25 and NSIC SP 30. ANOVA confirmed a significant varietal effect, and Tukey's test further showed that V3 differed significantly from the other two varieties. This suggests that the superior tuber diameter in NSIC SP 35 may be attributed to genetic characteristics that favor storage organ expansion through enhanced assimilate allocation to the tuber. While NSIC SP 30 excelled in vine length and NSIC SP 25 in tuber length, NSIC SP 35 appears genetically inclined toward producing larger tuber diameters—an important market trait in sweet potato production. Rahman et al. (2015) similarly emphasized that genetic variation plays a key role in determining root size and shape.

The present results align with the findings of Mukhongo et al. (2017), who reported that biofertilizers enhancing nutrient uptake and microbial activity significantly improved root crop biomass. Likewise, Boubaker et al. (2023) found that organic amendments, including biofertilizers, increased tuber diameters in root crops, underscoring their value in sustainable agriculture. Duan et al.

(2024) also noted that biofertilizers can match or even surpass conventional fertilizers in improving crop growth and yield parameters.

3.2.3 Number of tubers per hill

The analysis showed no significant interaction between variety and biofertilizer, but the main effect of variety was statistically significant. Among the fertilizer treatments, complete fertilizer recorded the highest average number of tubers per hill (4.93). However, ANOVA indicated no significant differences among biofertilizer treatments at the 5% level. This means that although numerical differences were observed, they were not statistically significant, and no treatment can be considered superior in influencing tuber number per hill.

Across varieties, NSIC SP 35 produced the highest average number of tubers per hill (5.09), while NSIC SP 25 had the lowest (2.97). ANOVA confirmed that V3 significantly outperformed both V1 and V2 (NSIC SP 30). This suggests that V3 has stronger genetic potential for tuber initiation and development, possibly due to more efficient assimilate partitioning toward multiple tuber formation. These results are consistent with the findings of Hartemink (2003) and Mwanga et al. (2017), who emphasized that varietal differences in sweet potato tuber production are largely governed by genetic traits such as sink strength, tuber initiation capacity, and overall yield architecture.

3.2.4 Weight of tubers per hill

The analysis showed no significant interaction between variety and biofertilizer (Table 3), but the main effects of both factors were statistically significant. Among the fertilizer treatments, complete fertilizer produced the highest mean tuber weight per hill (521.52 g), significantly outperforming the other treatments. This indicates that F6, a balanced fertilizer, enhanced tuber development by providing essential macronutrients such as nitrogen, phosphorus, and potassium, which are critical for root crop productivity. The significant difference was confirmed by ANOVA and further supported by Tukey's test, which showed F6 to be statistically superior at the 5% level.

The higher tuber weight under F6 may be attributed to increased photosynthetic activity and assimilate partitioning, particularly the role of potassium in tuber bulking and carbohydrate transport (Chowdary et al., 2021). This finding is consistent with Fageria (2008), who reported greater yield potential with complete fertilizers due to improved nutrient availability and uptake efficiency.

Across varieties, NSIC SP 35 consistently produced the highest tuber weight per hill across all fertilizer treatments, significantly surpassing NSIC SP 25 and NSIC SP 30. ANOVA confirmed a significant varietal effect at the 5% level, and Tukey's test indicated that NSIC SP 35 differed significantly from the other varieties.

The results suggest that NSIC SP 35 has superior genetic potential for tuber yield compared with the other varieties under study, regardless of fertilizer treatment. The consistently higher tuber weight in V3 indicates traits such as improved nutrient uptake efficiency and better biomass allocation to storage organs, which contribute to its yield advantage. This aligns with the findings of Ebem et al. (2021), who reported that sweet potato varieties differ significantly in yield performance due to genetic and environmental interactions, and that integrated nutrient management enhances productivity while maintaining soil health. The study also supports the findings of Higashikawa et al. (2025), who reported that high-yielding sweet potato varieties paired with efficient nutrient management can significantly improve food security and farm income, particularly in developing regions.

3.3.5 Weight of each tuber

The statistical analysis indicated that while there was no significant interaction between variety and biofertilizer, the main effect of variety showed a significant influence on tuber weight. Analysis of variance indicated that the interaction between variety and biofertilizer was not significant; however, the main effect of variety exhibited a statistically significant influence on tuber weight. This suggests that varietal differences played a more critical role in determining individual tuber size than fertilizer treatments.

Although complete fertilizer recorded the highest average weight per tuber (97.82 g), statistical analysis confirmed that the differences among biofertilizer treatments were not significant. The superior numerical performance of F6 may be associated with its balanced nutrient composition, providing an optimal supply of nitrogen, phosphorus, and potassium—elements essential for carbohydrate synthesis and tuber enlargement.

In contrast, varietal performance showed clearer distinctions. NSIC SP 35 consistently produced heavier individual tubers than the other varieties, while NSIC SP 25 also exhibited competitive results under most fertilizer regimes. The relatively lower tuber weight of NSIC SP 30 suggests that this variety may channel assimilates toward producing a greater number of smaller tubers, reflecting its inherent genetic tendency for higher tuber count rather than size.

These observations highlight genetic variation in assimilate partitioning and storage organ development among the varieties. NSIC SP 35 appears to possess stronger sink strength and greater efficiency in allocating carbohydrates toward tuber enlargement, a trait that directly contributes to its yield advantage. This aligns with the findings of Tumwegamire (2011), who emphasized that varietal differences in genetic makeup influence the synchronization of tuber growth and the efficiency of assimilate distribution. Such traits are crucial not only for yield potential but also for improving crop quality and post-harvest handling characteristics.

3.3 Economic Viability

Table 4 presents a detailed computation of the cost and return analysis. The analysis assumes uniform land area, labor, and management practices across all treatment combinations. Fixed and labor costs remain constant, while variable costs vary according to fertilizer application. All produce was sold at a fixed price of ₱60/kg, and net income and ROI were used to evaluate the economic performance of each treatment.

The economic evaluation revealed that complete fertilizer produced the highest mean return on investment (ROI) at 155.64%, followed by LABS at 107.13% and Seaweed Extract at 82.89%. The lowest ROI was observed with Bokashi at only 22.98%, largely due to the negative return recorded in NSIC SP 25 (-25.63%), indicating its inconsistent effectiveness. These results indicate that complete fertilizer substantially outperformed the organic-based fertilizers overall, suggesting that commercially formulated nutrient inputs remain more effective in enhancing profitability under the conditions of this study.

Table 4. Average return on investment (%) in the production of selected sweet potato varieties under different biofertilizer treatments.

Fertilizers	Return on investment (%)			Mean
	NSIC SP 25	NSIC SP 30	NSIC SP 35	
No Biofertilizer	12.46	2.98	212.70	76.04
IMO	46.70	19.54	122.96	63.07
LABS	55.12	17.34	248.93	107.13
Seaweed Extract	92.19	24.14	132.33	82.89
Bokashi	-25.63	24.47	70.09	22.98
Complete Fertilizer	165.56	64.99	236.38	155.64
Mean	57.73	25.58	170.56	

When evaluating varietal performance, NSIC SP 35 achieved the highest mean ROI (170.56%), followed by NSIC SP 25 (57.73%) and NSIC SP 30 (25.58%). NSIC SP 35 consistently generated strong returns across fertilizer treatments, particularly when combined with LABS, which yielded an ROI of 248.93%. This outcome reflects the variety's inherent advantages, including efficient nutrient utilization, high tuber yield, and adaptability to different fertilization strategies, making it a promising candidate for commercial cultivation.

Overall, profitability is maximized when an effective fertilizer is paired with a highly responsive variety. While complete fertilizer provided the greatest returns overall, the high ROI achieved by the NSIC SP 35 + LABS combination highlights that microbial biofertilizers can be economically viable when matched with varieties that efficiently convert available nutrients into yield. These results align with Raman et al. (2022), who reported that the effectiveness of LABS depends on crop responsiveness, microbial activity, and soil nutrient dynamics.

4. Conclusion

This study showed that sweet potato growth, yield, and profitability depend strongly on both variety selection and fertilizer input. Among the varieties, NSIC SP 35 consistently produced the largest tubers and highest yield at 14.24 t/ha, demonstrating superior genetic potential compared to NSIC SP 25 and NSIC SP 30, which yielded 8.32 and 6.95 t/ha, respectively. Complete fertilizer promoted vigorous growth and larger tubers, while LABS also supported high returns due to its lower production cost, particularly when paired with NSIC SP 35. In contrast, the NSIC SP 25 and Bokashi combination resulted in economic loss, highlighting that fertilizer effectiveness varies by varietal responsiveness. Overall, matching a high-performing variety such as NSIC SP 35 with an efficient fertilizer source can significantly improve productivity and profitability. Further research should refine nutrient management strategies and test more varieties under different field conditions.

5. Conflict of Interest

The author declares that there is no conflict of interest regarding the publication of this paper.

6. Use of Artificial Intelligence (AI)-Assisted Technology

During the preparation of this work, the author used ChatGPT and Grammarly to paraphrase and ensure accurate grammar. After using this tool/service, the author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

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