International Conference on Latest Trends in Science, Engineering, Management and Humanities (ICLTSEMH -2025)
19th January, 2025, Noida, India.

CERTIFICATE NO : ICLTSEMH /2025/C0125299

Enhancing Potato Growth and Tuber Yield Through Gibberellic Acid (GA_3) Under Aeroponic Conditions

Dhanorkar Shravani Shankarrao
Research Scholar, Department of Bio Technology, Mansarovar Global University, Sehore, M.P., India.

ABSTRACT

This study investigated the effect of gibberellic acid (GA_3) at 0.25 mg/L on the growth and tuber production of potato plants under aeroponic conditions. Tissue-cultured plantlets were acclimatized and grown in a controlled polyhouse using a standard hydroponic nutrient system. Growth parameters were recorded at 7, 15, 30, and 45 days and analysed against controls ($P < 0.05$). No significant differences were observed at 7 days; however, from day 15 onward, GA_3 treatment significantly improved shoot length, stem length, leaf length, and overall plant height. By day 45, increases in leaf thickness and tuber number were observed, with tuber yield compared to the control. These findings demonstrate that GA_3 enhances vegetative growth and tuber production, highlighting its potential application in aeroponic seed potato production systems.

Keywords: *Aeroponics; Gibberellic Acid (GA_3); Plant Growth; Tuber Yield.*

INTRODUCTION

This study examines the effect of gibberellic acid (GA_3) supplementation in hydroponic nutrient solutions on the growth and development of potato plants under aeroponic conditions. It focuses on changes in key morphological traits, including leaf, stem, and root characteristics, as well as the quantitative evaluation of tuber formation. The application of gibberellic acid (GA_3) is known to influence various physiological processes in plants, including stem elongation and tuber initiation (Çalışkan et al., 2021). This inhibitory effect often stems from gibberellin's role in promoting shoot growth over tuber development, thereby reallocating photosynthates towards canopy expansion (Hamdani et al., 2024). Given that potato mini-tubers are often cultivated in aeroponic systems to mitigate challenges like high temperatures and soil-borne diseases (Filho et al., 2022; Lhokitasari et al., 2022), understanding the precise hormonal interactions, particularly with gibberellins, becomes critical for maximizing yield and quality in controlled environments (Saidi & Hajibarat, 2021). In recent time use of phytohormones such as gibberellins, anti-gibberellins, and cytokinins has shown promise in modulating tuberization and overall plant morphology in potato (Bharath & B, 2024). Hence it is necessary to study about its dose and application regime to optimize potato development under aeroponic conditions (Bharath & B, 2024). In the current scenario, the use of phytohormones has not yet proven economically viable in many commercial aeroponic systems, highlighting the need for further research on optimized application strategies and cost-effective production methods.As a success story use of aeroponics along with phyto hormone for potato production in aeroponics has already been demonstrated to substantially improve mini-tuber production, with optimal conditions potentially inducing greater stolon development due to enhanced humidity and darkness at the stem base (García-Segura et al., 2021; Sharma et al., 2020).

METHODOLOGY

Collection and Acclimatisation of Plantlets: Healthy potato plantlets were obtained from a tissue culture facility and acclimatized under polyhouse conditions. The plantlets were hardened for a period of 30 days prior to their transfer to the aeroponic system.

Aeroponic System Setup: An aeroponic system was established to evaluate potato growth and seed tuber production under the influence of gibberellic acid (GA_3). Two separate setups were maintained: one as a control and the other supplemented with GA_3 at a concentration of 0.25 mg/L, applied twice during the experimental period.

Nutrient Solution and Polyhouse Management: A commercial hydroponic nutrient solution (Solution A and Solution B) was used, mixed in a 1:1 ratio. The nutrient composition included nitrate nitrogen (210 ppm), phosphorus (60 ppm), potassium (330 ppm), calcium (170 ppm), magnesium (50 ppm), sulphur (65 ppm), iron (6.0 ppm), manganese (2.0 ppm), boron (0.3 ppm), copper (0.06 ppm), zinc (0.06 ppm), and molybdenum (0.07 ppm). Total dissolved solids (TDS) were maintained between 500–1000 ppm depending on the plant growth stage. Routine monitoring and adjustment of pH, nutrient levels, and general plant management practices were carried out as per standard protocols.

Greenhouse Conditions: The experiment was conducted in a controlled greenhouse environment during the winter season (November to January). The temperature ranged from 15°C to 30°C, and relative humidity was maintained at approximately 75% throughout the study.

Data Collection and Statistical Analysis: The effect of GA_3 (0.25 mg/L) on potato plant growth under aeroponic conditions was assessed and compared with the control. Observations included shoot length, root length, stem length, leaf length, number of leaves, number of shoots, number of stems, plant height, leaf thickness, stem thickness, shoot thickness, stolon length, and number of tubers. Statistical analysis was performed using a t-test to determine significant differences between treatments at a significance level of $P < 0.05$.

RESULTS AND DISCUSSION

Effect of GA_3 on Potato Plant Growth (7th Day Analysis)

In this study, tissue-cultured potato plantlets treated with 0.25 mg/L GA_3 were evaluated alongside untreated controls under aeroponic conditions. Growth parameters including shoot length, root length, stem length, leaf length, number of leaves, number of shoots, number of stems, plant height, leaf thickness, and stem thickness were recorded and statistically analyzed on the 7th day.

The results indicated no significant differences ($P > 0.05$) between GA_3-treated and control plants at this early stage (Table 1). This suggests that the application of GA_3 at the tested concentration did not produce an immediate effect on the initial growth and morphological traits of potato plantlets.

However, these findings align with previous studies reporting that the physiological effects of GA_3 often become evident only after prolonged exposure or at later developmental stages (Kumari, 2023; Partap et al., 2020; Sharma et al., 2023). Earlier research has demonstrated that plant growth regulators, including GA_3 and anti-gibberellins, significantly influence potato growth and tuberization when applied during critical stages such as stolon formation (Bharath & B, 2024). Furthermore, optimization of GA_3 concentration and application timing has been shown to enhance dormancy breaking and sprouting in potato tubers, highlighting the importance of treatment timing and duration in eliciting measurable physiological responses.

These observations indicate that while no immediate effects were detected at 7 days, continued monitoring at later growth stages is essential to fully understand the impact of GA_3 on potato plant development under aeroponic conditions.

Table 1: Comparative Change in The Plant Parameters of *S. Tuberosum* Till 7th Day Upon GA_3 Treatment in Aeroponics

Parameters	Control	Experiment	P value	Significant
Shoot length	12±3.7	11±4.7	0.5965	No
Root length	8.4±3.4	8.5±3.7	0.9545	No
Stem length	1.5±0.94	2.0±1.3	0.1236	No
Leaf length	1.7±0.96	2.1±0.85	0.0732	No
No of leaves	23±11	31±12	0.1005	No
No of shoots	1.3±4.5	1.3±4.9	0.6701	No
No of stems	7.3±2.7	9.8±5.3	0.1622	No
Plant height	21±5.5	20±6.6	0.7591	No
Leaf thickness	0.38±0.23	0.51±0.25	0.0191	No
Stem thickness	1.2±0.63	1.3±0.55	0.5313	No
Shoot thickness	3.6±0.61	3.9±1.1	0.4318	No

15th Day Analysis

Under aeroponic conditions, the application of GA_3 as a growth regulator demonstrated a positive effect on potato plant growth by the 15th day. Comparative analysis between control and treated plants revealed significant increases in several aerial growth parameters, including shoot length (17 ± 3.7 cm vs 24 ± 8.8 cm; $P < 0.0241$), stem length (2.2 ± 0.82 cm vs 4.0 ± 1.4 cm; $P < 0.0001$), leaf length (2.7 ± 0.86 cm vs 4.4 ± 1.3 cm; $P < 0.0001$), and overall plant height (28 ± 5.4 cm vs 37 ± 9.5 cm; $P < 0.0092$).

In contrast, no significant differences ($P > 0.05$) were observed in root length, number of leaves, number of shoots, number of stems, leaf thickness, or stem thickness (Table 2). These findings indicate that GA_3 exerts a more pronounced effect on aerial growth components at this stage, while subterranean and structural parameters remain relatively unaffected.

This differential response suggests varying sensitivity of plant morphological traits to GA_3 during early growth stages. Similar observations have been reported in previous studies, where exogenous application of gibberellins showed limited or delayed effects due to complex endogenous hormonal regulation. Additionally, other research has demonstrated that GA_3 can significantly enhance growth characteristics such as sprout length and diameter, particularly when combined with factors like immersion duration and interaction with other growth regulators such as 6-benzylaminopurine (Lizarazo-Peña et al., 2020).

Overall, the results indicate that GA_3 begins to influence vegetative growth from the 15th day onward, primarily affecting elongation-related parameters in potato plants under aeroponic conditions.

Table 2: Comparative Change in The Plant Parameters of *S. Tuberosum* Till 15th Day Upon GA_3 Treatment in Aeroponics

Parameters	Control	Experiment	P value	Significant
Shoot length	17±3.7	24±8.8	0.0241	Yes
Root length	11±3.7	13±2.3	0.0825	No
Stem length	2.2±0.82	4.0±1.4	<0.0001	Yes
Leaf length	2.7±0.86	4.4±1.3	<0.0001	Yes
No of leaves	28±11	44±20	0.0301	No
No of shoots	1.3±0.45	1.4±0.51	0.4086	No
No of stems	12±3.8	11±3.7	0.3901	No
Plant height	28±5.4	37±9.5	0.0092	Yes
Leaf thickness	0.39±0.20	0.31±0.16	0.780	No
Stem thickness	0.99±0.53	0.82±0.33	0.0681	No
Shoot thickness	4.1±0.78	3.3±0.64	0.0109	Yes

30th Day Analysis

By the 30th day, the positive effects of GA_3 treatment on potato plant growth became more pronounced, with trends observed at the 15th day continuing and expanding to additional parameters. Notably, the number of leaves showed a significant increase in GA_3-treated plants compared to the control.

Statistical analysis revealed significant differences ($P < 0.05$) between control and treated plants for several growth parameters, including shoot length (25 ± 4.5 cm vs 32 ± 10 cm; $P < 0.0386$), stem length (2.8 ± 0.87 cm vs 3.8 ± 1.1 cm; $P < 0.0001$), leaf length (2.9 ± 0.80 cm vs 4.2 ± 1.2 cm; $P < 0.0001$), number of leaves (38 ± 14 vs 58 ± 22; $P < 0.0124$), and plant height (39 ± 4.8 cm vs 47 ± 11 cm; $P < 0.0328$).

International Conference on Latest Trends in Science, Engineering, Management and Humanities (ICLTSEMH -2025)
19th January, 2025, Noida, India.

However, no significant differences ($P > 0.05$) were observed in root length, number of shoots, number of stems, leaf thickness, stem thickness, or shoot thickness (Table 3).

These results indicate that GA_3 continues to predominantly influence elongation and expansion of aerial plant parts, while root development and secondary growth parameters remain relatively unaffected. This pattern suggests that different physiological processes may require distinct hormonal regulation or longer exposure periods for measurable changes.

The observed selective response aligns with previous studies reporting that gibberellic acid enhances stem elongation and internode growth without necessarily affecting stem thickness or root development (Li et al., 2022; Sardoei et al., 2024). Overall, the findings highlight the stage-specific and targeted role of GA_3 in modulating plant growth under aeroponic conditions.

Table 3: Comparative Change in The Plant Parameters of *S. Tuberosum* Till 30th Day Upon GA_3 Treatment in Aeroponics

Parameters	Control	Experiment	P Value	Significant
Shoot Length	25±4.5	32±10	0.0386	Yes
Root Length	14±3.4	15±2.1	0.4303	No
Stem Length	2.8±0.87	3.8±1.1	<0.0001	Yes
Leaf Length	2.9±0.80	4.2±1.2	<0.0001	Yes
No Of Leaves	38±14	58±22	0.0124	Yes
No Of Shoots	1.3±0.45	1.3±0.49	0.6701	No
No Of Stems	17±3.2	14±6.5	0.2437	No
Plant Height	39±4.8	47±11	0.0328	Yes
Leaf Thickness	0.46±0.23	0.55±0.18	0.0601	No
Stem Thickness	1.2±0.53	1.2±0.59	0.6004	No
Shoot Thickness	4.3±0.77	4.2±1.3	0.7460	No

45th Day Analysis (Comprehensive Evaluation)

By the 45th day, the effect of GA_3 was most pronounced, demonstrating a consistent and significant enhancement in overall plant growth and productivity under aeroponic conditions. The positive trends observed at earlier stages persisted, with additional improvements recorded in leaf thickness and, notably, in tuber production.

Statistical analysis revealed significant increases ($P < 0.05$) in GA_3-treated plants compared to the control for multiple parameters, including shoot length (25 ± 4.4 cm vs 33 ± 9.8 cm; $P < 0.0248$), stem length (3.0 ± 0.85 cm vs 3.9 ± 1.1 cm; $P < 0.0001$), leaf length (3.1 ± 0.77 cm vs 4.4 ± 1.1 cm; $P < 0.0001$), number of leaves (39 ± 13 vs 61 ± 22; $P < 0.0061$), leaf thickness (0.50 ± 0.15 cm vs 0.60 ± 0.16 cm; $P < 0.0065$), and number of tubers (4.0 ± 1.4 vs 9.3 ± 4.5; $P < 0.0168$) (Table 4; Fig. 5).

The substantial increase in tuber number highlights the effectiveness of GA_3 in enhancing yield under aeroponic systems. These findings support earlier studies indicating that gibberellic acid plays a critical role in regulating potato tuberization, particularly through its influence on node formation and subsequent tuber development (Bharath & B, 2024). Additionally, GA_3 has been reported to improve plant height and canopy spread in tuber crops, reflecting its broader role in promoting vegetative growth (Chaudhary & Bahadur, 2024).

The results of the present study are consistent with reports demonstrating the dose-dependent effects of GA_3 on potato growth and yield parameters (Paikra et al., 2020). However, previous research also cautions that excessive concentrations of GA_3 may negatively affect tuber quality, leading to reduced marketable yield and morphological abnormalities such as elongated tubers (Çalışkan et al., 2021). This emphasizes the importance of optimizing both concentration and application timing for achieving desirable outcomes in controlled cultivation systems.

The observed enhancements in plant height, leaf development, and tuber production can be attributed to the role of GA_3 in promoting cell division and elongation, thereby facilitating internode extension and overall shoot growth. Furthermore, GA_3 is known to regulate tuber initiation through complex interactions with environmental factors such as light and endogenous hormonal balance (Sumarni et al., 2022). Its involvement in dormancy breaking and metabolic activation—through increased enzyme activity, nucleic acid synthesis, and mobilization of stored reserves—further contributes to improved plant vigor and productivity.

Overall, the findings demonstrate that GA_3 application at 0.25 mg/L significantly enhances both vegetative growth and tuber yield in potato under aeroponic conditions, underscoring its potential for optimizing seed potato production systems when applied with precise regulation.

CONCLUSION

The application of gibberellic acid (GA_3) at 0.25 mg/L significantly enhanced the growth and productivity of potato plants under aeroponic conditions. Although no measurable effects were observed at the early stage (7 days), notable improvements in vegetative growth parameters—including shoot length, stem length, leaf length, and plant height—were evident from the 15th day onward. By the 45th day, GA_3 treatment further resulted in increased leaf thickness and a substantial rise in tuber production.

Overall, these findings demonstrate that GA_3 is effective in promoting both vegetative development and yield, highlighting its potential application in optimizing aeroponic seed potato production systems.

REFERENCES

1. Bharath, S. R., & B, M. R. (2024). Effect of Varied Levels of Gibberellin, Anti-Gibberellin and Cytokinin on Growth and Tuberization in Potato. *Madras Agricultural Journal, 111*. https://doi.org/10.29321/maj.10.000ma9.
2. Çalışkan, S., Hashemi, M., AKKAMIŞ, M., Aytekin, R. İ., & Bedir, M. (2021). Effect of gibberellic acid on growth, tuber yield and quality in potatoes (Solanum tuberosum L.). *Turkish Journal of Field Crops, 26*(2), 136. https://doi.org/10.17557/tjfc.1033429.

3. Chaudhary, H., & Bahadur, V. (2024). Effect of different plant growth regulators on growth, flowering and quality of tuberose (Polianthes tuberosa L.) cv. GKTC-4 under Prayagraj agro-climatic conditions. *International Journal of Advanced Biochemistry Research*, *8*(6), 278. https://doi.org/10.33545/26174693.2024.v8.i6d.1319.
4. Filho, J. B. da S., Fontes, P. C. R., Ferreira, J., Cecon, P. R., & Crutchfield, E. (2022). Optimal Nutrient Solution and Dose for the Yield of Nuclear Seed Potatoes under Aeroponics. *Agronomy*, *12*(11), 2820. https://doi.org/10.3390/agronomy12112820.
5. García-Segura, D. R., Valdéz-Aguilar, L. A., Ramírez, H., Zermeño-González, A., & Cadena-Zapata, M. (2021). Producción de mini tubérculos de papa en aeroponía en comparación con suelo y polvo de coco. *Terra Latinoamericana*, *39*. https://doi.org/10.28940/terra.v39i0.902.
6. Kumari, M. (2023). Gibberellic acid (ga3) alone and in combination with indole 3 butyric acid (iba) modulation during in vitro propagation of potato (solanum tuberosum l.) MICROPLANTS. *PLANT ARCHIVES*, *23*, 122. https://doi.org/10.51470/plantarchives.2023.v23.no1.021.
7. Lhokitasari, R. F., Hayati, M., & Rahmawati, M. (2022). Growth and production of potato mini tubers (Solanum tuberosum L.) in the aeroponic system by root zone treatment and concentration of leaf-fertilizer. *IOP Conference Series Earth and Environmental Science*, *951*(1), 12037. https://doi.org/10.1088/1755-1315/951/1/012037.
8. Li, L., Wang, J., Chen, J., Zh, W., Qaseem, M. F., Li, H., & Wu, A. (2022). Physiological and Transcriptomic Responses of Growth in Neolamarckia cadamba Stimulated by Exogenous Gibberellins. *International Journal of Molecular Sciences*, *23*(19), 11842. https://doi.org/10.3390/ijms231911842.
9. Lizarazo-Peña, P., Fornaguera-Espinoza, F., López, C. E. Ñ., Gutierrez, N. A. C., & Fonseca, L. P. M. (2020). Effect of gibberellic acid-3 and 6-benzylaminopurine on dormancy and sprouting of potato (Solanum tuberosum L.) tubers cv. Diacol Capiro. *Agronomía Colombiana*, *38*(2), 178. https://doi.org/10.15446/agron.colomb.v38n2.82231.
10. Paikra, S., Kumar, V., & Sharma, P. K. (2020). Studies on the effect of plant growth regulators and their application methods on growth, yield and quality attributes of potato (Solanum tuberosum L.) variety Kufri Pukhraj under agro-climatic conditions of Chhattisgarh plains. *International Journal of Chemical Studies*, *8*(2), 2714. https://doi.org/10.22271/chemi.2020.v8.i2ap.9160.
11. Partap, M., Kumar, P., Kumar, A., Joshi, R., Kumar, D., & Warghat, A. R. (2020). Effect of Elicitors on Morpho-Physiological Performance and Metabolites Enrichment in Valeriana jatamansi Cultivated Under Aeroponic Conditions. *Frontiers in Plant Science*, *11*. https://doi.org/10.3389/fpls.2020.01263.
12. Saidi, A., & Hajibarat, Z. (2021). Phytohormones: plant switchers in developmental and growth stages in potato [Review of *Phytohormones: plant switchers in developmental and growth stages in potato*]. *Journal of Genetic Engineering and Biotechnology*, *19*(1), 89. Elsevier BV. https://doi.org/10.1186/s43141-021-00192-5.

13. Sardoei, A. S., Tahmasebi, M., Bovand, F., & Ghorbanpour, M. (2024). Exogenously applied gibberellic acid and benzylamine modulate growth and chemical constituents of dwarf schefflera: a stepwise regression analysis. *Scientific Reports*, *14*(1). https://doi.org/10.1038/s41598-024-57985-0.
14. Sharma, A. K., Buckseth, T., & Singh, R. K. (2023). Effect of planting periods on production potential of potato (Solanum tuberosum) varieties under aeroponics. *The Indian Journal of Agricultural Sciences*, *93*(3). https://doi.org/10.56093/ijas.v93i3.122747.
15. Sumarni, E., Soesanto, L., Purnomo, W. H., & Priswanto, P. (2022). The Effect of Light Distance on Aeroponic Potato Seed Production in The Tropical High Land. *Jurnal Teknik Pertanian Lampung (Journal of Agricultural Engineering)*, *11*(1), 99. https://doi.org/10.23960/jtep-l.v11i1.99-109.