

The Effect of the Use of Organic Fertilizers Made from Industrial Waste on Beniazuma Sweet Potatoes under Different Plant Spacings

Ayutyas Sayekti¹, Prima Gandhi^{1,2}, Agief Julio Pratama³

¹Agribusiness Management Study Program, College of Vocational Studies, IPB University, Indonesia

²Graduate School of International Food and Agricultural Studies, Departement of Agricultural Economics, Tokyo University of Agriculture, Japan

³Production Technology and Agricultural Community Development Study Program, College of Vocational Studies, IPB University, Indonesia

¹ayutyassa@apps.ipb.ac.id, ²primagandhi@apps.ipb.ac.id, ³agiefjulio@apps.ipb.ac.id

ARTICLE INFO

Article History:

Received : 13-04-2026
Revised : 18-05-2026
Accepted : 09-06-2026
Online : 18-06-2026

Keywords:

*Circular Economy;
Industrial Waste Utilization;
Plant Spacing;
Sustainable Agriculture;
Tuber Yield.*



Crossref

ABSTRACT

Sweet potato productivity is largely determined by agronomic practices, particularly plant spacing and nutrient management. However, excessive reliance on chemical fertilizers may negatively affect soil sustainability. Therefore, alternative nutrient sources derived from industrial waste are increasingly explored within the framework of sustainable agriculture and circular resource utilization. This study aimed to evaluate the growth and yield performance of Beniazuma sweet potato under different fertilizer treatments and plant spacing arrangements. The experiment was conducted in Dramaga, Bogor Regency, Indonesia, from June to December 2022 using a factorial randomized complete block design. Two plant spacing levels (40 cm × 40 cm and 60 cm × 60 cm) and six fertilizer treatments (control, NPK, milk waste-based organic fertilizer, and compost at different doses) were applied. Observed variables included tuber number, tuber weight, and shoot biomass. Data were analyzed using analysis of variance followed by the LSD test at the 5% level. The findings revealed that plant spacing had a stronger influence on yield components compared to fertilizer treatments. Wider spacing (60 cm × 60 cm) increased tuber weight up to ~0.3 kg/plant compared to 0.1–0.2 kg at closer spacing. Organic fertilizers derived from industrial waste performed comparably to inorganic fertilizers, indicating their feasibility as sustainable nutrient sources in sweet potato cultivation.



This is an open access article under the [CC-BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license

A. INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) plays a crucial role in global food systems due to its nutritional value and adaptability to diverse environments. Despite its potential, improving sweet potato productivity remains a challenge, particularly in optimizing cultivation practices such as plant spacing and fertilizer application (Liu et al., 2023). The prolonged use of synthetic fertilizers has been associated with declining soil health and environmental concerns. As a result, sustainable agricultural approaches have increasingly emphasized the use of organic inputs, including those derived from industrial waste. Organic waste-based fertilizers improve soil structure, microbial activity, water retention, and nutrient availability, thereby enhancing nutrient absorption efficiency and plant physiological performance. Nutrients released from organic waste are gradually

mineralized through microbial decomposition, allowing nitrogen, phosphorus, potassium, and micronutrients to become more available for plant uptake over a longer period. In addition, organic matter stimulates root development and increases cation exchange capacity, which improves nutrient retention in the rhizosphere and reduces nutrient losses through leaching. Several studies also reported that organic waste-derived amendments can enhance nutrient translocation, chlorophyll synthesis, carbohydrate accumulation, and photosynthetic activity, ultimately promoting higher biomass production and crop yield (D'Amato et al., 2020; Huang et al., 2023; Rakoczy-Lelek et al., 2021). Such materials not only recycle nutrients but also contribute to improved soil structure and biological activity, ultimately enhancing plant growth performance (Adekiya et al., 2022; Yuan et al., 2023).

As the concept of sustainable agriculture and the circular economy develops, the use of industrial waste as organic fertilizer is beginning to receive attention as an alternative solution to reduce dependence on chemical fertilizers while minimizing waste (Antonious, 2024). Several studies have shown that organic fertilizers, both in the form of compost, biochar, and industrial organic waste, are able to improve the physical, chemical, and biological properties of the soil and improve the efficiency of plant nutrient absorption (Agbede & Oyewumi, 2022a; Li et al., 2022). However, its effectiveness is greatly influenced by environmental conditions and cultivation techniques, including planting distance.

Plant spacing is another key agronomic factor that regulates plant population density and resource competition. Lower density conditions tend to favor individual plant growth, whereas higher density systems maximize land productivity. Therefore, determining the appropriate spacing is essential to balance plant performance and yield per unit area (Liang et al., 2024). Research shows that a wider planting distance can increase the weight of tubers per plant, while a closer planting distance has the potential to increase yields per unit area through increasing crop populations (Adubasim et al., 2018; Balázs et al., 2024).

In Indonesia, sweet potato cultivation still largely depends on inorganic fertilizers, and the integration of organic waste-based fertilizers remains limited. At the same time, industrial by-products such as milk waste represent an underutilized resource that could potentially serve as an alternative nutrient source.

On the other hand, industrial waste, especially milk waste, is an abundant source of organic matter but has not been optimally utilized in the agricultural system. Several studies in Indonesia have shown that organic fertilizers made from waste can increase plant growth and yield, but the response is often inconsistent because it is influenced by soil conditions, dosage, and interactions with other cultivation factors (Manurung et al., 2018; Ulunggi et al., 2020). Previous studies on organic fertilizers have predominantly focused on compost, livestock manure, fishery waste, and domestic food waste, mainly emphasizing nutrient recovery, soil improvement, and greenhouse gas mitigation rather than direct field responses of sweet potato cultivation (Kolawole et al., 2025; Zhang et al., 2026). In contrast, studies evaluating fertilizers derived from milk industrial waste under field cultivation systems are still very limited. This shows that the use of industrial waste

as organic fertilizer still needs further study to obtain more precise agronomic recommendations.

Although various studies have examined the effects of planting spacing and fertilization on sweet potato growth and yield, most of these studies were conducted separately or focused on only one factor. Studies on the use of organic fertilizers made from industrial waste are still relatively limited, especially those that examine their interaction with planting distance in an integrated experimental design. In addition, the results of previous studies have shown that plant responses to fertilizers are not always consistent, depending on environmental conditions and cultivation systems (Darko et al., 2020).

Thus, there is still a knowledge gap related to how the combination of the type and dose of industrial waste organic fertilizer and planting spacing regulation affects the growth and production of sweet potatoes, especially in the Beniazuma variety which has specific characteristics. This study fills this gap by evaluating both factors simultaneously in local agroecological conditions. The novelty of this research lies in the integration of milk industrial waste-based organic fertilizer with plant spacing optimization under field conditions, while comparing its performance with other organic fertilizer sources and inorganic fertilizer systems. Unlike previous studies that mainly focused on fertilizer production technologies or laboratory-scale nutrient dynamics, this study directly evaluates the agronomic responses of Beniazuma sweet potato under local agroecological conditions, thereby contributing to the development of sustainable sweet potato cultivation and circular agricultural systems.

Based on this description, this study aims to compare the growth and production of sweet potatoes of the Beniazuma variety due to the use of organic fertilizers made from industrial waste and differences in planting distance. The results of this research are expected to provide a scientific basis for the development of sweet potato cultivation technology that is more efficient, productive, and sustainable, especially through the integration of industrial waste utilization in agricultural systems. This study provides a novel contribution by integrating industrial waste-based fertilizer with plant spacing optimization under local agroecological conditions.

B. METHODS

The study was conducted in Dramaga, Bogor Regency, Indonesia, from June to December 2022. The planting material consisted of F1 generation Beniazuma sweet potato cuttings weighing 10–15 g with an average length of 30 cm. A factorial randomized complete block design (RCBD) was used with two factors: plant spacing and fertilizer treatments. Plant spacing consisted of two levels: 40 × 40 cm and 60 × 60 cm. Fertilizer treatments consisted of six levels: control (P1), NPK fertilizer at 500 kg/ha (P2), milk waste-based organic fertilizer at 2 t/ha (P3), milk waste-based organic fertilizer at 1 t/ha (P4), compost at 2 t/ha (P5), and compost at 1 t/ha (P6). Each treatment combination was replicated three times, resulting in 36 experimental units, each with a plot size of 16 m². Observations included number of tubers, tuber weight, and shoot biomass. Data were

analyzed using analysis of variance (ANOVA), followed by the Least Significant Difference (LSD) test at a 5% significance level using Minitab 22.

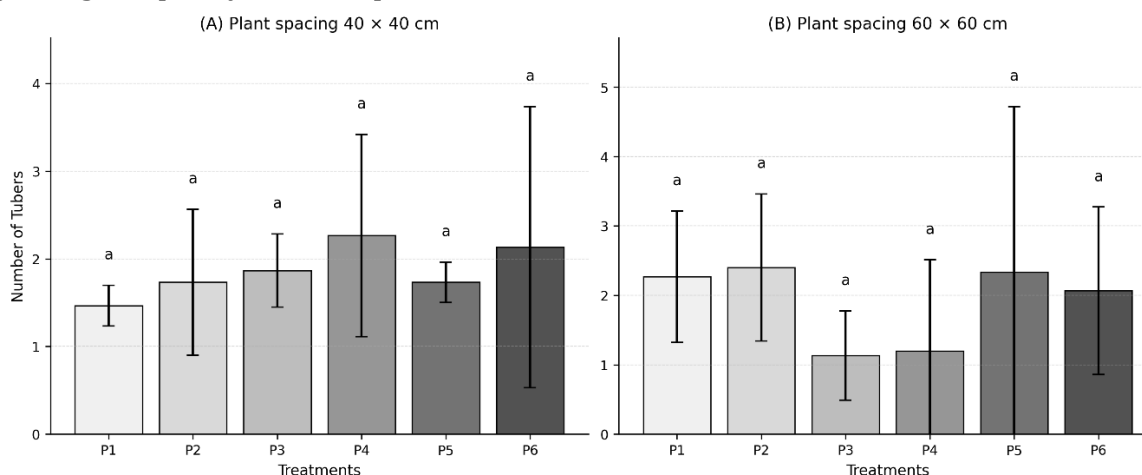
C. RESULT AND DISCUSSION

1. Number of Tubers

The results showed that the number of tubers was influenced by the combination of planting distance and fertilizer treatment (Figure 1). At a planting distance of 40 x 40 cm, the average number of tubers is in the range of 1.5-2.3 tubers per plant, with the highest value in the treatment of organic fertilizer of milk waste at a dose of 1 ton/ha. At a planting distance of 60 x 60 cm, the number of tubers is in the range of 1.1-2.4 tubers per plant, with the highest value in NPK treatment of 500 kg/ha. This pattern shows that wider spacing tends to provide each plant with more growing space, thereby increasing tuber formation per plant (Boonlertnirun et al., 2022; Cooper et al., 2024).

In contrast to previous studies (Cooper et al., 2024), this study shows a more pronounced effect of spacing on tuber weight, which may be attributed to local soil conditions. Adubasim et al., (2018) reported that planting spacing regulation affects leaf count, leaf area index, and sweet potato tuber yield, with different plant populations resulting in a compromise between per-crop performance and acreage yield. Abdissa, (2011) also showed that plant density significantly affects the components of sweet potato yield.

Biologically, the higher number of tubers at wide planting distances can be explained by the increased efficiency of net photosynthesis per plant. When competition decreases, the crown develops more optimally and the resulting assimilation can be better allocated to the organ store. Liang et al., (2024) assert that proper planting density improves the photosynthetic performance and commercial character of sweet potato root storage, while Balázs et al., (2024) show that plant density has a strong effect on the yield and physiological quality of sweet potatoes.



Noted: Different letters in the same column show a real difference based on the 5% BNT test

Figure 1. Effect of fertilizer treatment on the number of tubers at two planting distances

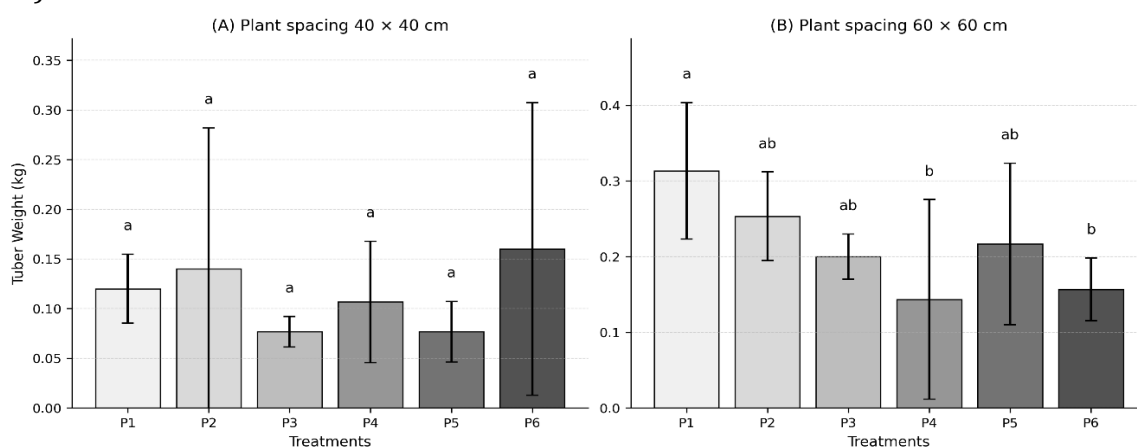
2. Tuber Weight

The weight of tubers per plant in this study showed a higher pattern at a planting distance of 60 x 60 cm compared to 40 x 40 cm (Figure 2). At a tight planting distance, the average weight of the tubers is only about 0.1-0.2 kg, while at a wide planting distance it can reach around 0.3 kg. At a planting distance of 40 x 40 cm, the IPB compost treatment at a dose of 1 ton/ha produced the highest tuber weight, while at 60 x 60 cm the control treatment and NPK showed a relatively high average.

Inferentially, this pattern suggests that in lower plant density populations, each plant has a greater chance of forming higher-weight tubers as resource competition decreases. Adubasim et al., (2018) showed that the weight of tubers per plant tends to decrease as density increases, although acreage yields can increase. Similar patterns have also been reported in modern crop density studies that emphasize the importance of population optimization, rather than simply widening or narrowing planting distances.

In terms of fertilization, the results of this study show that compost-based treatment provides a good response, especially at close distances. This can be explained because organic matter not only provides nutrients, but also improves the physical, chemical, and biological properties of the soil. Li et al., (2022) showed that various organic fertilizers can improve the properties of the rhizosphere soil and support the growth of sweet potatoes on new reclaimed land. (Yuan et al., 2023) also reported that long-term organic fertilization, especially the combination of NPK plus manure or NPK plus plant residues, improved K uptake, yield stability, and productivity of sweet potatoes.

In addition, potassium plays a central role in the formation of tuber weight because it is related to carbohydrate translocation, starch accumulation, and root storage quality (Garfansa et al., 2018; Geng et al., 2024). Adekiya et al., (2022) showed that the combination of biochar and potassium fertilizer improves soil properties, growth, and sweet potato yield. Liu et al., (2023) also showed that proper K fertilization can increase the amount of root storage, yield, and quality of sweet potato appearance. Therefore, the variation in tuber weight in this study is most likely the result of an interaction between growth space and nutrient use efficiency, particularly potassium availability (Geng et al., 2024).



Noted: Different letters in the same column show a real difference based on the 5% BNT test

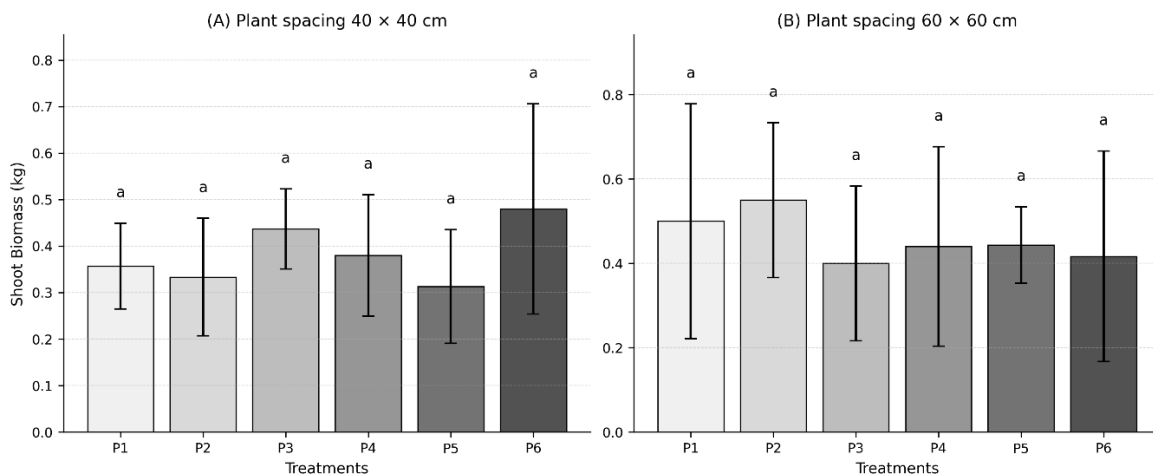
Figure 2. Effect of fertilizer treatment on tuber weight at two planting distances

3. Shoot Biomass

The shoot biomass in the study ranged from 0.3-0.5 kg at a planting distance of 40 x 40 cm and increased to 0.6 kg at a planting distance of 60 x 60 cm, especially in the NPK treatment of 500 kg/ha (Figure 3). This shows that vegetative growth tends to be better at a wider planting distance (Boonlertnirun et al., 2022).

From the physiological side of the plant, the shoot biomass reflects the development of the crown, the photosynthetic surface area, and the accumulation of vegetative biomass. At wide planting distances, plants gain better access to light and less competition between individuals, resulting in more intensive leaf and stem formation. At the same time, NPK fertilization has the potential to accelerate vegetative growth because nitrogen supports chlorophyll formation and leaf development (Gizachew et al., 2024; Sitinjak, 2025). The results of Manurung et al., (2018) showed that NPK Mutiara 16:16:16 had a significant effect on the weight of wet swabs and sweet potato product components, with medium doses producing the best response. This is consistent with findings that balanced fertilization improves plant growth and biomass accumulation in sweet potato cultivation systems (Abeshu, 2023).

However, the increase in vegetative biomass is not always linear with the increase in tuber weight. In some conditions, overly dominant crown growth can shift the allocation of assimilates to vegetative organs, resulting in decreased tuber formation efficiency. Fernandes et al., (2021) show that the excess availability of nutrients, particularly nitrogen, can enlarge crown growth but does not necessarily improve root yield proportionately.



Noted: Different letters in the same column show a real difference based on the 5% BNT test

Figure 3. Effect of fertilizer treatment on the shoot biomass at two planting distances

4. Interaction of Planting Distance and Fertilizer

The results of the variety-analysis showed that the interaction between planting distance and fertilizer treatment had no significant effect on all parameters (Table 1). The non-significant interaction may also indicate that the variability within treatments was relatively high, reducing the statistical sensitivity of the test. The effectiveness of fertilizer does not stand alone but is influenced by plant population conditions (Abeshu, 2023;

Gizachew et al., 2024). At a planting distance of 40 × 40 cm, plants are under higher competition pressure, so fertilizers that improve soil conditions and nutrient availability become more important (Abeshu, 2023). On the other hand, at a planting distance of 60 × 60 cm, the growing space is relatively sufficient so that readily available fertilizers such as NPK can be more efficiently utilized by plants (Gizachew et al., 2024).

Table 1. Two-way ANOVA for the effects of plant spacing, fertilizer treatment, and their interaction on sweet potato growth and yield variables

Source of variation	df	Number of tubers F-value	Number of tubers p-value	Shoot biomass F-value	Shoot biomass p-value	Tuber weight F-value	Tuber weight p-value
Plant spacing	1	0.007	0.932	1.572	0.222	12.005	0.002**
Fertilizer treatment	5	0.243	0.939	0.118	0.987	1.006	0.436
Plant spacing × Fertilizer treatment	5	0.694	0.633	0.555	0.733	1.018	0.429
Error	24	–	–	–	–	–	–

Note: **indicates significant at p<0.01

However, there is a tendency that the response of plants to fertilizer treatment differs at each planting distance. At a planting distance of 60 × 60 cm, some treatments such as P1 and NPK P2 fertilizer showed a higher increase in the number of tubers compared to the planting distance of 40 × 40 cm. In contrast, in certain organic fertilizer treatments, the increase did not occur consistently. Research on combinations of organic and inorganic fertilizers also shows that blending strategies are often more stable than single fertilizers. Agbede & Oyewumi, (2022b) found that the combination of biochar and poultry manure improved the soil properties and yield of sweet potatoes better than a single application. Antonious, (2024) also reported that biochar and organic fertilizers can improve the yield and nutritional composition of sweet potato stored roots.

This phenomenon shows that although the interaction is not statistically significant, there are indications of a biological interaction between the planting distance and the fertilizer. This can be explained through the mechanism of plant competition and the efficiency of nutrient utilization. At a wider planting distance, competition between plants for resources such as light, water, and nutrients is lower, so that plants can respond to fertilizer treatment more optimally. In contrast, at close planting distances, high competition can limit the effectiveness of fertilizers, making the plant's response less noticeable. This phenomenon is supported by a study by Darko et al., (2020) in Ghana, which showed that fertilizer responses in sweet potatoes are strongly influenced by agroecology and varieties, so not all fertilizer treatments give the same results in all locations. Manurung et al., (2018) also showed that the intermediate dose of NPK Mutiara 16:16:16 was more effective than higher or lower doses. This strengthens the suspicion

that in this study data the fertilizer response follows the optimal pattern of dose, not a simple linear relationship.

Agronomically, these results suggest that the main influences of planting spacing and fertilizer on sweet potato growth and yield tend to work independently, although under certain conditions the two can modulate each other's plant responses. Therefore, in cultivation practice, the arrangement of planting and fertilizing distances can be carried out flexibly according to the production objectives, without having to rely on a specific combination between the two factors.

In general, the results of this study confirm that the selection of planting distance and fertilizer must be adjusted to the production goals. If the purpose of cultivation is to obtain larger tubers per plant, then a planting distance of 60 x 60 cm is more advantageous. When converted to hectare basis, the 40 x 40 cm spacing produced higher yield per unit area due to higher plant population. On the other hand, if the cultivation system is directed at intensive production per unit area, then tighter planting distances remain relevant, but require better nutrient management so that competition does not suppress the formation of tubers excessively.

The application of circular economy concepts in this study is evident in the optimization of industrial waste as an alternative nutrient source. This step is not merely an effort to substitute fertilizers, but a manifestation of the "closing the nutrient loop" principle, where industrial by-products are returned to the agricultural ecosystem to support food production. These findings are consistent with previous studies showing that the interaction between plant spacing and fertilization is often influenced by environmental conditions and nutrient dynamics rather than solely by statistical significance (Abeshu, 2023; Cooper et al., 2024). This finding confirms that plant density plays a critical role in optimizing the trade-off between individual plant performance and overall field productivity.

Overall, these results highlight the importance of integrating spatial strategies and circular-based nutrient management strategies to achieve sustainable sweet potato production system. This study contributes to the development of sustainable fertilization strategies by demonstrating the potential of industrial waste as an alternative nutrient source under varying plant density conditions. The utilization of this waste directly reduces the environmental footprint by decreasing reliance on conventional synthetic fertilizers. Although, this study was limited to a single location and growing season, which may affect the generalization of the results. In addition, yield was evaluated primarily at the plant level, without comprehensive analysis at the hectare scale and tuber quality parameters. The results provide a strong foundation for cultivation strategies that are more environmentally friendly and resource-efficient.

D. CONCLUSION AND SUGGESTIONS

Wider plant spacing of 60 x 60 cm was more favorable for Beniazuma sweet potato, as it increased tuber weight per plant, although closer spacing may still be considered when the objective is to maximize yield per unit area. Organic fertilizer derived from milk industry waste showed performance comparable to NPK and compost for key yield

components, indicating that it can partially or fully substitute inorganic fertilizer depending on the target variable. The use of this industrial-waste-based fertilizer supports more sustainable sweet potato production by reducing dependence on chemical inputs and enhancing soil nutrient recycling. In addition, the valorization of milk industry waste into organic fertilizer strengthens circular economy practices at the local level by transforming potential pollutants into value-added agricultural inputs.

Further research is recommended to further study the combination of organic fertilizers made from industrial waste with inorganic fertilizers in various proportions in order to obtain the most efficient and optimal dosage for sweet potato plants. In addition, the evaluation of results should not only be carried out at the plant level, but also at the productivity scale per unit area (tons/ha) so that the resulting recommendations are more applicable to farmers. Further research also needs to be carried out on various soil conditions and growing seasons to determine the consistency of the plant's response to treatment. In addition, aspects of tuber quality such as size, starch content, and market quality need to be analyzed to complement quantitative parameters. Long-term studies related to the influence of organic fertilizers on improving the physical, chemical, and biological properties of the soil are also important to support the development of sustainable agricultural systems.

ACKNOWLEDGEMENT

This study was financially supported by the Vocational School of IPB University through the 2022 research grant program. The authors gratefully acknowledge all contributors involved in fieldwork and data collection. Appreciation is also extended to colleagues for their constructive feedback on the manuscript.

REFERENCES

- Abdissa, T. (2011). Yield and Yield Components of Sweet potato as Influenced by Plant Density: In Adami Tulu Jido Kombolcha District, Central Rift Valley of Ethiopia. *American Journal of Experimental Agriculture*, 1(2), 40–48. <https://doi.org/10.9734/ajea/2011/173>
- Abeshu, B. (2023). Evaluating the Growth and Yield Response of Sweet Potato [*Ipomoea batatas* (L.) Lam] to Combined Application of Nitrogen and Farmyard Manure Fertilizer. *Ethiopian Journal of Crop Science*, 11(2), 50–61.
- Adekiya, A. O., Adebiyi, O. V., Ibaba, A. L., Aremu, C., & Ajibade, R. O. (2022). Effects of wood biochar and potassium fertilizer on soil properties, growth and yield of sweet potato (*Ipomea batata*). *Heliyon*, 8(11), e11728. <https://doi.org/10.1016/j.heliyon.2022.e11728>
- Adubasim, C. V., Law-Ogbomo, K. E., & Obalum, S. E. (2018). Sweet potato (*Ipomoea batatas*) growth and tuber yield as influenced by plant spacing on sandy loam in humid tropical environment. *Agro-Science*, 16(3), 46. <https://doi.org/10.4314/as.v16i3.7>
- Agbede, T. M., & Oyewumi, A. (2022a). Benefits of biochar, poultry manure and biochar–poultry manure for improvement of soil properties and sweet potato productivity in degraded tropical agricultural soils. *Resources, Environment and Sustainability*, 7(February), 100051. <https://doi.org/10.1016/j.resenv.2022.100051>
- Agbede, T. M., & Oyewumi, A. (2022b). Soil properties, sweet potato growth and yield under biochar, poultry manure and their combination in two degraded Alfisols of humid tropics. *Scientia Horticulturae*, 304, 111331. <https://doi.org/10.1016/J.SCIENTA.2022.111331>
- Antonious, G. F. (2024). Impact of biochar and organic fertilizers on sweet potato yield, quality, ascorbic acid, β -carotene, sugars, and phenols contents. *International Journal of*

- Environmental Health Research*, 34(11), 3708–3719.
<https://doi.org/10.1080/09603123.2024.2318368>
- Balázs, V., Helyes, L., Daood, H. G., Pék, Z., Ilahy, R., Neményi, A., Égei, M., & Takács, S. (2024). Cultivation Technology and Plant Density Affecting the Yield and Carotenoid Content of Beauregard Sweet Potato. *Agronomy*, 14(11). <https://doi.org/10.3390/agronomy14112485>
- Boonlertnirun, S., Sirikesorn, L., Kongsorn, A., & Boonlertnirun, K. (2022). Effects of tillage in combination with spacing on yield and proximate composition of sweet potato (*Ipomoea batatas*) grown in an abandoned paddy field. *Tropical Agriculture*, 99(1), 1–10.
- Cooper, E., Meyers, S. L., Jennings, K., Adair, A., Gibson, K. D., & Johnson, W. G. (2024). Effect of in-row spacing on weed suppression and yield of “Covington” and “Monaco” sweetpotato. *Weed Technology*, 38. <https://doi.org/10.1017/wet.2024.63>
- D’Amato, R., Regni, L., Falcinelli, B., Mattioli, S., Benincasa, P., Dal Bosco, A., Pacheco, P., Proietti, P., Troni, E., Santi, C., & Businelli, D. (2020). Current Knowledge on Selenium Biofortification to Improve the Nutraceutical Profile of Food: A Comprehensive Review. *Journal of Agricultural and Food Chemistry*, 68(14), 4075–4097. <https://doi.org/10.1021/acs.jafc.0c00172>
- Darko, C., Yeboah, S., Amoah, A., Opoku, A., & Berchie, J. N. (2020). Productivity of sweet potato (*Ipomoea batatas* (L) Lam) as influenced by fertilizer application in different agro-ecologies in Ghana. *Scientific African*, 10, e00560. <https://doi.org/10.1016/J.SCIAF.2020.E00560>
- Fernandes, A. M., Ribeiro, N. P., Assunção, N. S., Geibel da Silva Nunes, J., Sorroche, C. P., & Leonel, M. (2021). Impact of nitrogen and green manure on yield and quality of sweet potato in sandy soil: A Brazilian case study. *Journal of Agriculture and Food Research*, 4, 100131. <https://doi.org/10.1016/J.JAFR.2021.100131>
- Garfansa, M. P., Sudiarmo, & Suminarti, N. E. (2018). Effect of Potassium Application on Growth and Yield of Sweet Potato. *Rjoas*, 11(83), 346–352.
- Geng, J., Zhao, Q., Li, Z., Yang, X., Lei, S., Zhang, Q., Li, H., Lang, Y., Huo, X., & Liu, Q. (2024). Effects of Various Potassium Fertilizer Dosages on Agronomic and Economic Assessment of Sweet Potato Fields. *Horticulturae*, 10(1). <https://doi.org/10.3390/horticulturae10010044>
- Gizachew, A., Shara, S., & Kifle, A. (2024). Impact of NPSB fertilizer on yield of orange-fleshed sweet potato (*Ipomoea batatas* (L.) Lam.) varieties in Southern Ethiopia’s agro-ecological zones. *Heliyon*, 10(23), e40660. <https://doi.org/10.1016/J.HELİYON.2024.E40660>
- Huang, S., Yu, K., Xiao, Q., Song, B., Yuan, W., Long, X., Cai, D., Xiong, X., & Zheng, W. (2023). Effect of bio-nano-selenium on yield, nutritional quality and selenium content of radish. *Journal of Food Composition and Analysis*, 115(February 2022), 104927. <https://doi.org/10.1016/j.jfca.2022.104927>
- Kolawole, F. O., Kolawole, I. D., Sanni-manuel, B. A., Kolawole, G. O., Bello, S. A., Kolade, O. S., Oni, K., Kolawole, S. K., & Kolawole, V. A. (2025). Organic fertilizers synthesized from domestic food waste: A green sustainable approach – A review. *Bioresource Technology Reports*, 31(May), 102231. <https://doi.org/10.1016/j.biteb.2025.102231>
- Li, X., Lu, Q., Li, D., Wang, D., Ren, X., Yan, J., Ahmed, T., & Li, B. (2022). Effects of Two Kinds of Commercial Organic Fertilizers on Growth and Rhizosphere Soil Properties of Corn on New Reclamation Land. *Plants*, 11(19). <https://doi.org/10.3390/plants11192553>
- Liang, Q., Chen, H., Chen, Y., Kumar, S., Chang, H., Wu, J., Chen, Y., Liu, Y., Wang, Q., & Zhu, G. (2024). Appropriate Planting Density Can Improve the Storage Root Yield and Commercial Features of Sweet Potato (*Ipomoea batatas* L.) by Optimizing the Photosynthetic Performance. *Agronomy*, 14(11). <https://doi.org/10.3390/agronomy14112579>
- Liu, B. K., Xv, B. J., Si, C. C., Shi, W. Q., Ding, G. Z., Tang, L. X., Xv, M., Shi, C. Y., & Liu, H. J. (2023). Effect of potassium fertilization on storage root number, yield, and appearance quality of sweet potato (*Ipomoea batatas* L.). *Frontiers in Plant Science*, 14(February), 1–11. <https://doi.org/10.3389/fpls.2023.1298739>
- Manurung, B., Zahrah, S., & Zulkifli. (2018). Application of Hormax and NPK pearls 16:16:16 to sweet potato plants (*Ipomoea batatas* L.). *Jurnal Dinamika Pertanian*, 34(2), 139–150.
- Rakoczy-Lelek, R., Smoleń, S., Grzanka, M., Ambroziak, K., Pitala, J., Skoczylas, Ł., Liszka-Skoczylas, M., & Kardasz, H. (2021). Effectiveness of Foliar Biofortification of Carrot With Iodine and Selenium in a Field Condition. *Frontiers in Plant Science*, 12(May), 1–16.

- <https://doi.org/10.3389/fpls.2021.656283>
- Sitinjak, W. (2025). Response of Growth and Production of Sweet Potato (*Ipomea Batatas L.*) Due to The Application of TSP Fertilizer and Cow Manure. *Jurnal Penelitian Pendidikan IPA*, 11(6), 383–389. <https://doi.org/10.29303/jppipa.v11i6.11875>
- Ulunggi, O., Musaad, I., Syamsudin, K., Tola, K., & Prabawardhani, S. (2020). *Response of growth and production of sweet potato (Ipomoea batatas L.) to the application of several types of fertilizer on Inceptisol Amban*. 8, 44–51.
- Yuan, J., Wang, J., Ye, J., Dai, A., Zhang, L., Wang, J., Li, J., Zhang, M., Zhang, H., Chen, D., & Zhang, Y. (2023). Long-term organic fertilization enhances potassium uptake and yield of sweet potato by expanding soil aggregates-associated potassium stocks. *Agriculture, Ecosystems & Environment*, 358, 108701. <https://doi.org/10.1016/J.AGEE.2023.108701>
- Zhang, J., Akyol, Ç., Luo, H., De Neve, S., & Meers, E. (2026). Nitrogen dynamics and greenhouse gas emissions from soil amended with biobased fertilizers derived from fishery waste and by-products. *Applied Soil Ecology*, 223(December 2025). <https://doi.org/10.1016/j.apsoil.2026.107060>