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Performance Evaluation of Sweet Potato (Ipomoea batatas L.) Varieties under Different Fertilization Strategies Intercropped with Mulberry Trees

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Abstract

Poverty and malnutrition remain pressing issues in the Philippines, with high incidences of underweight, under-height, and wasting among adults and children. Agroforestry, a sustainable farming system integrating trees and crops, presents a promising approach to improving livelihoods and addressing nutritional challenges. This study explored the intercropping of sweet potato (*Ipomoea batatas L.*) varieties with mulberry trees to enhance land productivity, economic returns, and food security. Four sweet potato varieties (V1 – Seven Flores, V2 – Seri Kenya, V3 – Immitlog, and V4 – Violeta) and four fertilization strategies (F0 – No Fertilizer, F1 – 100% Chicken Compost, F2 – 100% Urea, and F3 – 50% Chicken Compost + 50% Urea) were evaluated in a 4x4 split-plot design using a randomized complete block factorial layout with three replications. The experiment was conducted at SRDI DMMMSU NLUC, Bacnotan, La Union, from January to April 2019. The results revealed significant differences among sweet potato varieties and fertilization strategies in survival rate, biomass yield, vine growth, storage root yield, sugar content, and costbenefit ratio. Mulberry trees also exhibited significant variation in shoot growth, leaf development, and biomass yield under different fertilization treatments. These findings underscore the potential of intercropping sweet potato with mulberry trees, coupled with optimized fertilization strategies, to improve productivity and profitability in agroforestry systems. This study provides critical insights for advancing sustainable agriculture and food security in the Philippines and similar regions.

Keywords: *Agroforestry, Intercropping, Sweet Potato Varieties, Fertilization Strategies, and Food Security.*

INTRODUCTION

The persistent global rise in hunger and malnutrition presents an alarming challenge, with the number of undernourished individuals increasing from 804 million in 2016 to nearly 821 million in 2017 (FAO, 2018). Poverty and inequity, recognized as the root causes of food insecurity (FAO, 2015), continue to severely affect developing countries such as the Philippines, where agriculture is dominated by small-scale farms averaging only two hectares in size.

Despite the prevalence of these farms, widespread poverty persists, exacerbating the incidence of malnutrition. Among Filipino children, malnutrition rates remain critically high, with stunting prevalence reaching 33.6% (FNRI, 2011). This dire situation underscores the urgent need for sustainable and integrated solutions to combat poverty and malnutrition, particularly in Mindanao, home to many of the nation's poorest provinces (De Guzman et al., 2015).

Volume 64 | Issue 01 | January 2025
DOI: 10.5281/zenodo.14625716

Bridging the gap between agriculture and nutrition offers a transformative opportunity to address food security and improve livelihoods. Nutrition-sensitive agriculture, which integrates nutritional objectives into agricultural practices, emerges as a promising strategy to tackle the multifaceted dimensions of poverty, malnutrition, and environmental challenges (Virchow, 2013).

Among various approaches, agroforestry systems have proven effective in enhancing food production while promoting environmental sustainability. By combining trees and crops within farming systems, agroforestry increases land productivity, improves nutrition, and strengthens rural livelihoods (Sobola et al., 2015). Intercropping, a core component of agroforestry, further enhances these benefits by boosting yields, minimizing pest and weed issues, and optimizing resource use (Finley et al., 2018).

Sweet potato (*Ipomoea batatas* L.), a nutrient-rich and versatile crop, stands out as a key candidate for intercropping systems. Originating from Central America and now cultivated worldwide, sweet potato plays a significant role in ensuring food security and augmenting smallholder incomes. Rich in carbohydrates, dietary fiber, and essential vitamins, it is an indispensable crop for regions facing resource limitations (Zannou et al., 2017). Studies have demonstrated that intercropping sweet potato with crops such as hybrid maize enhances productivity and profitability (Islam et al., 2014). Furthermore, its adaptability to diverse environments and short growth cycles make it a reliable food source in challenging agricultural settings (Helen Keller International Tanzania, 2012).

This research explores a novel intercropping approach involving sweet potato varieties and mulberry (*Morus alba* L.) trees. Mulberry trees, widely recognized for their role in silk production, also possess high adaptability and potential for intercropping with high-value crops. Despite their versatility, limited studies have investigated the intercropping of sweet potato with mulberry trees, particularly under varying fertilization strategies.

This study seeks to evaluate the performance of sweet potatoes under two fertilization methods—organic (chicken compost) and inorganic (urea)—when intercropped with mulberry trees fertilized with NPK. By examining this system, the research aims to enhance agricultural productivity, diversify cropping systems, and contribute to addressing malnutrition and poverty.

General Objective:

This study aims to develop and evaluate an agroforestry system integrating mulberry trees and sweet potato to improve land productivity, economic returns, and food security.

Specific Objectives:

1. To evaluate the performance of four sweet potato varieties (*V1* – Seven Flores, *V2* – Seri Kenya, *V3* – Immitlog, and *V4* – Violeta) in terms of survival rate, biomass yield, vine growth, storage root yield, sugar content, and cost-benefit ratio under intercropping conditions with mulberry trees.
2. To determine the effects of four fertilization strategies (*F0* – No Fertilizer, *F1* – 100% Chicken Compost, *F2* – 100% Urea, and *F3* – 50% Chicken Compost + 50% Urea) on the growth and yield of sweet potato and mulberry trees.
3. To assess the compatibility and productivity of mulberry-sweet potato intercropping systems under optimized fertilization treatments.

Volume 64 | Issue 01 | January 2025
DOI: 10.5281/zenodo.14625716

MATERIALS AND METHODS

The study employed a Randomized Complete Block Design (RCBD) with a split-plot arrangement to evaluate the growth, yield, and economic viability of four sweetpotato varieties (*Seven Flores*, *Seri Kenya*, *Immitlog*, and *Violeta*) under four fertilization strategies: no fertilizer (control), organic fertilizer (chicken compost), inorganic fertilizer (urea), and a combination of organic and inorganic fertilizers. The experiment included three replications, with subplots measuring 8 m × 1.25 m.

Experimental Setup

Design and Layout. The main plots of the study consisted of sweetpotato varieties, while the subplots were designated for different fertilization strategies. Each block measured 8 m × 20 m in size. Sweetpotatoes were planted between rows of mulberry trees, with a spacing of 30 cm between plants and 50 cm between rows, ensuring optimal plant growth and resource allocation.

Materials Used. Agricultural tools, fertilizers, sweet potato cuttings, mulberry trees, and laboratory equipment were procured from reputable regional suppliers and research institutions to ensure quality and reliability for the study.

Land Preparation. The area was thoroughly prepared by weeding, pruning, flooding, and plowing to soften the soil and enhance moisture retention. Furrows were created at a depth of 25 cm using a carabao-drawn plow. Fertilizers were then applied directly into the furrows, incorporated into the soil, and followed by irrigation to ensure optimal nutrient distribution and soil hydration.

Cultural Management Practices

Planting. Sweet potato cuttings, measuring 30 cm with five nodes each, were planted. Replanting was conducted two weeks after the initial planting to replace any missing or dead plants.

Irrigation. Bi-weekly irrigation was performed to maintain adequate soil moisture.

Weeding and Hilling. These practices were carried out as necessary to manage weed growth and ensure proper tuber development.

Pest Surveillance. Weekly monitoring was conducted to detect and control insect pests and diseases.

Harvesting. Mulberry shoots and leaves were harvested at 60 days for silkworm rearing. Sweet potatoes were harvested at 90 days, then sorted and weighed for yield analysis.

Data Gathered

Sweet potato Growth and Yield

The survival rate, vine growth parameters, number and weight of storage roots, and total biomass were recorded. Additionally, yield metrics were documented for each subplot and converted to per-hectare values for comprehensive analysis.

Mulberry Tree Growth and Yield

The data on the number, weight, and dimensions of shoots and leaves, as well as biomass, were collected.

Volume 64 | Issue 01 | January 2025
DOI: 10.5281/zenodo.14625716

Economic Analysis

The net income from sweet potato and mulberry production was calculated by subtracting the total production costs from the gross income.

Soil and Climatic Data

Pre- and post-study soil analyses, along with climatological data (temperature, rainfall, and humidity), were recorded.

Data Analysis

Agronomic and yield data were analyzed using Analysis of Variance (ANOVA). Treatment means were compared with the Least Significant Difference (LSD) test at a 5% significance level. This methodology ensured a systematic evaluation of sweetpotato varieties and fertilization strategies in an intercropped system with mulberry trees, assessing agronomic performance, soil conditions, and economic returns.

RESULTS AND DISCUSSION

This study aimed to assess the performance of four sweet potato varieties and four fertilization strategies as intercrops in mulberry trees. The data collected from January 5 to March 11, 2019, showed significant results concerning the growth and yield of both sweet potato and mulberry, as well as the soil and climatological conditions.

Growth and Yield of Sweet potato Varieties. The study investigated the effects of different sweet potato varieties and fertilizer applications on the growth and yield of sweet potato plants. The results revealed significant variations among the varieties, particularly in vine length, number of secondary vines, and weight of storage roots per plot (Figures 1 and 2).

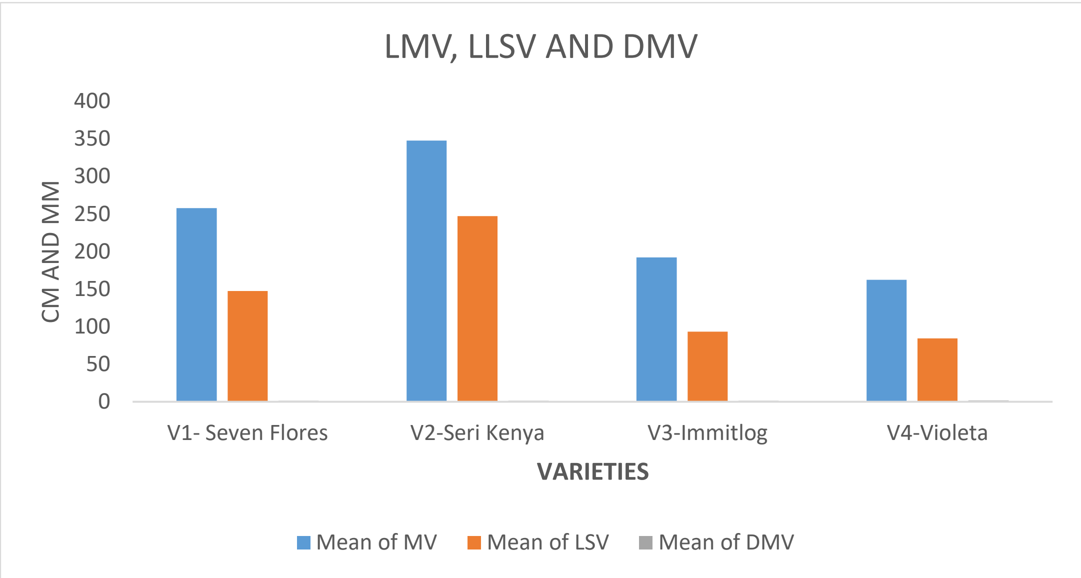

Fig 1: Length of the main vine, length of the longest secondary vine, and diameter of the main vine of sweet potato affected by varieties at 90 DAP.

Volume 64 | Issue 01 | January 2025
DOI: 10.5281/zenodo.14625716

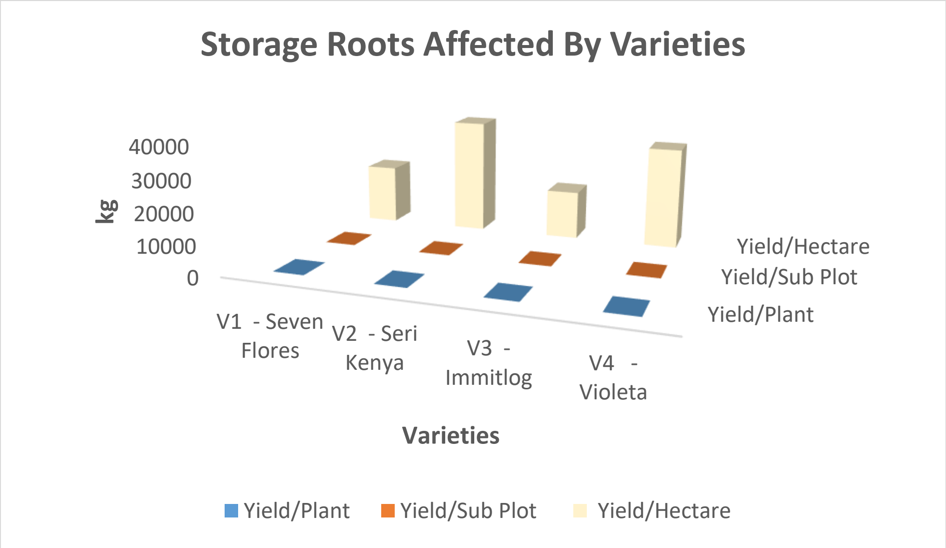

Fig 2: Fresh weight of storage roots yield per plant and per hectare of sweet potato varieties as affected by varieties at 90 DAP.

Among the varieties, **Immitlog** outperformed the others in all key growth parameters, showing the highest vine length, number of secondary vines, and storage root weight. This suggests that **Immitlog** has superior growth potential, likely due to its genetic traits, which enable it to thrive under the experimental conditions. The variety **Seven Flores** also performed well, yielding results that were comparable to **Immitlog**, indicating its potential as a competitive variety for cultivation. In contrast, **Violeta** and **Seri Kenya** exhibited lower but still acceptable yields. These varieties showed potential for cultivation, though their performance may not be as optimal as that of **Immitlog** and **Seven Flores**.

Fertilizer application significantly influenced the **number of storage roots per plant**, highlighting its importance in root production (Figure 3). However, other growth parameters, such as vine length and the number of secondary vines, were not significantly affected by fertilization. This suggests that while fertilizers play a crucial role in root development, they may have a limited impact on other growth characteristics under the current experimental conditions.

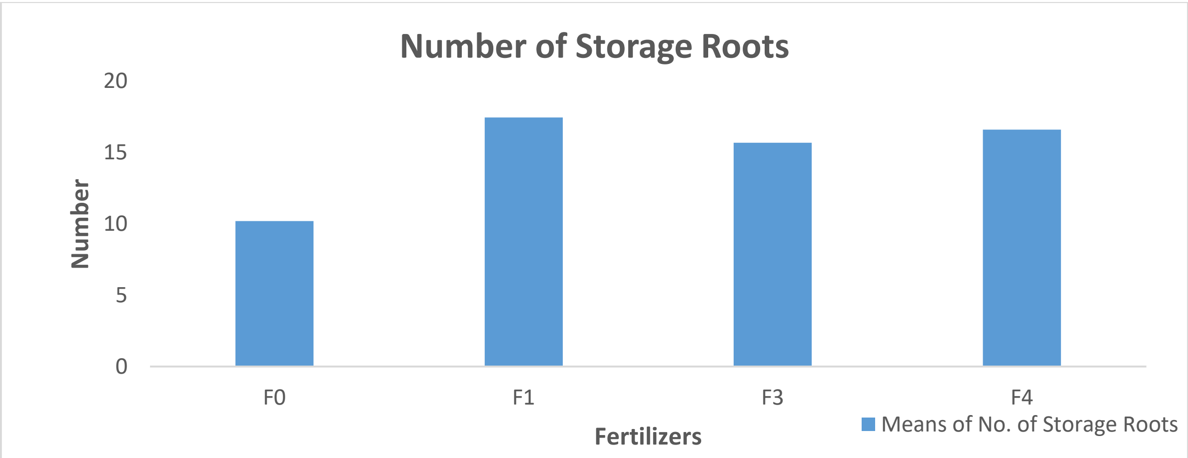

Fig 3: Number of storage roots per plant of sweet potato as an intercrop in mulberry trees, as affected by fertilizers.

Volume 64 | Issue 01 | January 2025
DOI: 10.5281/zenodo.14625716

Additionally, there was no significant interaction between sweet potato varieties and fertilization strategies regarding growth and yield. This indicates that the varieties responded to fertilizers independently, with no evidence that combining specific varieties with particular fertilization strategies produced a synergistic effect.

In conclusion, the results demonstrate that variety selection, especially **Immitlog** and **Seven Flores**, is a key factor for optimizing sweet potato growth and yield, while fertilizer application plays a significant role in promoting root development. The lack of variety-fertilizer interaction suggests that fertilizers can be applied uniformly across varieties for optimal root production without concerns of variety-specific responses.

Growth and Yield of Mulberry. The growth of mulberry trees intercropped with sweet potato was assessed in terms of biomass yield, shoot length, shoot diameter, and leaf development. The results indicated that the different sweet potato varieties did not significantly affect these growth parameters of mulberry trees. This suggests that while sweet potato intercropping may influence other aspects of the system, it does not have a notable impact on mulberry tree growth in terms of the measured variables.

On the other hand, **fertilization strategies** significantly influenced mulberry tree growth, with substantial improvements observed in biomass yield, shoot length, and leaf weight under fertilization treatments (Figures 4, 5 and 6). The application of fertilizers, particularly **urea** and **organic/inorganic combinations**, resulted in enhanced mulberry growth, suggesting that proper fertilization is crucial for optimizing mulberry production in intercropping systems. Fertilization appears to provide essential nutrients that promote robust growth, likely improving photosynthetic activity and overall tree health.

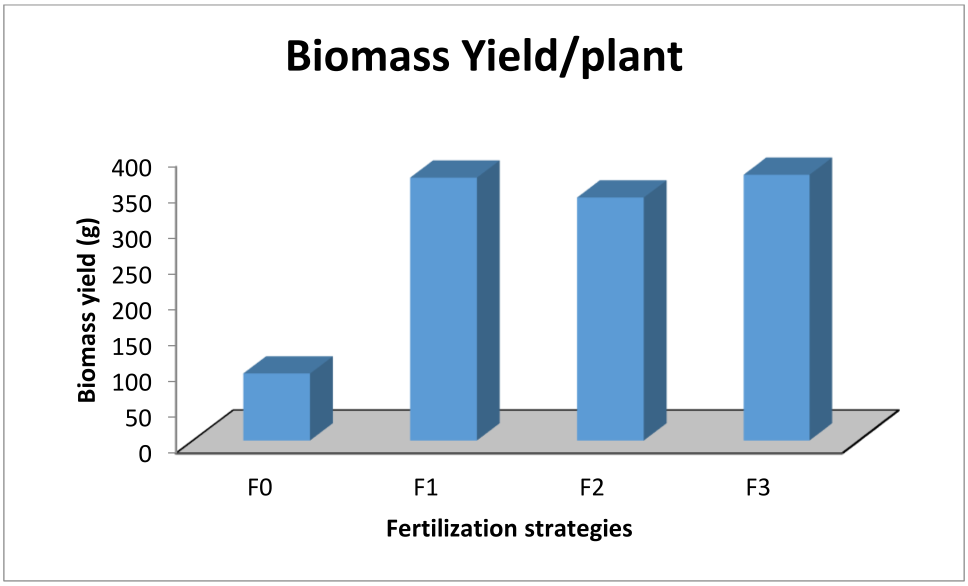

Fig 4: Biomass yield of mulberry trees as affected by fertilization strategies.

Despite the significant effects of fertilization strategies on mulberry growth, no significant interaction was observed between the sweet potato varieties and fertilization treatments regarding mulberry growth and yield.

Volume 64 | Issue 01 | January 2025
DOI: 10.5281/zenodo.14625716

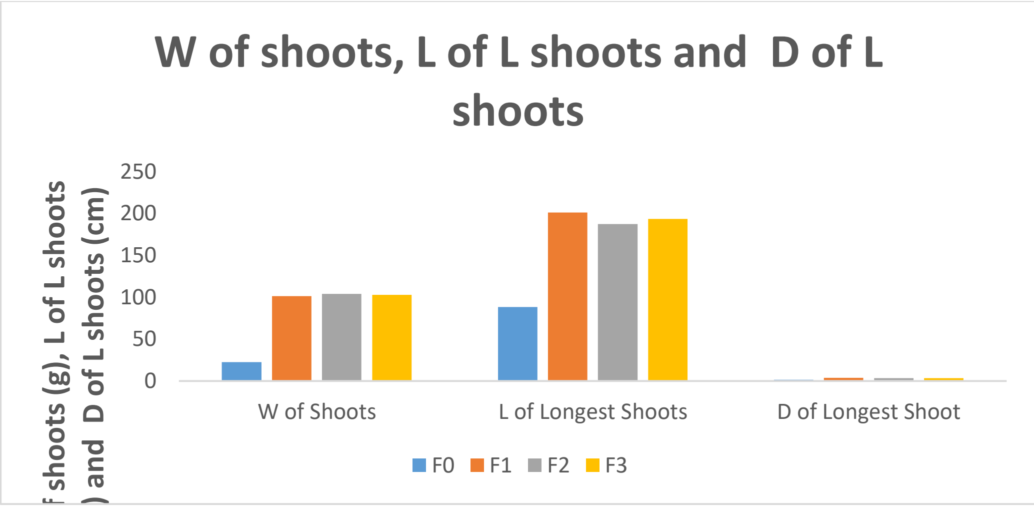

Fig 5: Shows the weight of shoots, the length of the longest shoot, and the diameter of the longest shoot of mulberry trees.

This indicates that sweet potato variety choice did not influence the efficacy of fertilization strategies on mulberry performance. The lack of interaction implies that mulberry growth can be optimized through fertilization independently of the specific sweet potato variety intercropped with it.

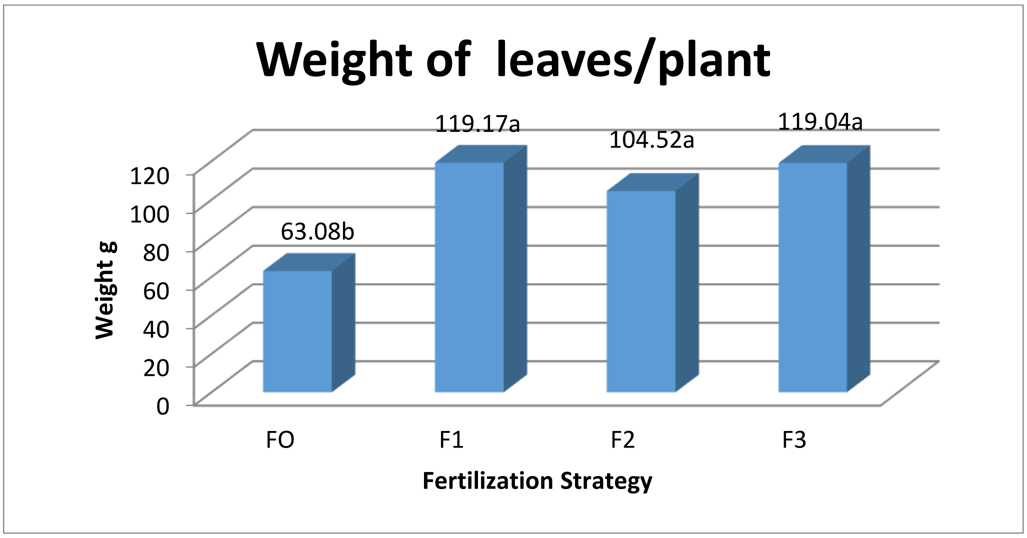

Fig 6: Shows the weight of leaves per plant of mulberry trees affected by fertilization strategies at 60 DAP.

In conclusion, while sweet potato varieties did not significantly impact mulberry tree growth, appropriate fertilization, especially with urea or organic/inorganic combinations, proved essential in enhancing mulberry growth and biomass yield. This highlights the importance of fertilization management in intercropping systems to maximize the productivity of both crops.

Climatological and Soil Data. The temperature and relative humidity throughout the growing season were found to be favorable for the growth of sweet potato, contributing positively to its development (Figure 7). However, despite the optimal climatic conditions, the rainfall levels during the growing season were insufficient, which could have limited water

Volume 64 | Issue 01 | January 2025
DOI: 10.5281/zenodo.14625716

availability and affected overall crop yield. These conditions highlight the importance of supplemental irrigation in regions where rainfall is not consistently adequate for crop growth. Soil analysis revealed a significant increase in soil pH and organic matter content after the growing period of sweet potato (Figure 8). The rise in soil pH may be attributed to the breakdown of organic matter and the release of basic cations, contributing to a more alkaline environment. The increase in organic matter is beneficial for soil fertility, as it improves soil structure, water retention, and microbial activity, all of which enhance the overall health of the soil.

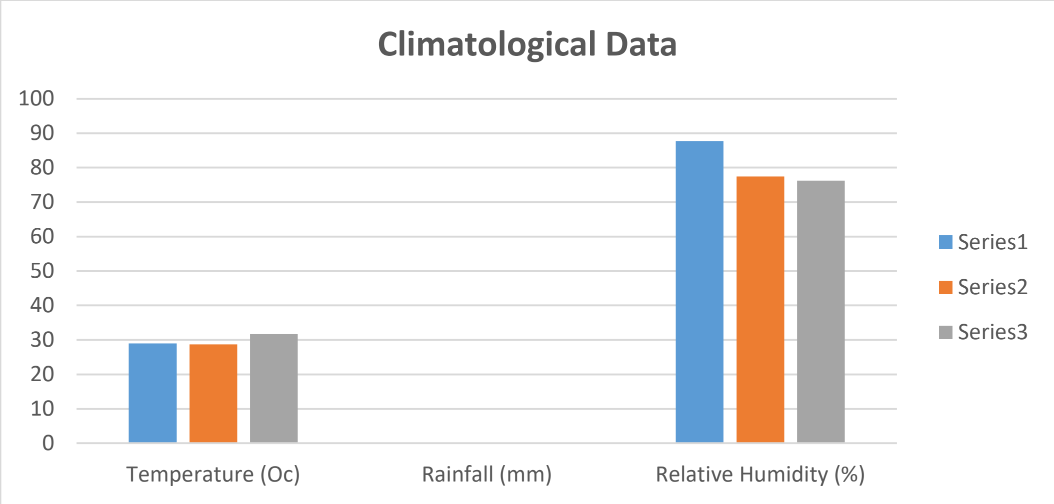

Fig 7: The 3-month climatological data during the conduct of the study.

On the other hand, a decrease in the levels of available phosphorus and potassium was observed, which can be attributed to the high nutrient uptake by the sweet potato crop during its growth (Figure 8). These essential nutrients are critical for root development, energy transfer, and overall plant health, and their depletion in the soil suggests that replenishment through fertilization may be necessary to maintain soil fertility for future crop cycles. This emphasizes the need for a balanced nutrient management strategy to sustain productivity and prevent soil nutrient exhaustion after intensive crop production.

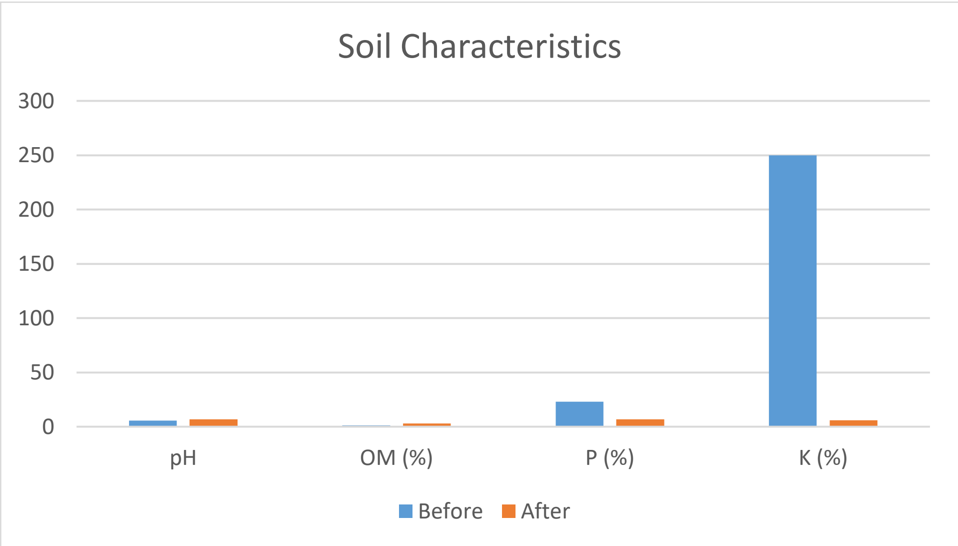

Fig 8: Soil Characteristics before and after the conduct of the study.

Volume 64 | Issue 01 | January 2025
DOI: 10.5281/zenodo.14625716

Economic Performance. The net income derived from the sweet potato and mulberry intercropping system was highest for plants that received a combination of ½ rate organic compost and ½ rate inorganic nitrogen fertilizer (Figure 9). This treatment resulted in the most favorable growth and yield, likely due to the balanced nutrient supply from both organic and inorganic sources, which supported optimal plant development. The close second in terms of net income was observed in plots treated with inorganic urea alone. This suggests that while the combined organic-inorganic fertilizer treatment performed best, inorganic nitrogen alone still contributed to a significant increase in crop yield and overall profitability, likely by meeting the plants' high nitrogen demands.

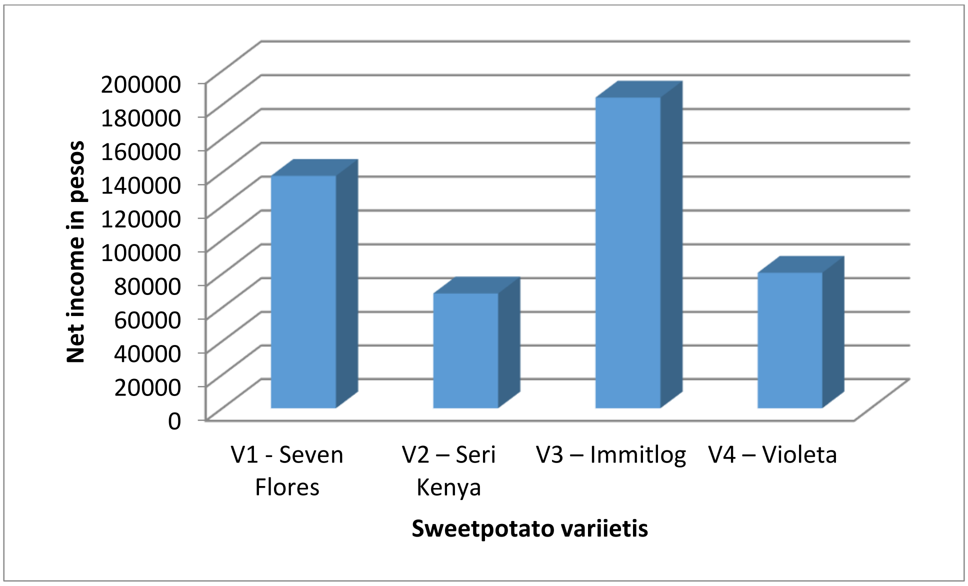

Fig 9: Net income derived from the production systems, as affected by varieties.

Conversely, the lowest net income was observed in unfertilized plots and those fertilized with chicken compost. The absence of any fertilizer led to nutrient limitations that hindered plant growth and reduced yields. While chicken compost is an organic fertilizer, its application alone may not have provided sufficient nutrients, particularly nitrogen, for optimal growth and productivity. These findings highlight the importance of appropriate fertilization strategies for maximizing yield and profitability in intercropping systems. The combination of organic and inorganic fertilizers appears to be the most effective approach for enhancing both the growth of sweet potato and mulberry and the financial returns of the intercropping system.

CONCLUSION

The study concludes that sweet potato can be successfully intercropped with mulberry trees. Varieties such as Seven Flores, Immitlog, and Violeta are suitable for intercropping, with Immitlog showing the highest storage root yield. There was no significant interaction between sweetpotato varieties and fertilization strategies in influencing the growth and yield of both crops. The climatic conditions were generally favorable for sweet potato growth, except for the insufficient rainfall. Additionally, soil properties showed significant changes, with an increase in pH and organic matter content but a decrease in available phosphorus and potassium. Fertilization strategies involving ½ organic compost and ½ inorganic nitrogen, as well as inorganic urea alone, produced the highest net returns.

Volume 64 | Issue 01 | January 2025
DOI: 10.5281/zenodo.14625716

Recommendations

Based on the findings, the following recommendations are proposed:

1. **Sweetpotato Variety Selection:** Immitlog is recommended for intercropping with mulberry trees due to its higher yield in terms of storage roots, leading to increased income.
2. **Fertilization Strategy:** A fertilization system of ½ rate organic compost and ½ rate inorganic nitrogen fertilizer, or RR inorganic N alone, is recommended to maximize growth and yield for both sweetpotato and mulberry.
3. **Soil Management:** Regular replenishment of phosphorus and potassium is suggested to maintain soil fertility, especially after intensive cropping.
4. **Climate Adaptation:** While temperature and humidity were suitable for sweetpotato growth, additional measures such as irrigation might be needed to compensate for insufficient rainfall during the growing season.

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Volume 64 | Issue 01 | January 2025
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