Effects of Combined Chemical and Biofertiliser Application on Sweet Potato Growth and Yield

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ABSTRACT

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| Due to its wide application in human food production and industrial uses sweet potato has a high economic value. The proper fertilization of the sweet potato is quite important and includes both inorganic and organic fertilisers. Sweet potato (*Ipomoea batatas* L.) is gaining popularity as a functional food with increasing global demand because of its health benefits, thus there is a need to enhance on its production and quality. The effectiveness of applying biofertilisers in conjunction with chemical fertilisers and the effect of various beneficial bacterial strains on the Lembayung sweet potato variety was established in this study. A factorial experiment was established using five treatments which included two bacterial strains (*Bacillus subtilis* and *Pseudomonas fluorescens*), a commercial biofertiliser and chemical fertiliser. The experiment was conducted in RCBD with four replications. The results of the experiment revealed that the use of biofertilisers in combination with chemical fertilisers significantly increased the tuber yield, growth of the plants and resistance to disease as compared to the other treatments. The treatment that produced the highest tuber yield and growth was the treatment with the use of biofertiliser. The use of biofertilisers greatly reduced the incidence and severity of viral diseases thus revealing their role in disease suppression. This approach not only improves the quality of production, but also promotes sustainable farming, which is in line with the efforts of enhancing soil fertility and increasing production. |

*Keywords: Sweet potato, biofertiliser, growth, yield, fertiliser.*

1. INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) rank as one of important crops in Malaysia, which is widely valued as a staple food as well as an industrial raw material. It is grown extensively all over the world, especially in sandy, well-drained soils like Sabah, Sarawak and parts of Peninsular Malaysia. Sweet potato is the second most important root crop in Malaysia after cassava. Currently, planting sweet potatoes in Malaysia is proving to be a challenge since most agricultural lands are now converted for industrial use. Apart from that, high input cost such as fertiliser, marketing issues, pest and disease outbreak also makes planting this crop difficult. (Tan et al., 2005, Loebenstein, 2009). The crop is favoured for its short growing cycle, resilience to marginal soils, and ability to thrive in tropical climates. In Malaysia, sweet potatoes are consumed fresh, processed into flour, chips, and snacks, or used in traditional delicacies. With increasing consumer awareness of its nutritional benefits, including high fibre, antioxidants, and low glycemic index properties, the demand for sweet potatoes has been steadily rising. In addition, current research and agricultural innovations such as the use of biofertilisers and sustainable agricultural practices are being developed to improve sweet potato yield, quality, and economics in the country. As biologicals, biofertilisers are living microorganisms that solubilise phosphorus, fix nitrogen, and facilitate plant-microbe symbiosis to improve nutritional availability. Biofertilisers are soil amendments that are friendly to the environment, introducing beneficial living microorganisms such as bacteria, fungi, and cyanobacteria, which improve the availability of nutrients for plants and soil. In sweet potato farming, biofertilisers are crucial for sustainable agricultural methods, as they aid in promoting plant growth, increasing tuber yield, and improving soil fertility through processes like nutrient solubilization, nitrogen fixation, and beneficial interactions. Utilizing biofertilisers reduces dependence on synthetic chemical fertilisers and encourages sustainable, eco-friendly farming practices. A key approach to maintaining agricultural productivity is the use of beneficial microorganisms, especially plant growth-promoting rhizobacteria (PGPR). PGPR are a diverse group of soil bacteria that inhabit plant root systems and enhance their growth through various means, including nutrient solubilization, biological nitrogen fixation, phytohormone production, and the inhibition of harmful pathogens. Certain biofertilisers, like *Bacillus subtilis* and *Pseudomonas fluorescens*, are recognised for producing antimicrobial compounds, such as antibiotics, hydrogen cyanide, and siderophores, which prevent the growth of harmful pathogens like *Fusarium*, *Rhizoctonia*, and *Pythium* (Fadhal, 2018). The use of these biofertilisers in sweet potato farming provides a sustainable and eco-friendly alternative to synthetic fertilisers and pesticides, thereby enhancing soil health and boosting crop yields. Numerous studies, including those by Shaista Nosheen et al. (2021), have demonstrated that biofertilisers improve nutrient absorption, crop yield, and quality traits. This study aimed to evaluate the combined effects of biofertiliser and chemical fertiliser application on the yield, growth, and disease resistance of Lembayung sweet potato grown in polybags.

2. material and methods

The research was conducted at MARDI’s experimental plots using a randomised complete block design (RCBD) with five treatments and four replications. The treatments included *Bacillus subtilis* (T1), *Pseudomonas fluorescens* (T2), a combination of both bacteria (T3), a control treatment with only NPK (T4), and N-biobooster (T5), all applied with a standard fertiliser rate of 450 kg/ha NPK. Lembayung sweet potato plants were propagated using shoot cuttings. Lembayung shoot cuttings (30 cm long) were treated with a carbaryl solution to prevent pests prior to being placed in polybags filled with a soil mix of sand, mineral soil, and organic fertiliser in a 6:3:1 ratio. Biofertilisers were applied during the 2nd and 4th weeks after planting, while chemical fertilisers were applied in the 3rd, 5th, and 8th weeks. Consistent irrigation was administered through a sprinkler system to ensure optimal soil moisture levels. The plants were harvested three months after planting. Yield, growth, and disease resistance parameters were evaluated statistically using ANOVA. Tukey’s Honest Significant Difference (HSD) test was employed to determine significant differences among treatments at a 5% probability level.

3. results and discussion

# Growth and yield performance

The results revealed that the use of biofertilisers has a significant impact on the weight of both the vine and the tuber in Lembayung. Treatment T5 (N-biobooster) produced the highest tuber weight (859.8 g), followed closely by T3 (combination of *Bacillus subtilis* and *Pseudomonas fluorescens*) at 737.0 g, and T1 (*Bacillus subtilis*) at 724.8 g. In contrast, the control treatment (T4) showed the least tuber weight, yielding only 510.5 g, which was considerably lower than that of T5 (Fig.1.). This finding suggests that different biofertiliser formulations influence tuber growth, likely due to variations in nutrient availability and microbial activity within the rhizosphere. For vine weight, T2 achieved the highest figure (1361.0 g), whereas T4 recorded the lowest (980.5 g). The reduced vine biomass in T4 may indicate the presence of nutrient shortages or an imbalance in microbial interactions that negatively impacted vegetative growth. A similar pattern has been noted in earlier studies involving sweet potato (*Ipomoea batatas*), where biofertilisers promoted improvements in both vegetative growth and tuber production by enhancing nutrient absorption and soil health (Rai et al., 2021). The increase in tuber weight observed under T5 can be linked to enhanced phosphorus solubilization and nitrogen fixation, both essential for root and tuber development (Patra et al., 2019). Various studies have highlighted the contribution of biofertilisers in boosting yield and biomass accumulation in tuber crops. For example, research on cassava (*Manihot esculenta)* showed that mycorrhizal inoculation, when paired with organic amendments, significantly improved tuber yield by maximizing the bioavailability of soil nutrients (Osundare et al., 2020). Similarly, biofertilisers that include nitrogen-fixing bacteria and phosphorus-solubilizing microorganisms greatly enhanced tuber yield in potato (*Solanum tuberosum*) (Hassan et al., 2022). The differences in response observed among the treatments in this study may be due to variations in microbial compositions, environmental conditions, and soil nutrient dynamics. Altogether, these results highlight the potential of biofertilisers to increase tuber yield in Lembayung while also indicating that their effects on vine growth may differ based on the specific formulations employed. Future studies should explore the long-term effects of biofertilisers on soil fertility and microbial diversity to optimize their use for sustainable agricultural practices.

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Fig.1. The effects of biofertilser on vine and tubers weight of Lembayung. Means in each graph with the different letters indicate significant differences at P≤0.05% level according to Tukey’s HSD.

The findings of this study highlight the potential efficacy of biofertilisers in enhancing sweet potato yield, particularly through the facilitation of superior tuber development. The N-biobooster (T5) demonstrated the most pronounced effectiveness, thereby affirming its suitability for the optimization of yield in sweet potato cultivation. The combination of *Bacillus subtilis* and *Pseudomonas fluorescens* (T3) also produced promising results, indicating a possible synergistic relationship among these beneficial microorganisms. These findings align with previous studies that illuminated the advantageous effects of biofertilisers on root tuber crops. For instance, research conducted by Mohamed et al. (2021) demonstrated that the application of biofertilisers to sweet potatoes improved nutrient solubilization and fixation, consequently enhancing root system development and nutrient uptake. Similarly, Hassan et al. (2005) discovered that the integration of biofertilisers with chemical fertilisers substantially augmented sweet potato yield while concurrently improving soil health and microbial activity. An additional study by Bhardwaj et al. (2014) indicated that *Bacillus subtilis* and *Pseudomonas fluorescens* played essential roles in promoting plant growth, nutrient assimilation, and comprehensive tuber development in both potato and sweet potato varieties. Furthermore, the observed increase in tuber yield associated with biofertiliser application may be attributed to enhanced nutrient availability and microbial interactions within the rhizosphere. Prior investigations by Bhardwaj et al. (2014) indicated that microbial inoculants such as *Bacillus* and *Pseudomonas* species facilitate plant growth by fixing atmospheric nitrogen, solubilizing phosphorus, and synthesizing compounds that promote development.

Table 1. The effects of biofertiliser on growth of Lembayung. Means in each graph with the different letters indicate significant differences at P≤0.05% level according to Tukey’s HSD.

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| --- | --- | --- | --- |
| Treatment | Vine length (cm) | Number of branches | Stem diameter (mm) |
| T1 | 126.1 bc | 5.6 ab | 12.9 a |
| T2 | 137.9 ab | 5.2 bc | 11.4 ab |
| T3 | 143.1 a | 5.2 bc | 11.4 ab |
| T4 | 106.6 d | 4.4 c | 10.0 b |
| T5 | 121.3 c | 6.3 a | 12.0 a |

*Means with different letters indicate significant differences at the P≤0.05 level according to Tukey's HSD test.*

The application of biofertiliser significantly influenced the growth parameters of Lembayung, including vine length, number of branches, and stem diameter. The results (Table 1) show that T3 exhibited the highest vine length (143.1 cm), which was significantly greater than other treatments except for T2 (137.9 cm). This suggests that biofertiliser application in T3 provided optimal nutrient availability, enhancing vegetative growth. Similarly, prior studies on sweet potato (*Ipomoea batatas)* have reported that biofertiliser containing beneficial microorganisms can enhance vine length by improving nutrient uptake efficiency (Ahmed et al., 2021). Regarding the number of branches, T5 recorded the highest value (6.3), which was significantly different from other treatments. This finding aligns with previous research where organic amendments, particularly biofertilisers, have been shown to promote lateral shoot development due to improved soil microbial activity and nutrient cycling (Chen et al., 2020). In contrast, T4 had the lowest number of branches (4.4), indicating that nutrient limitation or possible inhibitory effects of the applied treatment could have restricted plant growth. Stem diameter is an essential parameter reflecting plant vigor and stability. T1 and T5 exhibited the highest stem diameter (12.9 mm and 12.0 mm, respectively), suggesting that these treatments enhanced structural development in Lembayung. Similar findings were reported in other leguminous crops where biofertilisers contributed to increased stem thickness due to improved phosphorus and nitrogen availability (Kumar et al., 2019). Conversely, T4 recorded the lowest stem diameter (10.0 mm), which could be attributed to inadequate nutrient supply or suboptimal microbial activity within the rhizosphere. Overall, the findings demonstrate that biofertiliser application positively influences the growth performance of Lembayung, consistent with previous research on other leguminous and root crops. Further studies focusing on the microbial composition of biofertilisers and their specific interactions with Lembayung roots could provide deeper insights into optimizing their effectiveness.

**Disease incidence and severity**

The study investigated the incidence and severity of virus diseases, scab, and Fusarium stem rot in Lembayung sweet potato under different biofertiliser treatments. Sweet potato is highly susceptible to various pathogens, which can significantly affect its yield and quality. The results showed that biofertiliser treatments significantly reduced the incidence and severity of virus diseases compared to the control. The highest virus incidence and severity (Table 2) were observed in the control treatment (T4), with 68.40% incidence and 22.97% severity. In contrast, all biofertiliser treatments (T1, T2, T3, and T5) exhibited lower virus incidence, ranging from 26.53% to 38.61%, while severity values ranged from 6.58% to 10.69%. Among the treatments, *Bacillus subtilis* (T1) demonstrated the lowest virus incidence (26.53%) and severity (6.58%), suggesting that this bacterium effectively induced systemic resistance against viral infections. The ability of *Bacillus subtilis* to suppress viral diseases may be attributed to its production of antimicrobial compounds and its role in enhancing the plant’s immune response (Kloepper et al., 2004). Scab incidence was consistently high across all treatments, ranging from 60.10% to 64.81%, with no significant differences observed between treatments. Similarly, scab severity values showed no notable variations, remaining between 25.19% and 30.79%. This indicates that the application of biofertilisers had little impact on suppressing scab infection, suggesting that environmental factors such as humidity and soil conditions might play a more dominant role in scab development than microbial interventions (Lankau et al., (2020). The high and uniform scab incidence across treatments implies that additional disease management strategies, such as the use of resistant cultivars and improved field sanitation, may be necessary to control the disease effectively. Fusarium stem rot incidence varied across treatments, with the highest values recorded in T1, T2, and T3, ranging from 28.15% to 34.54%. Surprisingly, the control treatment (T4) had the lowest Fusarium incidence at 19.44%, contradicting the expected trend where biofertilisers should suppress pathogen development. The severity of Fusarium stem rot followed a similar pattern, with the highest values observed in T3 (21.16%), followed by T2 (19.96%) and T5 (18.24%). The control treatment exhibited the lowest severity at 7.41%. These findings suggest that certain biofertiliser applications might have inadvertently increased susceptibility to Fusarium infection, potentially due to microbial competition within the rhizosphere. The introduction of biofertilisers could have altered the soil microbial community, inadvertently reducing populations of native antagonistic fungi that naturally suppress Fusarium growth. In summary, the application of biofertilisers significantly reduced the incidence and severity of virus diseases in Lembayung sweet potato, demonstrating their potential as biocontrol agents. However, their effectiveness against scab was limited, as incidence and severity remained consistently high across treatments. The unexpected increase in Fusarium stem rot incidence in some biofertiliser treatments highlights the complexity of microbial interactions in the soil, emphasizing the need for further research to optimise microbial combinations for effective disease suppression. These findings underscore the importance of targeted microbial applications in sweet potato disease management and suggest that future studies should focus on identifying optimal biofertiliser formulations that enhance plant health while minimizing unintended pathogen proliferation (Huang et al., (2029). Overall, these findings reinforce the potential of biofertilisers as a disease management strategy for viral infections in Lembayung sweet potato but also emphasize the need for careful selection and combination of microbial agents to minimize negative effects.

Table 2. Incidence and severity of virus diseases, scab and fusarium stem rot in Lembayung sweet potato under different treatments.

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| --- | --- | --- |
| **Treatment** | **Incidence (%)** | **Severity (%)** |
| **Virus** | **Scab** | **Fusarium stem rot** | **Virus** | **Scab** | **Fusarium stem rot** |
| T1 | 26.53 b | 60.10 a | 28.15 a | 6.58 b | 25.25 a | 17.45 a |
| T2 | 38.61 b | 62.96 a | 34.54 a | 10.40 b | 27.31 a | 19.96 a |
| T3 | 36.39 b | 62.41 a | 34.26 a | 9.96 b | 30.79 a | 21.16 a |
| T4 | 68.40 a | 64.81 a | 19.44 a | 22.97 a | 25.81 a | 7.41 a |
| T5 | 34.44 b | 64.26 a | 34.07 a | 10.69 b | 25.19 a | 18.24 a |

***Means with different letters indicate significant differences at the P≤0.05 level according to Tukey's HSD test.***

4. Conclusion

This study demonstrated that the use of biofertilisers had a significant impact on the growth, yield, and disease resistance of Lembayung sweet potato. Among the various treatments, N-biobooster (T5) achieved the highest tuber yield, indicating its potential as a highly effective biofertiliser for enhancing sweet potato productivity. The combination of *Bacillus subtilis* and *Pseudomonas fluorescens* (T3) also yielded encouraging results, indicating a synergistic effect that promotes plant growth and productivity. The use of biofertilisers aided in improved nutrient absorption, particularly through phosphorus solubilization and nitrogen fixation, which are essential for tuber development. Furthermore, the application of biofertilisers significantly reduced the occurrence and severity of viral diseases, underscoring their potential role as biocontrol agents in sustainable agriculture. Overall, this research offers valuable insights into the utilization of biofertilisers as a sustainable strategy for enhancing sweet potato cultivation. The findings advocate for the incorporation of biofertilisers into an integrated nutrient management plan to boost yield and soil health while decreasing dependence on chemical inputs. Future investigations should emphasize long-term field trials, examining the interactions between biofertilisers and soil microbial communities to further enhance their effectiveness in sustainable sweet potato production.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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