International Journal of Bio-resource and Stress Management

https://ojs.pphouse.org/index.php/IJBSM

Crossref

IJBSM January 2026, 17(1): 01-08

Article AR6726

Research Article

Natural Resource Management

DOI: HTTPS://DOI.ORG/10.23910/1.2026.6726

Foliar Spray of Biostimulants as a Sustainable Strategy to Enhance Growth and Floral Productivity of Marigold (*Tagetes erecta* L.)

Vignesh M.[1], Manjusha M. R.[2], Bharathi S.[3], Dharani J.[4], Gowshika R.[5], Gopika C.[6], Anchana K.[4], Devi Esakkiammal S.[5], Aneesha J.[5] and Udhayakumar K.[7]

[1]Dept. of Horticulture, College of Agricultural Technology, Kullapuram, Theni, Tamil Nadu (625 562), India
[2]Dept. of Horticulture, Kerala Agricultural University, Wayanad, Kerala (673 593), India
[3]Dept. of Horticulture, School of Agriculture and Animal Sciences, Gandhigram Rural Institute, Dindigul, TNAU, Tamil Nadu (624 302), India
[4]Dept. of Fruit Science, Horticultural College and Research Institute, Periyakulam, Tamil Nadu (625 604), India
[5]Dept. of Vegetable Science, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu (641 003), India
[6]Dept. of Horticulture, Krishna College of Agriculture and Technology, Usilampatti, Tamil Nadu (625 532), India
[7]Dept. of Horticulture, RVS Padmavathy College of Horticulture, Dindigul, Tamil Nadu (624 707), India

Open Access

Corresponding dharanijegatheesh@gmail.com

0009-0002-3675-2899

ABSTRACT

A field experiment was conducted during 2025 (April–August) at Department of Horticulture, College of Agricultural Technology, Kullapuram to study the effect of foliar application of biostimulants on growth, yield and quality of marigold (*Tagetes erecta* L.). The petals served as an excellent source of xanthophylls, with lutein accounting for 80–90 % of the total content, underscoring its significance beyond floriculture. The experiment consisted of five treatments viz., Fish Amino Acid at 3%, Panchagavya at 3%, Seaweed Extract at 3%, Vermiwash at 3%, and Control, laid out in a Randomized Block Design with four replications. Among the treatments, foliar application of Fish Amino Acid at 3% markedly enhanced growth parameters such as plant height (63.22 cm), number of branches (24.19) and number of leaves (251.15). It also recorded the highest physiological traits, including chlorophyll (49.34 SPAD) and leaf area (9.07 cm^2). Yield attributed were similarly improved, with earliest flowering (34.73 days), maximum flower number (48.84), greatest individual flower weight (20.03 g), highest flower yield $plant^{-1}$ (978.27 g) and longest vase life (6.57 days). The findings confirmed that foliar application of biostimulants, particularly fish amino acid, was a highly effective method for improving the overall growth, yield, and quality of marigold.

KEYWORDS: Biostimulants, fish amino acid, foliar spray, marigold, yield

***Citation* (VANCOUVER):** Vignesh et al., Foliar Spray of Biostimulants as a Sustainable Strategy to Enhance Growth and Floral Productivity of Marigold (*Tagetes erecta* L.). *International Journal of Bio-resource and Stress Management*, 2026; 17(1), 01-08. HTTPS://DOI.ORG/10.23910/1.2026.6726.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

RECEIVED on 26th September 2025 RECEIVED in revised form on 02nd December 2025 ACCEPTED in final form on 20th December 2025 PUBLISHED on 27th December 2025

1. INTRODUCTION

Marigold (*Tagetes erecta* L.), a native of Mexico and a member of the *Asteraceae* family, is one of the most important ornamental crops cultivated worldwide. In India, it holds a significant place in floriculture due to its attractive blooms, religious importance, and wide use in garland making, landscaping, and decoration (Devdhara and Polara, 2024). Its significance goes well beyond ornamental value, covering diverse applications in gardening, medicine, and industry (Bhusaraddi et al., 2024). Worldwide, marigold cultivation has increased not only for loose flower production but also for the commercial extraction of carotenoids, which serve as natural colorants in food, cosmetics, and poultry feed (Sharma et al., 2022). Owing to their year round cultivation and wide variety, marigold is widely cultivated flower in India. 608.97 th m t of loose flowers and 7.90 tm t of cut flower of marigold are produced annually on an area of approximately 64.65 tha in India (Hinai et al., 2022). Madhya Pradesh, Karnataka, Gujarat, Andhra Pradesh, West Bengal, Chhattisgarh, Orissa, Haryana, Sikkim, Tamil Nadu and other states grow it for commercial use (Vikas et al., 2024). In India, the commercial extraction of lutein and other carotenoids is gaining popularity across several states, reflecting the crop's growing economic value (Kolambkar et al., 2022). Plant growth and yield are primarily influenced by two major factors: management practices and genetic makeup. In recent years, the use of bio regulators has emerged as a third crucial technological intervention for enhancing growth and flowering in ornamentals (Singh et al., 2023). However, achieving higher productivity and quality in marigold requires efficient nutrient management strategies. Flower production has long relied on chemical fertilizers to boost yields, but this practice presents significant long term risks to soil health and environmental safety. In response, the floriculture industry emphasizes innovative approaches to achieve higher and more sustainable yields with superior quality flowers (Gupta et al., 2025). Among these approaches, biostimulants derived from natural and organic sources play a key role in enhancing plant growth, improving flower quality, boosting yield, increasing stress tolerance and nutrient use efficiency without being direct sources of nutrients (Swathi et al., 2017). When applied as foliar sprays, biostimulants have been shown to improve vegetative and reproductive performance by enhancing physiological functions (Rathore et al., 2009). Moreover, their eco-friendly nature and lack of residual effects make them one of the most promising tools for sustainable yield improvement in modern crop production systems (Mallick et al., 2024). Organic stimulants like panchakavya, amirthakaraisal, fish Amino Acid (FAA), egg Amino Acid (EAA), and vermiwash are increasingly used to promote crop growth and productivity (Ramesh et al., 2020). Panchakavya has been widely studied for its beneficial properties, whereas information on Fish Amino Acid remains limited (Siddique et al., 2023). FAA is a fermented product rich in nitrogen, amino acids, vitamins, and minerals, which enhances plant metabolism, stimulates hormone like activity, and improves chlorophyll synthesis through efficient nutrient uptake (Li et al., 2024). Similarly, seaweed extract provides cytokinins, auxins, and micronutrients that regulate cell division and chlorophyll formation (Rao, 1991). Traditional preparations such as panchagavya and vermiwash also act as biostimulants by supplying plant growth regulators and beneficial microbes (Yasmin et al., 2021). Despite their proven role in enhancing crop performance, comparative studies on the efficacy of foliar biostimulants in marigold (*Tagetes erecta* L.) remain scarce, particularly under Tamil Nadu conditions. Considering the economic and ornamental importance of marigold, the present study was undertaken to evaluate the effect of selected foliar biostimulants on growth, flower yield, and quality parameters.

2. MATERIALS AND METHODS

2.1. Study sites

The experiment was carried out during 2025 (April–August) at the Department of Horticulture, College of Agricultural Technology, Kullapuram, under Tamil Nadu Agricultural University to assess the influence of foliar application of biostimulants on the growth, yield, and quality of marigold (*Tagetes erecta* L.). The experimental site was situated at 10.5°N latitude and 77.5°E longitude and at an altitude 300.6 m or 986.1 feet above MSL. The soil type was sandy loam, including moderate amounts of accessible potassium, phosphorus, and nitrogen.

2.2. Experimental design and treatments

The trial was conducted using a Randomized Block Design (RBD) with five treatments and four replications. The treatments included: T_1: Fish Amino Acid at 3%, T_2: Panchagavya at 3%, T_3: Seaweed Extract at 3%, T_4: Vermiwash at 3%, T_5: Control (Water spray).

2.3. Treatment application and observations

Foliar applications were done at regular intervals starting from 30 days after transplanting. Standard cultural practices were followed uniformly across all treatments to ensure proper crop establishment and growth. For recording observations, five representative plants replication^{-1} were selected. Data were collected on key growth parameters (plant height, number of branches, number of leaves, leaf area, and chlorophyll content), flowering traits (days to first flowering, number of flowers, and individual flower weight), and yield and quality attributes (flower yield plant^{-1} and vase life). The data collected were subjected to analysis of variance (ANOVA), and treatment means were compared at the *p*=0.05% level of significance to determine statistical differences among treatments.

3. RESULTS AND DISCUSSION

3.1. Growth attributes

The data on vegetative growth parameters were presented in Table 1, which indicated that foliar application of different biostimulants significantly influenced plant height, number of branches plant^{-1}, and number of leaves plant^{-1} at 30, 45, and 60 days after planting.

3.1.1. Plant height (cm)

At 30 DAP, the application of biostimulants had no statistically significant effect on plant height. However by 45 DAP, the tallest plants were recorded under Fish amino acid at 3% (T_1) (50.24 and 63.22 cm), followed by Seaweed extract at 3% (T_3) (47.16 and 62.48 cm) at 45 and 60 DAP, whereas the shortest plants were noted in the control (T_5) (36.68 and 47.19 cm). The superior performance of Fish Amino Acid may be attributed to its high nitrogen content and abundance of essential nutrients, which enhance protein synthesis and promote greater plant height. Furthermore, Fish Amino Acid appears to upregulate growth hormone signaling pathways including auxin/IAA, GH3, and SAUR thereby stimulating cell expansion and contributing to improved overall plant development. Similarly, Li et al. (2024) reported that the application of 500 fold diluted amino acids increased plant height by 35.68% in tobacco. Additionally, Haghighi et al. (2022) observed that exogenous application of 300 mg l^{-1} amino acids increased plant height by 1.13-fold in cabbage and Faezah et al. (2021) reported a 23.78% increase in plant height in Chinese kale following foliar application of 30% fish amino acids.

Table 1: Effect of foliar application of biostimulants on growth attributes of marigold

Treatments	Plant height (cm)			Number of branches plant^{-1}			Number of leaves plant^{-1}			Stem girth (cm)
	30 DAP	45 DAP	60 DAP	30 DAP	45 DAP	60 DAP	30 DAP	45 DAP	60 DAP	
T_1	33.39	50.24	63.22	12.17	17.38	24.19	205.72	231.45	251.15	5.13
T_2	32.65	45.68	61.74	10.43	15.93	21.54	191.27	220.25	239.05	4.74
T_3	31.93	47.16	62.48	11.04	16.44	23.85	201.18	228.72	244.72	4.86
T_4	33.18	42.89	60.35	11.97	14.81	20.32	186.53	209.52	217.04	4.29
T_5	30.04	36.68	47.19	10.13	14.02	18.26	179.28	189.37	204.77	3.93
Grand mean	32.25	44.53	58.99	11.12	15.71	21.63	192.79	215.82	231.34	4.59
SEd±	0.91	0.65	0.90	0.78	0.17	0.39	10.43	3.81	3.35	0.05
CD (p= 0.05)	NS	1.42**	1.97**	1.70**	0.38**	0.85**	NS	8.30**	7.72**	0.12**

T_1: Fish amino acid at 3%; T_2: Panchagavya at 3%; T_3: Seaweed extract at 3%; T_4: Vermiwash at 3%; T_5: Control

3.1.2. Number of branches plant^{-1}

The number of branches plant^{-1} also increased progressively with crop growth (from 30 to 60 DAP). Among the treatments, Fish Amino Acid at 3% (T_1) produced the highest number of branches (17.38 and 24.19), followed closely by Seaweed Extract at 3% (T_3) (16.44 and 23.85), while the control (T_5) recorded the lowest (14.02 and 18.26) at 45 and 60 DAP respectively. Our findings are also consistent with those of Khan et al. (2019), who reported that the exogenous application of amino acid (L-methionine (20 mg l^{-1}) enhances chlorophyll content, chloroplast development, and cytokinin levels, thereby promoting greater lateral growth by 23.60% in lettuce. Fish Amino Acid (FAA) have been reported to enhance lateral branching due to their rich composition of amino acids, plant growth regulators, and essential trace elements. The amino acids acted as growth promoters, facilitating carbon dioxide uptake during photosynthesis. These observations align with Luo et al. (2023) and Yang et al. (2022), indicating that foliar absorption of amino acids led to increased cell division and chloroplast development, which in turn enhanced axillary bud growth.

3.1.3. Number of leaves plant^{-1}

The number of leaves plant^{-1} at 45 and 60 days after planting (DAP) was significantly influenced by the foliar application of biostimulants. Among the treatments, the application of Fish amino acid at 3% (T_1) recorded the highest number of leaves (231.45 and 251.15), followed by T_3 (Seaweed extract at 3%) with 228.72 and 244.72 leaves plant^{-1}. In contrast, T_5 (control) recorded the lowest number of branches (189.37 and 204.77). These findings were in agreement with the results reported by Tayi et al. (2025) in tomato and Sivasankar et al. (2021) in marigold, who also observed enhanced vegetative growth and leaf proliferation in response to foliar application of organic biostimulants. The superior performance of FAA could be attributed to its high nitrogen content, an essential nutrient for vegetative development. Nitrogen plays a crucial role in chlorophyll synthesis and photosynthetic activity, which promotes vigorous leaf growth and the formation of new shoots. Furthermore, the increased availability of nitrogen through FAA application might have enhanced chlorophyll concentration, resulting in improved photosynthetic efficiency and greater assimilate production. This, in turn, could have led to higher leaf production compared with untreated plants. A study by Ramesh et al. (2020) reported that foliar spray of 1% fish amino acid increased the number of leaves (11.6) in green amaranthus than control plants (10.3). Gasana et al. (2020) reported the combined application of fish amino acid and oriental herbal nutrients (3 ml l^{-1} each) significantly enhanced the number of leaves (129.3 leaves $plant^{-1}$) than control (97.2 leaves $plant^{-1}$).

3.1.4. Stem girth (cm)

Among the treatments, T_1 recorded the maximum stem girth of 5.13 cm, which was significantly higher than the other treatments followed by T_3 with 4.86 cm. On the other hand, the minimum stem girth was observed in T_5 with 3.93 cm. The increase in stem girth under biostimulant treatments might be attributed to improved internal transport of nutrients and water, facilitated by enhanced xylem and phloem activity stimulated through biostimulant application. Similar observations were reported by Yasmin et al. (2021) in brinjal, where foliar application of fish based formulations significantly promoted stem thickening and internodal elongation. The superior performance of Fish Amino Acid could be due to its richness in essential amino acids such as methionine, tryptophan, and lysine, which play vital roles in plant metabolism and protein synthesis (Mohanty et al., 2014). These amino acids are crucial for cell division and tissue development, contributing to increased accumulation of fresh and dry biomass, which in turn enhanced stem girth. Comparable results were also reported by Ahmad et al. (2025) in *Eustoma grandiflorum* L. and *Matthiola incana* L, who noted 5.26 and 64.86% increase in stem girth following the application of Isabion, an amino acid based biostimulant (3 ml l^{-1}).

3.2. Physiological and yield attributes

3.2.1. Leaf area

This study examined the impact of various treatments on leaf area in marigold plants, and the results revealed significant differences (Figure 1). The maximum leaf area (9.07 cm^2) was reported in T_1, which was ensued by T_3 with 8.65 cm^2. Nevertheless, reduction in leaf area (6.23 cm^2) was reported in T_5. The amino acids presented in FAA were well known biostimulants and acts as a precursors of growth hormones. These components improved the overall health of the plant and enhanced leaf expansion by stimulating cell division and elongation. The exogenous application of amino acids also stimulated the synthesis of proteins and phytohormones, such as auxins, by increasing the availability of key amino acids particularly tryptophan which in turn promoted cell expansion in plants. Faezah et al. (2021) demonstrated that the application of 30% fish amino acid increased the leaf area by 107% in Chinese kale. The foliar application of an amino acid mixture at 0.25 l ha^{-1} significantly increased the leaf area in tomato seedlings (Calero Hurtado et al., 2025). Almutairi et al. (2022) reported that the combined application of glutamic acid, arginine and glycine (1000 ppm) enhanced the leaf area upto 1.53 times. These studies demonstrated that amino acids are easily absorbed by leaf tissues and play an important role in protein synthesis and chlorophyll formation, thereby improving photosynthetic efficiency, crop yield, and overall quality.

3.2.2. Chlorophyll content

The highest chlorophyll content (49.34) was registered in the treatment T_1 (Fish amino acid at 3%), which was proceeded by the treatment T_3 (Seaweed extract at 3%) with 46.16. Meanwhile lowest chlorophyll content (40.09) was registered in the treatment T_5 (Control) (Figure 1).

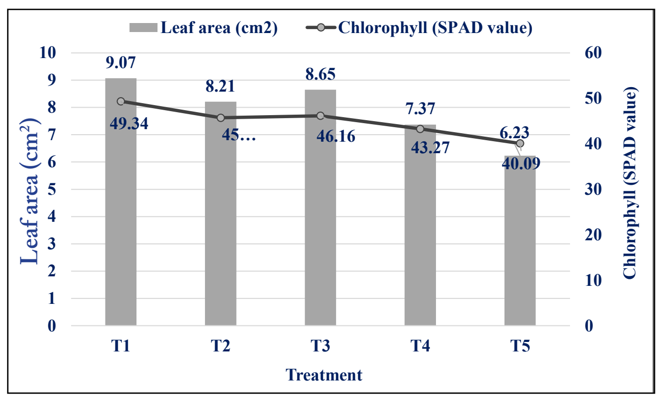

Figure 1: Effect of foliar application of biostimulants on leaf area and chlorophyll content of marigold

Enhanced chlorophyll synthesis and larger leaf area supported increased photosynthesis, which in turn boosts plant growth and flower production. Fish amino acid was a rich source of essential amino acids, peptides, and organic nitrogen, all of which were critical for improving metabolic functions and photosynthesis. The amino acids provided by this treatment might enhance the synthesis of chlorophyll molecules and improved the plant's ability to absorb and utilize nutrients (Rathore et al., 2009 and Yunsheng et al., 2015). Our findings align closely with those of Wang et al., 2019 and Kandil et al. (2016) who reported that the application of Fish Amino Acid (FAA) contributed to maintaining and improving the ultrastructure of mesophyll cells, particularly the plastids, thereby enhancing photosynthetic efficiency. This improvement in photosynthetic capacity subsequently increased the production of assimilates required for new cell formation, which was reflected in the greater leaf area and higher chlorophyll content observed in the treated plants. Bhuimbar and Dandge (2023) demonstrated that the application of 10 and 15 ml fish hydrolysate enhanced the chlorophyll content by 1.51 and 1.75 times in cow pea and chilli respectively.

3.2.3. Days taken for first flowering

The data on days to first flowering showed that T_1 (Fish Amino Acid at 3%) flowered earliest at 34.73 days, followed by T_3 (Seaweed Extract at 3%) at 38.92 days, while T_5 (Control) had the longest duration of 45.21 days (Table 2). The early flowering in T_1 could be attributed to its rich content of readily available proteins, amino acids, and essential nutrients, which promoted vigorous vegetative growth and stimulated metabolic activity. Amino acids acted as precursors for plant proteins, enhanced nutrient uptake, regulated enzyme activity, and influenced hormone synthesis, all of which were critical for rapid bud initiation and flower development. The promoting effect of amino acids on flowering behavior has also been reported by several investigators. Patokar et al. (2017) observed improved flowering in marigold, while Al-Fatlawi et al. (2022) reported that foliar application of 150 mg l^{-1} tryptophan in Gladiolus accelerated flowering, with treated plants taking 87.15 days to flower compared to 95.73 days in the control. Ahmad et al. (2023) observed earlier pod formation in plants applied with 225 mg l^{-1} amino acid (30.83 days) against 49.25 days in control.

Table 2: Effect of foliar application of biostimulants on physiological and yield attributes of marigold

Treatments	Days taken for first flowering	Flowering duration	Individual flower weight (g)	Flower yield plant^{-1} (g)	Shelf life (days)
T_1	34.73	44.29	20.03	978.27	6.57
T_2	40.11	39.22	17.42	758.82	5.04
T_3	38.92	41.31	18.17	822.92	5.72
T_4	42.56	37.96	17.21	719.03	4.63
T_5	45.21	35.18	15.19	579.80	4.12
Grand mean	40.31	39.59	17.60	771.76	5.21
SEd±	0.54	0.79	0.34	10.92	0.07
CD (p=0.05)	1.18**	1.73**	0.64**	23.80**	0.17**

T_1: Fish amino acid at 3%; T_2: Panchagavya at 3%; T_3: Seaweed extract at 3%; T_4: Vermiwash at 3%; T_5: Control

3.2.4. Days taken for flower duration

As shown in Table 2, the foliar application of Fish amino acid at 3% (T_1) recorded the longest flowering duration (44.29 days). This was followed by T_3 (Seaweed extract at 3%), which showed 41.31 days of flowering. The shortest flowering duration (35.18 days) were noted in T_5 (Control). The prolonged flower duration observed was likely associated with the balanced availability of essential nutrients, which enhanced plant vigor and delayed senescence, thereby contributing to sustained floral longevity. Furthermore, amino acids (AAs) acted as key biomolecules regulating various physiological processes, including enzyme activation within plant tissues, which supported optimal metabolic activity and extended the flowering period (Abdelkader et al., 2023). These observations were consistent with the findings of Abdossi and Danaee (2019) in Carnation.

3.2.5. Individual flower weight

The data presented in Table 2 showed significant differences in individual flower weight (g) among the various biostimulant application. The highest individual flower weight (20.03 g) was recorded in T_1 (Foliar application of Fish amino acid at 3%), which was ensued by T_3 (Seaweed extract at 3% application) (18.17 g). Meanwhile, lowest flower weight was observed in the control treatment (T_5), which recorded 15.19 g. FAA contained a higher proportion of essential amino acids that played pivotal roles in nitrogen metabolism, including nitrogen uptake, transport, and distribution within plant tissues, while also enhancing photosynthetic efficiency. This led to greater carbohydrate accumulation and increased flower biomass. Moreover, FAA stimulated cell division and metabolic activity, thereby promoting tissue formation and contributing to higher final flower weight (Hamza and Al-Taey, 2020). The present results are in agreement with the findings of Tayi et al. (2025) in tomato, who reported a 45.50% increase in biomass with the application of 1.5 ml l^{-1} protein hydrolysate. Similarly, Haghparvar et al. (2023) observed a 2.64% increase in the fresh weight of marigold flowers following foliar application of 1000 μM arginine, glutamine and proline.

3.2.6. Flower yield plant^{-1}

The effect of foliar application of biostimulants showed significant variation on flower yield plant^{-1}. The highest flower yield (978.27 g) was registered in T_1 (Fish amino acid at 3%), which was on par with the treatment T_3 (Seaweed extract at 3%) (822.92 g). However, the lowest flower yield (579.80 g) was registered in the control (T_5) (Table 2). The enhanced flower yield could be attributed to improved nutrient uptake and the provision of essential organic compounds that promoted vigorous floral development. Furthermore, fish amino acids facilitated efficient nutrient translocation to sink tissues, leading to greater assimilate accumulation in flowers and, consequently, higher yield. This is consistent with the findings of Ruamrungsri et al. (2021), who reported improved yield in foxtail millet with 3% fish amino acid, and Khan et al. (2019), who observed similar enhancements in lettuce with the application of 0.2 mg l^{-1} L-methionine.

3.2.7. Shelf life

The longest vase life was recorded in T_1 (Fish Amino Acid at 3%) at 6.57 days, followed by T_3 (Seaweed Extract at 3%) with 5.72 days, while the control (T_5) showed the shortest vase life of 4.12 days (Table 2). The enhanced shelf life in T_1 could be attributed to the increased nitrogen and amino acid content, which helped delay petal senescence, maintained water balance, and supported antioxidative enzyme activity. These processes minimized reactive oxygen species accumulation and stabilized cell membranes, thereby prolonging flower longevity (Souri et al., 2018). Similar findings were done by Abd-Elkader et al. (2020) in Gerbera. Seyed Hajizadeh et al. (2024) reported that nano encapsulated arginine (nCS-Arg) and phenylalanine (nCS-Phe) enhanced the longevity upto 16.3 days in *Rosa hybrida* Morden Fireglow.

4. CONCLUSION

The foliar application of Fish Amino Acid at 3% (T_1) significantly improved the growth, physiological efficiency, flowering, and yield traits in marigold. Seaweed Extract at 3% (T_3) also demonstrated strong potential as an organic growth stimulant. These treatments offered ecofriendly and sustainable alternatives to synthetic inputs in floriculture. Hence, Fish Amino Acid at 3% was recommended as the most effective foliar biostimulants for commercial marigold cultivation under Tamil Nadu conditions.

5. ACKNOWLEDGEMENT

The authors gratefully acknowledge the Department of Horticulture, College of Agricultural Technology, Kullapuram, under Tamil Nadu Agricultural University, for providing the necessary facilities and support to carry out this research.

6. REFERENCES

Abd-Elkader, H.H., Massoud, H.Y., El-Baz, T.T., El-Erian, M.A., 2020. Effect of amino acids spray on growth, flowering and keeping quality of *Gerbera jamesonii* L. as a pot plant. Journal of Plant Production 11(2), 201. https://doi.org/10.21608/jpp.2020.79110.

Abdelkader, M., Voronina, L., Baratova, L., Shelepova, O., Zargar, M., Puchkov, M., Arinov, B., 2023. Biostimulants-based amino acids augment physio-biochemical responses and promote salinity tolerance of lettuce plants (*Lactuca sativa* L.). Horticulturae 9(7), 807. https://doi.org/10.3390/horticulturae9070807.

Abdossi, V., Danaee, E., 2019. Effects of some amino acids and organic acids on enzymatic activity and longevity of *Dianthus caryophyllus* cv. Tessino at pre-harvest stage. Journal of Ornamental Plants 9(2), 93–104 Available at: www.jornamental.iaurasht.ac.ir.

Ahmad, I., Ashfaq, H., Dole, J.M., Hussain, T., Safdar, H., Jabeen, A., 2025. Biostimulants improve growth, yield and quality of *Eustoma grandiflorum* L. and *Matthiola incana* L. Ornamental Horticulture 31, p.e312816. https://doi.org/10.1590/2447-536X.v31.e312816.

Ahmad, B., Hussain, F., Shuaib, M., Shahbaz, M., Hadayat, N., Shah, M., Yaseen, T., Rauf, A., Anwar, J., Khan, S., Jabeen, A., 2023. Effect of salicylic acid and amino acid on pea plant (*Pisum sativum*) late season, growth and production. Polish Journal of Environmental Studies 32(3). https://doi.org/10.15244/pjoes/156881.

Al-Fatlawi, K.A.E., Hasan, A.E., Al-Dulaymi, H.I., 2022. Effect of amino acid on the growth and flowering of the Gladiolus plant (priscilla cultivar). International Journal of Agricultural & Statistical Sciences 18, 1555.

Almutairi, K.F., Saleh, A.A., Ali, M.M., Sas-Paszt, L., Abada, H.S., Mosa, W.F., 2022. Growth performance of guava trees after the exogenous application of amino acids glutamic acid, arginine, and glycine. Horticulturae 8(12), 1110. https://doi.org/10.3390/horticulturae8121110.

Amin, A.A., Gharib, F.A., El-Awadi, M., Rashad, E.S.M., 2011. Physiological response of onion plants to foliar application of putrescine and glutamine. Scientia Horticulturae 129(3), 353–360. https://doi.org/10.1016/j.scienta.2011.03.052.

Bhuimbar, M.V., Dandge, P.B., 2023. Production of organic liquid biofertilizer from fish waste and study of its plant growth promoting effect. Proceedings of the National Academy of Sciences, India Section B: Biological Sciences 93(1), 235–243. https://doi.org/10.1007/s40011-022-01413-8.

Bhusaraddi, P., Bhagat, V., Kulkarni, B., Cholin, S., Kiran, K.N., 2024. Assessment of genetic variability and association of traits in french marigold (*Tagetes patula* L.) genotypes. International Journal of Bio-resource and Stress Management 15(5), 01–10. https://doi.org/10.23910/1.2024.5260.

Calero Hurtado, A., Melendrez Rodriguez, J.F., Pena Calzada, K., Perez Diaz, Y., Jimenez Medina, A., 2025. Foliar application of a mixture of amino acid based growth promoters enhances tomato seedling production. Horticulturae 11(6), 582. https://doi.org/10.3390/horticulturae11060582.

Devdhara, U.R., Polara, N.D., 2024. Effect of foliar application of biostimulants and micronutrients on chlorophyll and xanthophylls content of African marigold cv. Pusa Narangi Gainda. International Journal of Plant & Soil Science 36(12), 463–470. https://doi.org/10.9734/ijpss/2024/v36i125220.

Faezah, O.N., Najihah, S.N., Nakasha, J.J., Suhaili, M.Y., 2021. Fish amino acid application to improve growth performance and yield of Chinese Kale (*Brassica oleracea*). Journal of Applied Horticulture 23(2), 162–166. https://doi.org/10.37855/jah.2021.v23i02.30.

Gasana, Q.G., Kim, D.H., 2020. Effect of foliar spraying mixed with fish amino acids (FAA) and oriental herbal nutrient (OHN) extract on growth, yield and quality of watermelon (*Citrullus lanatus*). Rwanda Journal of Agricultural Sciences 2(1), 127–136. https://www.ajol.info/index.php/rjeas/article/view/200853.

Gupta, S., Dolezal, K., Novak, O., Dolezalova, I., Hrdlicka, J., Kulkarni, M.G., Van Staden, J., 2025. Role of biostimulants in flowering. In: Gupta, S., Dolezal, K., Van Staden, J. (Eds.), Biostimulants for improving reproductive growth and crop yield. Academic Press, 87–112. ISBN 9780443132070, https://doi.org/10.1016/B978-0-443-13207-0.00009-3.

Haghighi, M., Barzegar Sadeghabad, A., Abolghasemi, R., 2022. Effect of exogenous amino acids application on the biochemical, antioxidant, and nutritional value of some leafy cabbage cultivars. Scientific reports 12(1), 17720. https://doi.org/10.1038/s41598-022-21273-6.

Haghparvar, F.R., Hashemabadi, D., Kaviani, B., 2023. The effect of foliar application of amino acids on some nutritional properties, antioxidant capacity and some other physiologic parameters of African marigold (*Tagetes erecta* L.), Taishan 'Yellow'and 'Orange'. Acta Scientiarum Polonorum Hortorum Cultus 22(1), 107–124. https://doi.org/10.24326/asphc.2023.4580.

Hamza, O.M., Al-Taey, D.K., 2020. A study on the effect of glutamic acid and benzyl adenine application upon growth and yield parameters and active components of two broccoli hybrids. International Journal of Agriculture and Statistical Science 16(2), 1163–1167. https://connectjournals.com/03899.2020.16.1163.

Hinai, A., Jayasuriya, H., Pathare, P.B., Shukaili, T., 2022. Present status and prospects of value addition industry for agricultural produce: A review. Open Agriculture 7(1), 207–216. https://squ.elsevierpure.com/en/publications/present-status-and-prospects-of-value-addition-industry-for-agric.

Kandil, A.A., Sharief, A.E.M., Seadh, S.E., Altai, D.S.K., 2016. Role of humic acid and amino acids in limiting loss of nitrogen fertilizer and increasing productivity of some wheat cultivars grown under newly reclaimed sandy soil. International Journal of Advanced Research in Biological Sciences 3(4), 123–136. http://s-o-i.org/1.15/ijarbs-2016-3-4-18.

Khan, S., Yu, H., Li, Q., Gao, Y., Sallam, B.N., Wang, H., Jiang, W., 2019. Exogenous application of amino acids improves the growth and yield of lettuce by enhancing photosynthetic assimilation and nutrient availability. Agronomy 9(5), 266. https://doi.org/10.3390/agronomy9050266.

Kolambkar, R.A., Suryawanshi, R.R., Shinde, H.R., Deshmukh, K.V., 2022. A study on marketing of marigold in Western Maharashtra. International Research Journal of Agricultural Economics and Statistics 5(2), 143–147. https://doi.org/10.15740/HAS/IRJAES/5.2/143-147.

Li, T., Chen, X., Cao, S., Liu, Z., Tian, L., Gao, Z., Liu, P., 2024. Integrated physiological and transcriptome analyses of the effects of water-soluble amino acid fertilizer on plant growth. Journal of King Saud University-Science 36(11), 103504. https://doi-org.elibrarytnau.remotexs.in/10.1016/j.jksus.2024.103504.

Luo, H., Imran, M., Yao, X., Zhang, S., Yi, W., Xing, P., Tang, X., 2023. Foliar application of glutamate and phenylalanine induced regulation in yield, protein components, aroma, and metabolites in fragrant rice. European Journal of Agronomy 149, 126899. https://doi.org/10.1016/j.eja.2023.126899.

Mallick, S., Karak, C., Roy, B., Chakraborty, B., Das, P., Bhutia, P., 2024. Effects of bio stimulants on growth, yield and quality of tomato. International Journal of Economic Plants 11(3), 347–352. https://doi.org/10.23910/2/2024.5493b.

Mohanty, B., Mahanty, A., Ganguly, S., Sankar, T.V., Chakraborty, K., Rangasamy, A., Sharma, A.P., 2014. Amino acid compositions of 27 food fishes and their importance in clinical nutrition. Journal of Amino Acids 2014(1), 269797. https://doi.org/10.1155/2014/269797.

Rao, R.K., 1991. Effect of seaweed extract on *Zizyphus mauritiana* Lamk. Journal of the Indian Botanical Society 71, 19–21. Available at: https://indianbotsoc.org/assets/upload/uploaded/19-21%20K.Rama%20Rao.pdf.

Ramesh, T., Rathika, S., Murugan, A., Soniya, R.R., Mohanta, K.K., Prabharani, B., 2020. Foliar spray of fish amino acid as liquid organic manure on the growth and yield of Amaranthus. Chemical Science Review and Letters 9(34), 511–515. https://chesci.com/wp-content/uploads/2020/07/37_CS205101114_p511-515.pdf.

Rathore, S.S., Chaudhary, D.R., Boricha, G.N., Ghosh, A., Bhatt, B.P., Zodape, S.T., Patolia, J.S., 2009. Effect of seaweed extract on the growth, yield and nutrient uptake of soybean (*Glycine max*) under rainfed conditions. South African Journal of Botany 75(1), 351–355. https://doi.org/10.1016/j.sajb.2008.10.009.

Ruamrungsri, S., Panjama, K., Ohyama, T., Inkham, C., 2021. Nitrogen in flowers. In: Nitrogen in agriculture-physiological, agricultural and ecological aspects. IntechOpen. https://www.google.co.in/books/edition/Nitrogen_in_Agriculture/ZdFGEAAAQBAJ?hl=en&gbpv=1&pg=PA3&printsec=frontcover.

Seyed Hajizadeh, H., Rouhpourazar, M., Azizi, S., Zahedi, S.M., Okatan, V., 2024. Nanochitosan based encapsulation of arginine and phenylalanine improves the quality and vase life of rosa hybrida morden fireglow. Journal of Plant Growth Regulation 43(3), 686–700. https://doi.org/10.1007/s00344-023-11126-5.

Sharma, G., Rajhansa, K.C., Sharma, P., Singh, A., Sharma, A., Sahu, M.K., Pandey, A.K., 2022. Marigold (*Tagetes* spp.): a diverse crop with multipurpose value for health and environment: a review. Agricultural Reviews 45(4), 618–626. https://doi.org/10.18805/ag.R-2475.

Siddique, A.S., Indianraj, N., Reshma, J., Harish, N., 2023. Fish amino acid - a review. International Journal of Advanced Research in Science, Communication and Technology (IJARSCT) 3(1), 235–240. https://www.ijarsct.co.in/Paper13637.pdf.

Singh, D., Keditsu, R., Hemanta, L., Yepthomi, G.I., Kumar, N., 2023. Effect of plant growth regulators on the performance of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda. International Journal of Minor Fruits, Medicinal and Aromatic Plants 9(1), 38–44. https://doi.org/10.53552/ijmfmap.9.1.2023.38-44.

Sivasankar, S., Ilakkiya, P., Rameshkumar, S., Muruganandam, C., Karthikeyan, P.K., 2021. Effect of organic manures and foliar application of fish amino acid on yield and quality parameters of African marigold (*Tagetes erecta* L.). Plant Archives 21(1), 2532–2534. https://doi.org/10.51470/plantarchives.2021.v21.S1.413.

Souri, M.K., Goodarzizadeh, S., Ahmadi, M., Hatamian, M., 2018. Characteristics of postharvest quality of chrysanthemum cut flowers under pretreatment with nitrogenous compounds. Acta Scientiarum Polonorum Hortorum Cultus 17(3), 83–90. https://doi.org/10.24326/asphc.2018.3.8.

Swathi, K., Sarkar, I., Maitra, S., Sharma, S., 2017. Organic manures and bio-inoculants mediated influence on growth and flowering of African Marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda. International Journal of Bio-resource and Stress Management 8(3), 429–432. https://doi.org/10.23910/IJBSM/2017.8.3.1690a.

Tayi, F., Metomo, F.N.N.N., Essamlali, Y., Akil, A., Amadine, O., Aboulhrouz, S., Zahouily, M., 2025. Preparation and characterization of fish-derived protein hydrolysate and assessment of its effect on tomato and sorghum plants growth and productivity. Sustainable Chemistry and Pharmacy 43, 101877. https://doi.org/10.1016/j.scp.2024.101877.

Vikas, A.W., Kerutagi, M.G., Gorabal, K., Patil, R., Naveen, M.P., 2024. Production of marigold in Northern Karnataka: An economic analysis. International Journal of Advanced Biochemistry Research 8(3), 132–135. https://doi.org/10.33545/26174693.2024.v8.i3Sb.708.

Wang, D., Deng, X., Wang, B., Zhang, N., Zhu, C., Jiao, Z., Shen, Q., 2019. Effects of foliar application of amino acid liquid fertilizers, with or without *Bacillus amyloliquefaciens* SQR9, on cowpea yield and leaf microbiota. PLoS One 14(9), e0222048. https://doi.org/10.1371/journal.pone.0222048.

Yang, G., Wei, X., Fang, Z., 2022. Melatonin mediates axillary bud outgrowth by improving nitrogen assimilation and transport in rice. Frontiers in Plant Science 13, 900262. https://doi.org/10.3389/fpls.2022.900262.

Yasmin, S., Ahmed, S., Hossain, M.S., 2021. Effect of foliar application of vermiwash on growth and quality of brinjal. International Journal of Agricultural Science and Research 11(2), 75–81. http://doi.org/10.26480/jwbm.01.2021.31.34.

Yunsheng, L., El-Bassiony, A.M., Fawzy, Z.F., El-Awadi, M.E., 2015. Effect of foliar spray of glutamine on growth, yield and quality of two snap bean varieties. Journal of Agricultural Science and Engineering 1(2), 39–45. https://api.semanticscholar.org/CorpusID:207984902.