J. Trop. Agric. and Fd. Sc. 53 (1)(2025): 77 – 81

Effect of plant growth regulator (PGR) concentration on plant growth, yield and quality of sweet potato (*Ipomea Batatas* [L.] Lam.)

Yaseer Suhaimi, M. and Siti Norzahidah, Z. A.

Industrial Crop Research Centre, MARDI Headquarters, 43400 Serdang, Selangor, Malaysia

Abstract

This study examined the impact of varying concentrations of indole-3-acetic acid (IAA), a plant growth regulator, on the growth, yield, and quality of sweet potato (*Ipomoea batatas* [L.] Lam.) under conventional soil planting. Field experiments were conducted at the MARDI Serdang using a randomised complete block design with four treatments (0, 3, 5 and 7 ppm IAA concentration) and five replications across 20 plots. Sweet potato cv. Beni Hanuka was propagated via 30-cm stem cuttings, and the application of IAA was performed as a foliar spray at 21 days after planting. Notably, the 5 ppm concentration (T3) resulted in the highest tuber yield per plot (76.5 kg) and HI (0.53), suggesting improved biomass partitioning toward the storage organs. The 5 ppm treatment enhanced TSS (12.6 °Brix) and produced the highest tuber count (6 tubers per plant) with superior tuber length compared to the other treatments. These results suggest that a moderate IAA concentration optimises both yield and quality by improving root differentiation, photosynthetic efficiency, and assimilate allocation. Overall, the study indicated that a 5 ppm IAA concentration is optimal for sweet potato cultivation, balancing the promotion of storage root development with improved physiological and yield traits.

Keywords: *sweet potato, tuber, booster fertiliser, nutrient, yield*

Introduction

Sweet potato [*Ipomoea batatas* (L.) Lam.] is a vital root crop with significant potential for enhancing food security, especially in regions like Malaysia where current yields remain below optimum levels. Malaysia's average sweet potato yield is about 13 mt/ha, substantially lower than the target of 25 mt/ha. Consequently, the country achieves only an 80% self-sufficiency rate (SSR), necessitating the importation of approximately 20% of its sweet potatoes (Mohd Yusrizal 2021). This yield gap is largely attributed to physiological constraints—specifically, the low conversion rate of pencil roots into storage roots, which ultimately limits the accumulation of marketable tubers (Singh et al. 2020). Studies attribute this challenge to hormonal and environmental factors, where nodal roots often remain as non-productive pencil roots instead of differentiating into starch-accumulating storage organs (Zierer et al. 2021).

Propagation of sweet potato through stem cuttings typically results in the emergence of several adventitious, or nodal, roots. While a portion of these nodal roots can differentiate into storage roots, many remain as pencil roots and fail to contribute effectively to yield (Nakatani et al. 2002). Researchers have identified several key factors to optimise storage root initiation, including soil moisture levels, nitrogen fertiliser amounts, sucrose content, and the use of plant growth regulators (PGRs) (Eguchi and Yoshida 2007). Among these factors, PGRs have shown promise in enhancing the conversion of pencil roots into storage roots. Research by Carluccio et al. (2022) highlights the role of PGR in promoting cambium and metaxylem cell proliferation, a process essential for storage root initiation. Similarly, Eguchi and Yoshida (2008) demonstrated that exogenous application of plant growth regulators (PGRs), combined with sucrose, enhances tuberisation efficiency, underscoring the potential of hormonal modulation to improve root differentiation. Application of PGR is believed to modulate the hormonal balance within the plant, encouraging more nodal roots to differentiate into storage roots (Wang et al. 2015). This adjustment in root development not only increases total yield but also improves tuber quality.

Article history
Received: 16.4.2025
Accepted: 3.7.2025

Authors' full names: Yaseer Suhaimi Mohd and Siti Norzahidah Zainal Abidin
Corresponding author: ysuhaimi@mardi.gov.my

Similar research has demonstrated that exogenous application of PGR can significantly enhance storage root formation and overall yield in sweet potatoes (Sakamoto and Suzuki 2020). Building on these findings, the present study investigates the effects of varying concentrations of IAA on sweet potato growth parameters, yield, and tuber quality under conventional soil planting conditions. The objective is to identify an optimal IAA concentration that maximises the conversion rate of pencil roots to storage roots, thereby contributing to higher productivity and reduced import reliance. Improving sweet potato yield is critical for boosting national food security and reducing dependency on imports. By elucidating the role of IAA in sweet potato physiology, this research aims to pave the way for more effective agronomic practices that close the current yield gap. Findings from the study could address the low conversion rate of pencil roots, thereby bridging the yield gap and enhancing Malaysia's food security by reducing import dependency.

Materials and method

The study was conducted at MARDI Serdang, Selangor, Malaysia (2° 59' 31.7292'' N, 101° 41' 56.706'' E) from January to March 2022. The site featured mineral soil with pre-planting soil analysis revealing a pH of 5.8 ± 0.5, organic matter content of 2.2%, and baseline N-P-K levels of 17, 12, and 35 mg/kg, respectively. The experimental layout followed a Randomised Complete Block Design (RCBD) with four treatments and five replications, totalling 20 plots (5 m × 5 m each) with 90 plants per experimental units. Yield component for growth and tuber quality parameters were measured from six plants selected randomly from each experimental unit. For each experimental unit, 9 m^2 of area was harvested to evaluate tuber yield and harvest index. Raised beds (60 cm height, 100 cm base width) were spaced 1.2 m apart measured from raised bed tips to accommodate vine expansion. Sweet potato cv. Beni Hanuka was propagated using 30 cm stem cuttings (5 – 7 nodes) sourced from healthy 2.5 month old mother plants. Cuttings were pre-treated with a 0.1% Benomyl and 0.2% copper oxychloride solution to mitigate fungal and bacterial infections and planted horizontally at 30 cm spacing. Four concentrations of indole-3-acetic acid (IAA) 0 (control), 3, 5, and 7 ppm were applied as a foliar spray at 21 days after planting (DAP) using a calibrated knapsack sprayer (20 L/min volume). Crop management included chicken dung as basal fertiliser application (5 t/ha) during bed preparation and granular NPK 12:12:17:2 + TE fertiliser applied at 1 t/ha at 1, 2, 5 and 8 weeks after planting. Drip irrigation delivered 2–3 L/m²/day, adjusted for rainfall events. Pest control involved biweekly malathion (84%) sprays and manual weeding. Vegetative growth parameters—main stem diameter, vegetative weight per plot, tuber yield/plot and harvest index were recorded after 90 DAP. At harvest (90 DAP), six plants per plot were randomly sampled to quantify tuber yield (tuber number/plant) and quality parameters: Brix (refractometer), pH and dry moisture. Data were analysed using SAS 9.4 with ANOVA and DMRT test (α = 0.05).

Results and discussion

The ANOVA results revealed that the application of plant growth regulators (PGR) had a highly significant ($p < 0.01$) effect on stem diameter, tuber yield per plot, vegetative weight per plot, and harvest index in sweet potato plants after three months of cultivation (*Table 1*). The treatment mean squares for all parameters were substantially higher than the replication mean squares, indicating strong treatment effects. The highest variability was observed in tuber yield/plot (CV = 20.88%) and harvest index (CV = 32.92%), suggesting that PGR application led to notable differences in these traits. The highly significant treatment effects suggest that PGR application plays a crucial role in enhancing sweet potato growth and yield. The substantial increase in tuber yield/plot and vegetative weight per plot indicates that PGRs likely improved photosynthetic efficiency and nutrient partitioning, leading to better biomass accumulation and tuber development. The higher harvest index further implies that PGRs may have optimised the allocation of assimilates toward tuber production rather than excessive vegetative growth.

The ANOVA results indicated that the application of PGR had a highly significant effect on all the measured sweet potato quality parameters after three months of cultivation (*Table 2*). Specifically, the treatment mean square values for parameters such as total soluble solids (8.18), tuber dry matter content (51.72), and tuber flesh pH (0.29) were markedly higher compared to the replication values, indicating that the differences observed among the treatments were statistically significant at the 0.01 level. Moreover, quality attributes related to tuber yield including tuber yield per plant (604855.44), number of tubers/plant (26.31), and various dimensions of the tubers (upper, middle and lower part diameters with values of 323.66, 87.87, and 354.25, respectively, along with tuber length at 61.68) further support the pronounced positive influence of PGR applications on both yield and physical characteristics. The relatively low coefficients of variation (ranging from 2.16% to 21.23%) across these parameters also underscore the reliability and consistency of the experimental data.

Effect of PGR on plant growth and tuber yield

The application of different concentrations of Indole-3-acetic acid (IAA) significantly influenced plant growth, tuber yield, and harvest index (HI) of sweet potato after three months of cultivation (*Table 3*). Stem diameter was significantly higher in all IAA-treated plants compared to the control (T1), with the highest diameter recorded in T2 (3 ppm, 0.90 cm). Tuber yield per plot showed a significant increase at 5 ppm IAA (T3), producing the highest yield of 76.5 kg/plot, which was significantly higher than T1, T2 and T4. Interestingly, vegetative weight per plot was highest in the control treatment (216 kg) and

Table 1. ANOVA mean square analysis for the effect of PGR on sweet potato growth and yield performance after three months of cultivation

Source of variance	Parameter			
	Stem diameter	Tuber yield/plot	Vegetative weight/plot	Harvest index
Replication	0.01	5.14	13.67	0.00
treatment	0.09**	874.46**	4889.09**	0.28**
grand mean	0.85	57.03	177.57	0.27
C.V (%)	8.14	20.88	15.86	32.92

Mean followed by * indicates significant difference at 0.05; mean followed by ** indicates significant difference at 0.01

Table 2. ANOVA mean square analysis for the effect of PGR on sweet potato quality parameters after three months of cultivation

Parameter	Replication	Treatment	Grand mean	C.V. (%)
Total soluble solid	0.06	8.18**	11.80	4.54
Tuber dry matter content	0.20	51.72**	72.31	2.16
Tuber flesh pH	0.01	0.29**	5.74	2.18
Tuber yield/plant	1576.03	604855.44**	642.91	21.23
Number of tubers/plant	0.25	26.31**	4.72	20.30
Upper part diameter	8.25	323.66**	41.12	8.55
Middle part diameter	4.88	87.87**	43.54	5.70
Lower part diameter	1.12	354.25**	31.87	11.37
Tuber length	0.37	61.68**	13.93	11.18

Mean followed by * indicates significant difference at 0.05; mean followed by ** indicates significant difference at 0.01

lowest in T3 (144 kg), suggesting a trade-off between vegetative growth and tuber development. The harvest index (HI), which indicates the efficiency of biomass partitioning to economic yield, was markedly improved by IAA application. T3 (5 ppm) recorded the highest HI of 0.53, indicating optimal resource allocation toward tuber production at this concentration. Conversely, the lowest HI was observed in the control (0.23), reflecting less efficient conversion of biomass into tubers. These results suggest that moderate concentrations of IAA, particularly at 5 ppm, enhance stem growth and tuber yield while reducing excessive vegetative growth, ultimately improving the harvest index and productivity of sweet potato.

These findings are consistent with previous studies that reported the beneficial effects of auxins like Indole-3-acetic acid on root and tuber development in various crops (Noh et al. 2013). For instance, Asakaviciute and Almantas (2023) found that PGR application significantly enhanced tuber yield and harvest index in potato by promoting root differentiation and assimilate translocation to storage organs. Similarly, Roumeliotis et al. (2022) observed that moderate levels of PGR improved storage root development in potato, emphasizing the critical role of auxin concentration in optimising yield components. The current study aligns with these observations, reinforcing the idea that appropriate exogenous application of IAA can stimulate physiological responses that favour tuber formation over vegetative biomass, thereby improving overall crop efficiency and economic yield.

The application of different concentrations of Indole-3-acetic acid (IAA) significantly influenced plant growth and tuber yield, corroborating findings from studies on auxin-mediated storage root development. Noh et al. (2010) demonstrated that SRD1, a MADS-box gene, enhances auxin-dependent proliferation of cambium and metaxylem cells, which aligns with the observed increase in stem diameter and tuber yield in IAA-treated plants. Similarly, Eguchi and Yoshida (2004) highlighted that optimal root zone aeration and hormonal balance are critical for tuber initiation, supporting the improved harvest index (HI) at 5 ppm IAA, where resource allocation favored tuber over vegetative growth. These results underscore the role of auxin in modulating cell division and assimilate partitioning, key drivers of sweet potato productivity.

Effect of PGR on tuber quality

The results revealed that different concentrations of Indole-3-acetic acid (IAA) significantly affect the quality attributes of sweet potato tubers (*Table 4*). Total soluble solids (TSS) were highest at 5 ppm IAA (T3, 12.6 °Brix), significantly exceeding the values recorded at 0 ppm, 3 ppm, and 7 ppm, which all registered around 11.5 – 11.6 °Brix. Tuber dry matter content was highest in

Table 3. Effects of PGR (Indole-3-acetic acid) on plant growth and tuber yield after three months of cultivation

Treatment	Stem diameter (cm)	Tubers yield/plot (kg)	Vegetative weight (shoot and leaves) per plot (kg)	Harvest index (HI)
T1	0.78^{b}	49.5^{c}	216^{a}	0.23^{d}
T2	0.90^{a}	57.1^{b}	175.5^{b}	0.33^{b}
T3	0.87^{a}	76.5^{a}	144^{c}	0.53^{a}
T4	0.85^{a}	46.8^{c}	180^{b}	0.26^{c}

Mean values in the same column followed by the same letter are not significantly different at $p < 0.05$ Duncan Multiple Range Test (DMRT)

Table 4. Effects of PGR on tuber quality after three months of cultivation

Treatment	Total soluble solid (Brix value)	Tuber dry matter content (%) (1 g)	Tuber flesh pH	Tuber yield/ plant (g)	Number of tubers/plant	Tuber diameter (mm)			Tuber length (cm)
						Upper part	Middle part	Lower part	
T1	11.5^{b}	73.3^{a}	5.6^{a}	550^{b}	4^{b}	35.8^{c}	42^{b}	28.43^{c}	13.3^{b}
T2	11.6^{b}	72.5^{b}	5.8^{a}	634^{b}	4^{b}	44^{a}	45.68^{a}	35.9^{a}	14^{b}
T3	12.6^{a}	72.8^{b}	5.8^{a}	850^{a}	6^{a}	42.31^{b}	42.68^{b}	29^{c}	16^{a}
T4	11.5^{b}	70.1^{c}	5.7^{a}	520^{b}	5^{ab}	42.1^{b}	43.52^{b}	33.56^{b}	13^{b}

Mean values in the same column followed by the same letter are not significantly different at $p < 0.05$ Duncan Multiple Range Test (DMRT)

the control treatment (T1, 73.3%), while the application of IAA reduced this value slightly, with T4 (7 ppm) showing the lowest percentage (70.1%). Tuber flesh pH remained statistically similar across treatments, maintaining an average around 5.6 – 5.8. Additionally, T3 produced the highest number of tubers per plant (6 tubers), and tuber dimensions varied, with T2 showing the largest diameters on the upper and middle parts, whereas T3 had the longest tuber length (16 cm).

These findings suggested that a moderate concentration of IAA (5 ppm) enhanced specific quality parameters, particularly increasing TSS and tuber count, which are crucial for both consumer appeal and market value. The increase in TSS at T3 may indicate improved sweetness and overall flavour, while the higher tuber number demonstrates enhanced tuber initiation, likely linked to improved cellular division and growth dynamics under optimal auxin levels. Although the control treatment exhibited higher dry matter content, the overall balance of quality parameters, including increased tuber length and number at 5 ppm, underscores the potential for IAA application to improve the quality of sweet potato tubers. The shape of the tuber is tapered at the top and bottom with the middle part expanded. All treatments produced similar tuber shapes with T2 or 3 ppm of PGR producing the highest tuber diameter for upper, middle and lower parts. Although 3 ppm of PGR was able to produce the highest tuber diameters, it did not result in the longest tuber length. The longest tuber length was obtained from a plant supplemented with 5 ppm of PGR. Good quality sweet potatoes should be smooth and firm, with uniform shape and size (Cantwell and Suslow 2002).

These outcomes are consistent with previous studies that have reported the beneficial effects of auxin on tuber quality and yield. For instance, Sarah (2023) revealed that applying optimal concentrations of PGR significantly increased the quality of sweet potato and suggesting that fine-tuning hormone levels can enhance both the biochemical and physical properties of tubers alignment with earlier research supports the notion that a 5 ppm concentration of IAA is effective in balancing quality and yield parameters, offering a viable strategy for improving sweet potato production in commercial cultivation. The enhancement of tuber quality parameters, such as total soluble solids (TSS) and tuber dimensions, under IAA treatment parallels findings from studies on nutrient-hormone interactions. Sulaiman et al. (2003) reported that calcium application increased starch and sugar content in tubers, akin to the elevated TSS observed at 5 ppm IAA, suggesting synergistic effects of nutrients and auxins on carbohydrate metabolism. Furthermore, Eguchi and Yoshida (2008) demonstrated that cytokinin and sucrose co-application induces tuber formation and improves quality, resonating with the current study's results where moderate IAA levels optimised tuber length and number. This consistency across studies emphasises the importance of balanced phytohormone levels in achieving desirable tuber morphology and biochemical quality.

Conclusion

In conclusion, the application of Indole-3-acetic acid (IAA) significantly enhanced both the growth and quality of sweet potato plants. The data indicated that a moderate concentration of 5 ppm IAA resulted in an optimal balance, with increased stem diameter, the highest tuber yield per plot, and the best harvest index, suggesting more efficient biomass partitioning toward storage organs. Additionally, improvements in quality parameters such as total soluble solids, tuber dimensions, and tuber count were observed, reinforcing that IAA not only boosts yield but also enhanced tuber quality. The variability analysis of the pooled data further confirms the consistency of these effects, providing a strong basis for recommending an optimal IAA dosage for improving sweet potato production.

References

Asakaviciute, R. & Almantas, R. (2023). Effect of growth regulators on the formation of potato (*Solanum tuberosum* L.) micro-plants in vitro. *Potato J. 50*, 10–16

Cantwell, M. & Suslow, T. (2002). Postharvest handling systems: Fresh-cut fruits and vegetables. *Postharvest Technology of Horticultural Crops Univ*, 445–464

Carluccio, A.V., David, L.C., Claussen, J., Sulley, M., Adeoti, S.R., Abdulsalam, T., Gerth, S., Zeeman, S.C., Gisel, A. & Stavolone, L. (2022). Set up from the beginning: the origin and early development of cassava storage roots. *Plant Cell and Environment 45*, 1779–1795

Eguchi, T. & Yoshida, S. (2004). A cultivation Method to Ensure Tuberous Root Formation in Sweetpotatoes (*Ipomoea batatas* (L.) Lam.). *Environment Control in Biology 42(4)*, 259–266

Eguchi, T. & Yoshida, S. (2007). Effects of Gas Exchange Inhibition and Hypoxia on Tuberous Root Morphogenesis in Sweetpotato (*Ipomoea batatas* (L.) Lam.). *Environment Control in Biology* 45, 103–111

Eguchi, T. & Yoshida, S. (2008). Effects of application of sucrose and cytokinin to roots on the formation of tuberous roots in sweetpotato (*Ipomoea batatas* (L.) Lam.). *Plant Root 2*, 7–13

Nakatani, M., Tanaka, M. & Yoshinaga, M. (2002). Physiological and anatomical characterization of a late-storage root forming mutant of sweetpotato. *J. Am. Soc. Hortic. Sci. 127*, 178–183

Noh, S. A., Lee, H. S., Huh, E. J., Huh, G. H., Paek, K. H., Shin, J. S., & Bae, J. M. (2010). SRD1 is involved in the auxin-mediated initial thickening growth of storage root by enhancing proliferation of metaxylem and cambium cells in sweetpotato (*Ipomoea batatas*). *Journal of experimental botany, 61(5)*, 1337–1349

Noh, S.A., Lee, H.S., Kim, Y.S., Paek, K.H., Shin, J.S. & Bae, J,M. (2013). Down-regulation of the IbEXP1 Gene enhanced storage root development in sweetpotato. Journal of Experimental Botany 64, 129–142.

Mohd Yusrizal, A.B., (2021). Akaun Pembekalan dan Penggunaan Komoditi Pertanian Terpilih, Malaysia 2016–2020. Department of Statistics Malaysia

Roumeliotis, E., Kloosterman, B., Oortwijn, M., Kohlen, W., Bouwmeester, H. J., Bachem, C. W.B. & Visser, R. G. F. (2022). Over-expression of a YUCCALike gene results in altered shoot and stolon branching and reduced potato tuber size. *Potato Research 66*, 67–84

Sarah, R. M. (2023). Deciphering the hormone regulatory mechanisms of storage root initiation in sweet potato: challenges and future prospects, *AoB PLANTS 15(3)*

Singh, V., Zemach, H., Shabtai, S., Aloni, R., Yang, J., Zhang, P., Sergeeva, L., Ligterink, W. & Firon, N. (2020). Proximal and distal parts of Sweetpotato adventitious roots display differences in root architecture, lignin, and starch metabolism and their developmental fates. *Frontiers in Plant Science 11*, 609923

Sakamoto, M. & Suzuki, T. (2020). Effect of Nutrient Solution Concentration on the Growth of Hydroponic Sweetpotato. *Agronomy 10(11)*, 1708

Sulaiman, H., Osamu, S., Tomohide, S., Naoya, Chishaki. & Shunji, I, (2003). Effect of Calcium Application on the Growth of Sweet Potato (*Ipomoea batatas* Lam.) plant. *Pakistan Journal of Biological Sciences 6*, 1519–1531

Wang, Z., Fang, B., Chen, X., Liao, M., Chen, J., Zhang, X., Huang, L., Luo, Z., Yao, Z. & Li, Y. (2015). Temporal patterns of gene expression associated with tuberous root formation and development in sweetpotato (*Ipomoea batatas*). *BMC Plant Biology 15*, 180

Zierer, W., Rüscher, D., Sonnewald, U. & Sonnewald, S. (2021). Tuber and tuberous root development. *Annual Review of Plant Biology 72*, 551–580