Journal of Engineering Science and Technology
Vol. 21, No. 2 (2026) 512- 523
© School of Engineering, Taylor's University

INTEGRATING SOCIAL MEDIA KNOWLEDGE MINING, HPLC PHYTOHORMONE PROFILING, AND GERMINATION BIOASSAYS TO IDENTIFY PLANT-BASED BIOSTIMULANTS

SARI KUSUMA DEWI, YUNI SRI RAHAYU, PUTUT RAKHMAD PURNAMA, YULIANI, MAHANANI TRI ASRI, ALI IMRON

Universitas Negeri Surabaya, Surabaya, Indonesia
*Corresponding Author: yunirahayu@unesa.ac.id

Abstract

The identification of plant-based biostimulants requires integrative approaches that link community-derived knowledge with experimental validation. This study integrates social media knowledge mining, high-performance liquid chromatography (HPLC) phytohormone profiling, and germination bioassays to identify plant-derived biostimulants. Indonesian local plants were screened from TikTok, Instagram, and YouTube based on growth-related claims, then processed into aqueous filtrates. Endogenous indole-3-acetic acid (IAA), gibberellic acid (GA_3), and trans-zeatin were quantified using HPLC, and biological efficacy was evaluated through mung bean (Vigna radiata) germination assays at different filtrate concentrations. The results revealed pronounced interspecific variation in phytohormone profiles and significant improvements in germination percentage, uniformity, seedling growth rate, and vigor index for several filtrates, particularly at 50-75% concentrations. Multivariate analyses demonstrated clear associations between hormonal composition and germination performance. This integrated framework provides a robust and scalable approach for identifying plant-based biostimulants by bridging digital knowledge mining with analytical and biological validation.

Keywords: Biostimulants, Germination bioassay, Phytohormones, Social media Sustainable agriculture.

1. Introduction

Modern agriculture increasingly relies on plant growth regulators to enhance germination, seedling vigor, and early crop establishment. Many reports regarding agriculture have been well-developed [1, 2] since agriculture relates to food sustainability [3]. Although synthetic regulators are effective, their prolonged use raises concerns related to environmental persistence, soil health degradation, and ecological imbalance [4]. Consequently, plant-based biostimulants derived from natural phytohormones have gained attention as environmentally compatible alternatives that support sustainable crop production [5, 6].

Plants naturally synthesize phytohormones such as auxins, cytokinins, and gibberellins, which regulate fundamental physiological processes, including cell division, elongation, and seed germination [7]. Previous studies have shown that extracts from various plant tissues, including shoots, roots, and agricultural residues, contain endogenous phytohormones capable of improving germination and early growth performance. Indonesia, as one of the world's biodiversity hotspots, possesses a vast range of local plant species with potential biostimulant properties; however, systematic, comparative, and quantitative evaluations of these resources remain limited.

Alongside formal scientific investigations, extensive empirical knowledge on plant-based growth stimulants is disseminated through social media platforms such as TikTok, Instagram, and YouTube. These platforms function as large, informal repositories of community-derived observations regarding plant usage and perceived growth-promoting effects. Despite their richness, such digital knowledge is rarely subjected to rigorous analytical validation and often lacks quantitative biochemical and physiological evidence [8, 9]. This disconnect highlights a critical gap between community knowledge dissemination and experimentally verified plant biostimulant discovery.

To address this gap, the present study integrates social media knowledge mining with high-performance liquid chromatography (HPLC)-based phytohormone profiling and controlled germination bioassays. Selected Indonesian local plants identified through digital screening were analysed for endogenous indole-3-acetic acid (IAA), gibberellic acid (GA_3), and trans-zeatin contents and evaluated for their effects on mung bean (Vigna radiata) germination and early seedling performance.

The novelty of this study lies in the development of an integrative and data-driven framework that systematically bridges social media-derived community knowledge with analytical chemistry and biological validation. Unlike previous studies that examine plant extracts or phytohormones in isolation, this work quantitatively links digital knowledge claims, phytohormone composition, and germination responses within a unified experimental workflow. This approach provides a scalable methodology for identifying and validating plant-based biostimulants grounded in both community insight and measurable biochemical and physiological evidence.

2. Methodology

Figure 1 summarizes the integrated workflow applied in this study, beginning with social media-based screening to select Indonesian local plants with potential phytohormone activity. Selected plant filtrates were evaluated using HPLC-based phytohormone quantification and mung bean (Vigna radiata) germination bioassays at different concentrations. The resulting data were integrated using ANOVA, heatmap visualization, and principal component analysis (PCA) to identify and classify potential plant-based germination biostimulants.

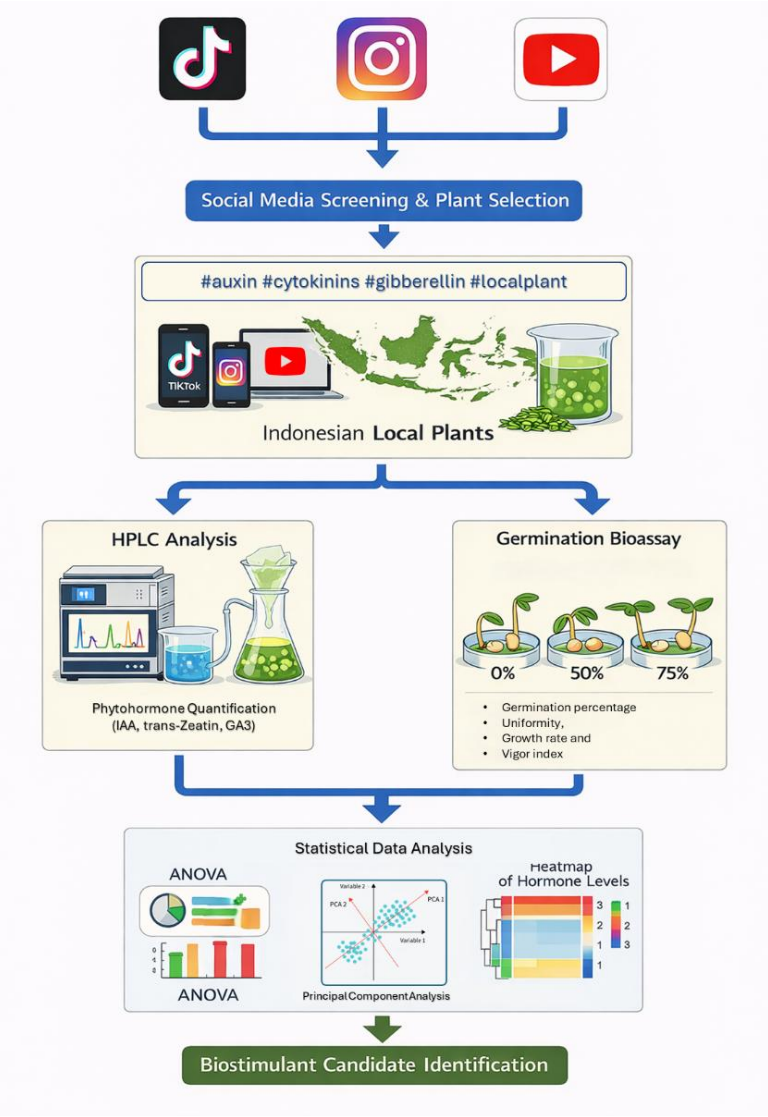

Fig. 1. Systematic workflow for screening, quantifying, and validating plant-derived germination biostimulants.

2.1. Social media knowledge mining and plant selection

Potential plant-based biostimulants were identified through systematic screening of public content on TikTok, Instagram, and YouTube. Searches used predefined keywords related to plant growth regulators (e.g., auxin, cytokinin, gibberellin, plant extract, usage, waste) in English and Bahasa Indonesia. Content published within the last five years was analysed to identify frequently mentioned Indonesian local plants associated with growth-promoting effects.

2.2. Preparation of plant filtrates and germination bioassay

Selected plant materials were processed following the filtrate preparation method. Fresh materials were cleaned, air-dried, homogenized, and extracted with distilled water to obtain crude filtrates (100 g/L), which were diluted to 0%, 50%, and 75% (v/v). Expired commercial mung bean (Vigna radiata) seeds were soaked in the filtrates for 6 h and incubated under controlled conditions. Germination percentage, uniformity, seedling growth rate, and vigor index were recorded. Each treatment was conducted in triplicate.

2.3. Phytohormone quantification by HPLC

Endogenous indole-3-acetic acid (IAA), gibberellic acid (GA_3), and trans-zeatin contents in the plant filtrates were quantified using HPLC. Analyses were performed using a Shimadzu HPLC system equipped with a C18 column (150 × 4.6 mm, 5 µm). Hormone identification was based on retention times of authentic standards, and quantification was conducted using external calibration curves with high linearity ($R^2 > 0.93$).

2.4. Statistical analysis

All germination data were analysed using R software (version 4.5.2). Two-way ANOVA was applied to evaluate the effects of plant species and filtrate concentration, followed by Tukey's HSD test ($p < 0.05$). Multivariate analyses, including heatmap visualization and principal component analysis (PCA), were performed to classify plant filtrates based on phytohormone profiles.

3. Results and Discussion

3.1. Social media screening outcomes

The social media screening results, as shown in Table 1, highlight the broad awareness and popularity of certain Indonesian local plants in relation to their phytohormone-related activities on digital platforms, including Instagram, YouTube, and TikTok. This diversity and frequency of mention strongly suggest that community knowledge and interest in natural bio-stimulants derived from local plants are well established, particularly for species such as bean sprouts, bananas, bamboo shoots, and coconut water.

Bean sprouts have emerged as a particularly prominent species, widely recognized across all platforms for their association with multiple key phytohormones, including auxin, cytokinin, and gibberellin. The association of bean sprouts with multiple key phytohormones, such as auxin, cytokinin, and gibberellin, is consistent with the roles that these hormones play in plant growth and development. Auxin and cytokinin are known to interact closely to regulate growth processes, with auxin promoting cell elongation and cytokinin contributing to cell division and differentiation [10]. Gibberellins also play significant roles alongside auxins and cytokinins, particularly in stimulating stem elongation and sprouting [11]. These interactions underline the multi-hormonal regulation that likely occurs in species such as bean sprouts, which have been widely recognized on various platforms for their bio-stimulant potential involving these hormones

Table 1. Social media-derived identification of Indonesian local plants associated with phytohormone activity.

	Plant Hormone				**Social media**		
Specimen	**Auxin**	**Cytokinin**	**Gibberellin**	***Unspecific**		**YouTube**	**Tik-Tok**
Aloe vera	v			v	v	v	v
Apple Shoot				v			v
Bambo Shoot		v	v	v	v		
Banana	v		v	v		v	
Banana Corms		v		v	v	v	
Bean Sprout	v	v	v	v		v	v
Broccoli				v	v		v
Coconut Water		v	v			v	v
Corn Kernel		v		v			v
***Moringa oleifera* leaf**			v	v			v
Potato Tubber				v		v	v
Pumpkin				v			v
Rhizophora mucronata				v	v		
Shallot	v		v	v		v	v
Strawberry				v			v
Tomato				v		v	
Water Hyacinth			v	v			v

*Unspecifically mentioned which hormones

.Similarly, repeated references to bananas, bamboo shoots, and coconut water across multiple platforms, along with their associations with various phytohormones, highlight their multifunctional roles in promoting growth. For instance, coconut water has been documented in the scientific literature to contain natural cytokinins and growth regulators, supporting its traditional and contemporary use as a growth enhancer. The popularity of such plants on social media may facilitate the dissemination of sustainable plant-based growth promotion strategies, echoing the broader academic recognition of phytohormones as crucial regulators of plant physiology and important mediators of stress resilience and development [12].

In contrast, species such as broccoli and corn kernels were principally associated with general growth-promoting claims without explicit hormonal attribution. This finding may reflect either less comprehensive public or scientific knowledge available to the general audience on their phytohormonal profiles or a tendency in social media content to simplify or generalize effects for a broader appeal. The absence of specific hormone claims indicates a need for more targeted research and communication to clarify the precise phytohormonal mechanisms by which these plants exert their influence, thereby fostering more scientifically grounded community knowledge. Growing evidence supports the notion of complex crosstalk among multiple hormones in mediating plant growth and stress responses, highlighting that such unspecified claims may mask intricate, underlying biochemical interactions [13].

In conclusion, social media screening underscores the dynamic interface between traditional botanical knowledge, modern scientific insights, and popular communication channels. This convergence could accelerate the utilization of local Indonesian plant species as natural sources of phytohormones to promote sustainable agricultural practices in Indonesia. However, the variability in specificity across platforms necessitates improved dissemination of detailed, evidence-based information to effectively guide community knowledge and practical applications.

3.2. Phytohormone content of plant filtrates

Figure 2 quantitatively compares the concentrations of indole-3-acetic acid (IAA), cytokinin (trans-zeatin), and gibberellic acid (GA_3) in the filtrates derived from selected plant species. As shown in Fig. 2(A), IAA concentrations varied by more than one order of magnitude among species, ranging from values below 1×10^5 ng/mL in several filtrates to levels exceeding 3×10^6 ng/mL in shallots, banana corms, and potato shoots. The variation in IAA by more than an order of magnitude, with pronounced peaks in shallots, banana corms, and potato shoots, aligns with research demonstrating that phytohormone levels within plant tissues can differ significantly depending on the species, tissue type, and developmental stage. For instance, potatoes show tissue-specific cytokinin and auxin profiles, reflecting their specialized roles in growth regulation and stress responses. Similarly, studies investigating localized patterns of IAA distribution in plants, such as Eucommia ulmoides during bark recovery and rice seedlings (Oryza sativa), have shown marked increases in IAA (in the range of 10^5 ng/mL) [14].

Similarly, cytokinin levels exhibited a broad distribution, Fig. 2(B), which is consistent with the finding that cytokinin levels fluctuate in response to nutrient conditions and developmental cues, thereby mediating adaptive growth [15]. Peak trans-zeatin concentrations ($\sim 3 \times 10^6$ ng/mL) in some species underscore the role of this hormone in promoting cell division and differentiation across diverse plant taxa. In comparison, trans-zeatin concentrations have been observed in Arabidopsis seedlings, where metabolic regulation via O-glucosylation sustains cytokinin homeostasis. Free trans-zeatin levels exhibit dynamic fluctuations but consistently reside within the high nanomolar to low micromolar range, indicating the active regulation of cellular division and differentiation processes [16].

GA_3 levels peaked at approximately 4×10^6 ng/mL in shallot and banana corms, Fig. 2(C), further supporting the notion that gibberellins are key regulators of developmental processes, such as seed germination, stem elongation, and flowering [17]. Quantitative studies have indicated that GA_3 actively modulates these processes across diverse species. For example, in soybeans, elevated GA_3 content in stems is associated with increased internode elongation, where GA_3 levels regulate cell wall extensibility and promote tissue expansion, contributing to overall stem growth.

Overall, the quantitative ranking highlighted pronounced differences in endogenous phytohormone abundance among plant filtrates, underscoring the heterogeneity of hormone profiles that may contribute to the differential germination and seedling responses observed in subsequent bioassays.

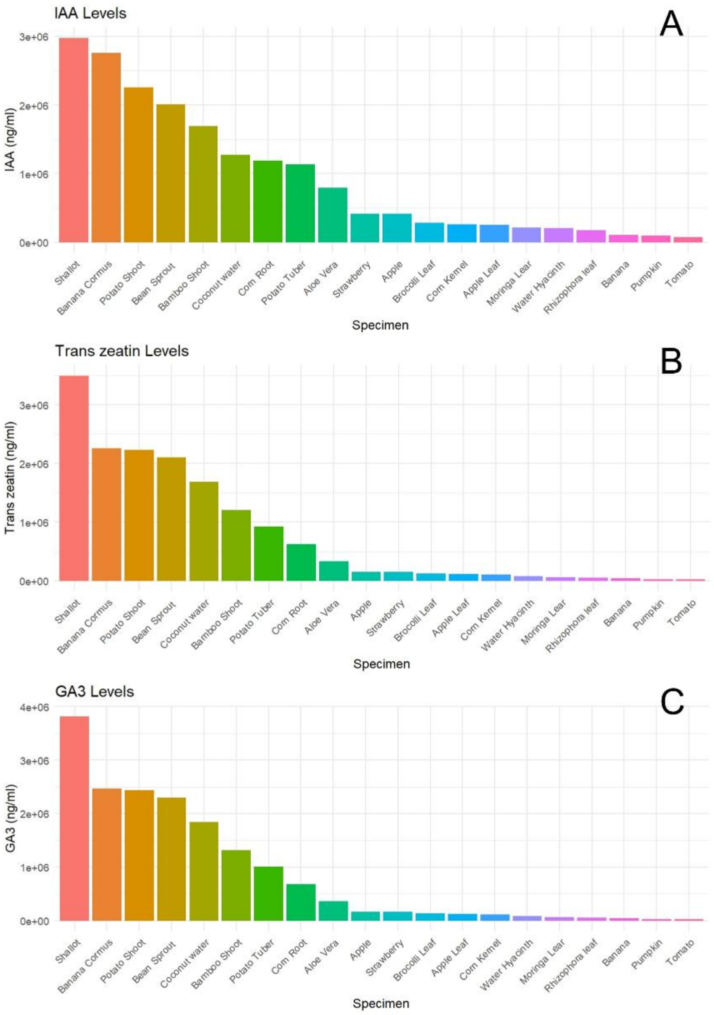

Fig. 2. Comparative profiles of endogenous phytohormone concentrations in selected plant filtrates identified through social media screening, including (A) Auxin/IAA, (B) Cytokinin/trans-zeatin, and (C) Gibberellic acid / GA3.

The clustering of plant filtrates based on their endogenous phytohormone profiles aligned with previous studies using heatmaps, Fig. 3(A) and PCA, Fig. 3(B) to identify distinct groups characterized by variations in auxin (IAA), gibberellin (GA_3), and cytokinin (trans-zeatin) levels, respectively. For example, research analysing phytohormone profiles in tomato revealed that cytokinin signalling components regulate plant height through coordinated changes in GA and IAA levels, highlighting distinct hormone interaction patterns that can be distinguished by multivariate analyses. Another study on flowering Chinese cabbage demonstrated the crosstalk between auxin and gibberellin during stalk elongation, where combined hormone levels drove differential growth and gene expression patterns, with PCA effectively illustrating hormone-driven variation [18].

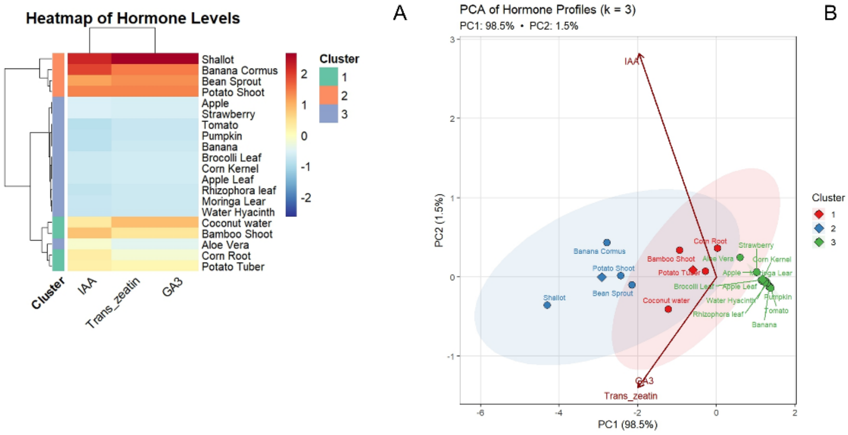

Fig. 3. (A) Heatmap and (B) Principal component analysis of phytohormone profiles in selected plant filtrates.

Furthermore, metabolic and transcriptomic analyses in banana have shown how variations in endogenous GA and IAA contribute to phenotypic differences, reflecting discrete phytohormonal signatures detectable by clustering approaches [19]. These studies collectively support the identification of distinct hormone-enriched clusters, with PCA loadings emphasizing the primacy of IAA and trans-zeatin variation in driving the separation between these clusters.

3.3. Effects of plant filtrates on mung bean germination

Figure 4 shows the quantitative effects of plant filtrate type and concentration on mung bean germination and early seedling growth. As shown in Fig. 4(A), the germination percentage increased markedly with increasing filtrate concentration across most plant species, with values at a 75% concentration generally ranging from approximately 60 to over 85% compared to 15-25% in the control (0%) group. Several filtrates, including banana corms, mung bean sprouts, shallots, and coconut water, achieved the highest germination percentages at 50-75% concentrations. This stimulatory effect aligns well with previous research, indicating that bioactive substances in plant extracts significantly promote germination.

For instance, studies have shown that the application of endogenous growth regulators, such as gibberellic acid, improves germination rates in mung beans and related legumes, often enhancing germination by several-fold compared with that in untreated controls. The highest germination percentages observed for filtrates, such as banana corm and coconut water, echo the findings that these natural extracts contain high levels of cytokinins, auxins, and gibberellins, which are known to act synergistically in promoting seed breaking dormancy and radicle emergence [19].

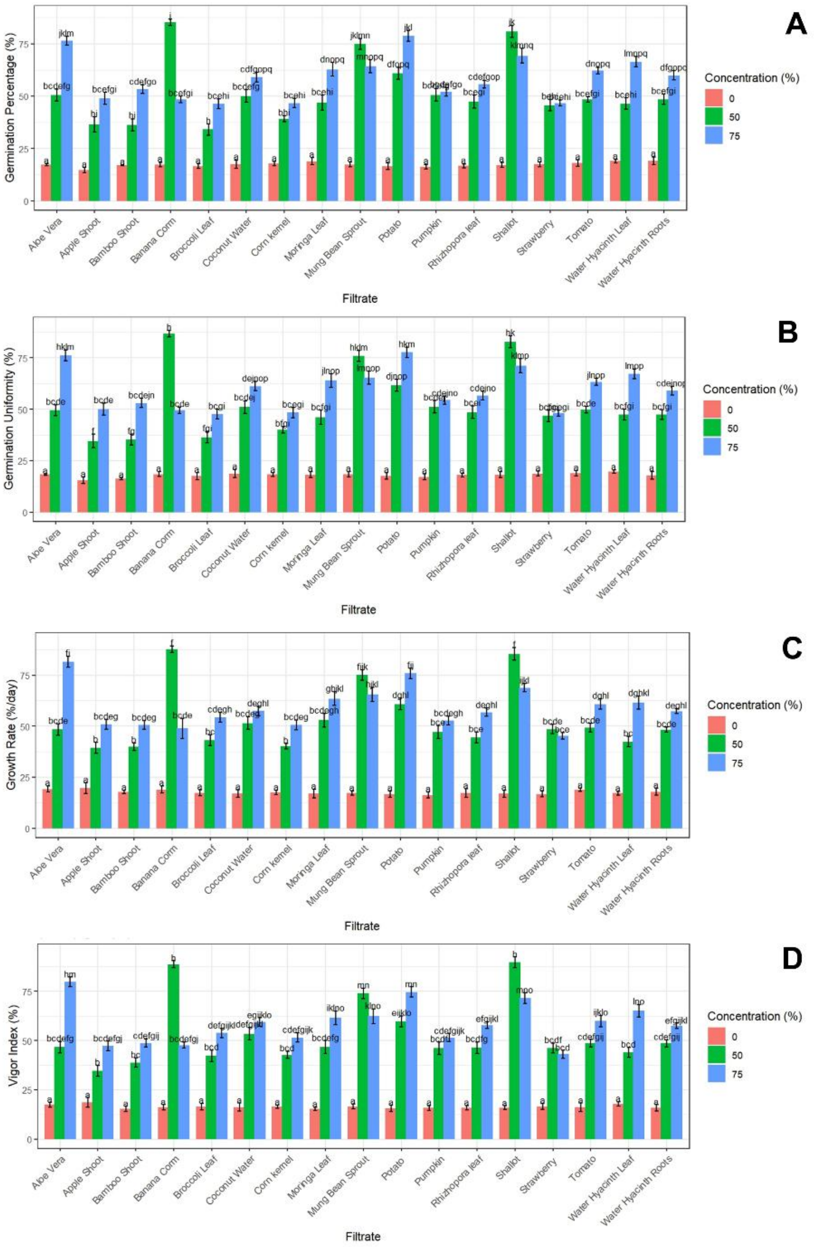

Fig. 4 Effects of plant filtrate type and concentration on mung bean germination and early seedling performance. Panels A-D show the effects of different plant filtrates applied at 0%, 50%, and 75% concentrations on (A) germination percentage, (B) germination uniformity, (C) seedling growth rate (%/day), and (d) vigor index (%) of mung beans (*Vigna radiata*). Values

represent the mean ± standard error (n = 3). Different letters above the bars indicate significant differences according to Tukey's HSD test ($p < 0.05$).

Similarly, the reported increase in germination uniformity with filtrate concentration, reaching over 60% at 75% filtrate strength versus below 25% in controls, reflects improved synchronization of seedling emergence, which is an important agronomic trait, Fig. 4(B). This finding aligns with the observations in plasma-treated mung bean seeds, where treatment-induced hormonal regulation results in more uniform and rapid germination. Moreover, seedling growth rates showed a substantial enhancement under higher filtrate concentrations, with rates rising from approximately 20-25% per day in the controls to peaks approaching 70-85% per day, demonstrating the biostimulatory capacity of phytohormonal complexes within the filtrates, Fig. 4(C). This magnitude of growth promotion has parallels in experiments with plant growth-promoting rhizobacteria and nanoparticles, which restored growth rates under stress conditions, resulting in nearly 30-35% improvement, emphasizing the synergy between bioactive compounds and microbiome effects.

The vigor index, which integrates germination and growth responses, exceeded 70% at a 75% filtrate concentration compared to below 25% in the controls, quantifying the overall enhancement in early seedling performance. These improvements are significant because seedling vigor is critically linked to crop stand establishment and yield potential, Fig. 4(D). Similar quantitative vigor increases have been reported with exogenous seed treatments with melatonin and salicylic acid, which enhance antioxidant defence mechanisms and mitigate adverse environmental stresses, such as drought and heavy metals, in mung bean seedlings [20-23].

4. Conclusion

This study outlines a systematic and integrative method for the identification and evaluation of plant-based germination biostimulants, utilizing social media knowledge mining, quantitative phytohormone analysis, and controlled germination bioassays. Social media platforms have demonstrated efficacy in screening candidate plant species with growth-promoting properties, serving as a valuable resource for hypothesis generation when integrated with experimental validation. Quantitative HPLC analysis demonstrated significant interspecific variability in the endogenous IAA, GA_3, and trans-zeatin concentrations, resulting in distinct phytohormonal profiles among the plant filtrates. Germination assays demonstrated that various filtrates significantly improved mung bean germination and seedling vigor in a concentration-dependent manner, especially at 50-75% concentrations. Multivariate clustering revealed hormone-specific groupings that were aligned with varying bioassay responses. These findings collectively indicate the potential of Indonesian local plants as sources of natural biostimulants and highlight the importance of integrating digital knowledge with empirical research in this field. This framework provides a scalable approach to enhancing sustainable agriculture by employing evidence-based, biodiversity-driven plant growth regulators.

Acknowledgements

The authors are grateful to the Directorate of Research and Community Service, Directorate General of Research and Development, Ministry of Higher Education, Science, and Technology, Indonesia for funding this present study in fiscal 2025 through Rector's Decree Number B/74062/UN38.III.1/LK.04.00/2025 on 28 Mei 2025. This study was carried out with the help of students, laboratories, and other facilitators at the Department of Biology, Universitas Negeri Surabaya, Indonesia.

References

1. Umar, A.; Gbenga, A.A.; Yusuf, M.N.O.; Faridah, A.; Emmanuel, A.T.; and Adekitan, A.F. (2025). Production and characterization of briquettes from agricultural wastes for sustainable energy solutions. *ASEAN Journal for Science and Engineering in Materials*, 4(2), 121-136.
2. Salsabila, Q.; Adnin, J.; Rochania, T.K.F.; and Hibatulloh, A.Y. (2023). Influence of grower agent on growth of bayam (Amaranthus sp.) plants with nutrient film technique in hydroponic system. *ASEAN Journal of Agricultural and Food Engineering*, 2(2), 121-128.
3. Febriani, D.; and Pasaribu, P.T. (2024). Food security strategy through regenerative agriculture for capacity building of farmers with integrated nutrient management training program. *ASEAN Journal of Community Service and Education*, 3(1), 49-54.
4. Rademacher, W. (2015). Plant growth regulators: Backgrounds and uses in plant production. *Journal of Plant Growth Regulation*, 34(4), 845-872.
5. Chaurasiya, D.K.; Papnai, N.; and Sahni, S. (2022). Biostimulants: Concept, types and way to enhance soil health. *International Journal of Plant and Soil Science*, 34(20), 24-40.
6. Masondo, N.A.; Aremu, A.O.; Moyo, M.; and Gupta, S. (2024). Editorial: The application of phytohormones in plant biotechnology for sustainable agriculture. *Frontiers in Plant Science*, 15, 1382055.
7. Choudhary, M.; and Kumari, A. (2021). Understanding plant hormones: Mechanisms and functions in growth and development. *Plant Science Archives*, 6(1), 14.
8. Steinke, J.; van Etten, J.; and Zelan, P.M. (2017). The accuracy of farmer-generated data in an agricultural citizen science methodology. *Agronomy for Sustainable Development*, 37(4), 32.
9. Van De Gevel, J.; van Etten, J.; and Deterding, S. (2020). Citizen science breathes new life into participatory agricultural research: A review. *Agronomy for Sustainable Development*, 40(5), 35.
10. Hussain, S.; Nanda, S.; Zhang, J.; Rehmani, M.I.A.; Suleman, M.; Li, G.; and Hou, H. (2021). Auxin and cytokinin interplay during leaf morphogenesis and phyllotaxy. *Plants*, 10, 1732.
11. Hartmann, A.; Sonnewald, S.; Sonnewald, U.; Hedden, P.; and Senning, M. (2010). Reactivation of meristem activity and sprout growth in potato tubers require both cytokinin and gibberellin. *Plant Physiology*, 155, 776-796.
12. Ali, J.; Mukarram, M.; Ojo, J.; Dawam, N.; Riyazuddin, R.; Ghramh, H.A.; Khan, K.A.; Chen, R.; Kurjak, D.; and Bayram, A. (2024). Harnessing phytohormones: Advancing plant growth and defence strategies for sustainable agriculture. *Physiologia Plantarum*, 176, e14307.

13. Denancé, N.; Molina, A.; Sánchez-Vallet, A.; and Goffner, D. (2013). Disease resistance or growth: The role of plant hormones in balancing immune responses and fitness costs. *Frontiers in Plant Science*, 4, 155.
14. Du, H.; Liu, H.; and Xiong, L. (2013). Endogenous auxin and jasmonic acid levels are differentially modulated by abiotic stresses in rice. *Frontiers in Plant Science*, 4, 397.
15. Eggert, K.; and von Wirén, N. (2017). Response of the plant hormone network to boron deficiency. *New Phytologist*, 216, 868-881.
16. Hošek, P.; Hoyerová, K.; Kiran, N.S.; Motyka, V.; Müller, K.; Dobrev, P.I.; Filepová, R.; Zahajská, L.; and Kamínek, M. (2019). Distinct metabolism of N-glucosides of isopentenyladenine and trans-zeatin determines cytokinin metabolic spectrum in Arabidopsis. *New Phytologist*, 225, 403-418.
17. Karadeniz, A.; Topcuoğlu, Ş.F.; and İnan, S. (2006). Auxin, gibberellin, cytokinin and abscisic acid production in some bacteria. *World Journal of Microbiology and Biotechnology*, 22, 1061-1064.
18. Kou, E.; Huang, X.; Liu, H.; Zhu, Y.; Sun, G.; Song, S.; Hao, Y.; Su, W.; and Chen, R. (2021). Crosstalk between auxin and gibberellin during stalk elongation in flowering Chinese cabbage. *Scientific Reports*, 11, 2391.
19. Deng, B.; Wang, X.; Tang, W.; Long, X.; Zhang, J.; Peng, X.; Fang, R.; Zhou, S.; Yao, J.; An, Z.; Huang, W.; and Gao, Y. (2021). Plant hormone metabolome and transcriptome analysis of dwarf and wild-type banana. *Journal of Plant Growth Regulation*, 41, 1-13.
20. Ramzani, P.M.A.; Coyne, M.S.; Anjum, S.; Khan, W.U.D.; and Iqbal, M. (2017). In situ immobilization of Cd by organic amendments and their effect on antioxidant enzyme defense mechanism in mung bean (Vigna radiata L.) seedlings. *Plant Physiology and Biochemistry*, 118, 561-570.
21. Hayyawi, N.J.H.; Al-Issawi, M.H.; Alrajhi, A.A.; Al-Shmgani, H.; and Rihan, H. (2020). Molybdenum induces growth, yield, and defence system mechanisms of the mung bean (Vigna radiata L.) under water stress conditions. *International Journal of Agronomy*, 2020(1), 8887329.
22. Li, S.W.; Zeng, X.Y.; Leng, Y.; Feng, L.; and Kang, X.H. (2018). Indole-3-butyric acid mediates antioxidative defense systems to promote adventitious rooting in mung bean seedlings under cadmium and drought stresses. *Ecotoxicology and Environmental Safety*, 161, 332-341.
23. Alam, M.Z.; McGee, R.; Hoque, M.A.; Ahammed, G.J.; and Carpenter-Boggs, L. (2019). Effect of arbuscular mycorrhizal fungi, selenium and biochar on photosynthetic pigments and antioxidant enzyme activity under arsenic stress in mung bean (Vigna radiata). *Frontiers in Physiology*, 10, 193.