



Biostimulants for Promoting Growth, Yield and Flower Quality in *Anthurium andreanum* Lind

Jewel Maria Thomas ^{a++*}, Reshmi CR ^{a#}, Rafeekher M ^{a†},
Priyakumari I ^{a#} and Aparna B ^{b‡}

^a, Department of Floriculture and Landscaping, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala- 695 522, India.

^b Department of Soil Science and Agriculture Chemistry, College of Agriculture, Ambalavayal, Wayanad, Kerala – 673 593, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2024/v14i23948

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/112115>

Original Research Article

Received: 01/12/2023

Accepted: 05/02/2024

Published: 08/02/2024

ABSTRACT

The present study was carried out at the Department of Floriculture and Landscaping, College of Agriculture, Vellayani, Kerala Agricultural University, during 2022-23 with an aim to evaluate the effect of foliar application of different biostimulants on growth, yield, and flowering attributes of Anthurium under naturally ventilated polyhouse condition. The experiment was laid out in CRD with ten replications. There were fifteen treatments including the control. Fertilizers and manures were applied as per the Package of Practices Recommendations of Kerala Agricultural University (i.e., application of cow dung supernatant + 2 g L-119:19:19 weekly once) to all the treatments including

⁺⁺ PG scholar;

[#] Assistant Professor;

[†] Assistant Professor and Head;

[‡] Professor and Head;

*Corresponding author: E-mail: jewelmaryat@gmail.com;

the control (T1). In addition, for treatments T2 to T15, different biostimulants were applied as foliar sprays either alone or in combination fortnightly or monthly as per the treatment specifications. Being a popular cut flower, improvement in floral attributes is very much valued in Anthurium. The study concluded that the treatment T8 i.e., application of cow dung supernatant and 2 g L-119:19:19 weekly once as foliar spray along with foliar application of 2% humic acid - fulvic acid mixture and 100 mg L-1 salicylic acid at fortnightly intervals exhibited superior values for stalk length, spathe length, spathe width, number of flowers, flower longevity and vase life and it also recorded earliest flower bud initiation. The results revealed that growth and floral attributes of Anthurium can be improved through the foliar application of treatment T8.

Keywords: *Biostimulants; growth; yield; flower quality.*

1. INTRODUCTION

Anthurium andreanum Lind., a tropical decorative plant, is globally admired for its vibrant and enduring distinct flowers, along with its appealing foliage. Anthurium blooms are cherished for their unique shapes and come in a variety of colors. The cultivation of anthurium as a cut flower has experienced a significant surge in popularity in recent years. Flower arrangers particularly favor them for their striking impact and enduring characteristics. The profitability of cultivating and marketing anthurium has been evident due to the rising demand in both local and global markets.

The production and quality of anthurium flowers are influenced by environmental, nutritional, and management factors. It comes up well under temperatures of 21°C - 24°C, and relative humidity of 60% - 80% with low to medium light intensity of 20000 to 25000 Lux. Growth and yield can be achieved at 60% - 80 % shade in different conditions [1]. Nevertheless, attaining prosperity in commercial cultivation relies on optimizing nutrient availability and effective utilization by the plant. In favorable agro-climatic settings, mineral nutrition plays a crucial role in shaping the growth, yield, and quality of anthurium flowers. Numerous sources can meet the nutrient requirements of anthurium, with chemical fertilizers playing a significant role. The foliar application of nutrients proves to be a convenient and swift method to fulfil the nutritional needs of anthurium, as stated by [2].

Overusing traditional fertilizers in an imbalanced manner can reduce the efficiency of nutrient uptake by plants, leading to a decline in crop yield. Weekly once foliar application of 30:10:10 (NPK) at 0.2% recorded significantly maximum plant height, number of leaves, leaf petiole and plant spread. Whereas early flower bud emergence, early unfurling of spathe, and maximum stalk length diameter, spathe length,

spathe width and flower yield were recorded in plants sprayed with 12:61:40 (NPK) at 0.2 % once in a week [3]. In the current global context, there is a significant push towards adopting environmentally friendly agricultural practices to ensure sustainable production. This is particularly important due to the escalating costs of inorganic fertilizers, making them unaffordable for small and marginal farmers. Biofertilizers and biostimulants have recently emerged as alternatives to mineral fertilizers, with the potential to improve both crop yield and quality.

A plant biostimulant refers to any substance or microorganism applied to plants with the intention of improving nutrition efficiency, tolerance to abiotic stress, and/or quality traits, irrespective of its nutrient content, as defined by [4]. Numerous studies have demonstrated that both microbial and non-microbial plant biostimulants have the ability to induce various morpho-anatomical, biochemical, physiological, and molecular responses in plants. These responses encompass enhancements in crop productivity, nitrogen use efficiency (NUE), and increased resilience to abiotic stresses. The application of biostimulants in the cultivation of flower crops promotes higher levels of sustainability by reducing the need for fertilizers, minimizing environmental contamination, and boosting plant resilience to both abiotic and biotic stresses, thereby improving internal and external quality.

The current experiment carried out to evaluate the impact of different biostimulants on growth, yield and quality of anthurium is crucial for optimizing nutrient management. This experiment provides valuable insights into the specific biostimulants that enhance plant growth, improve stress resistance and elevate ornamental quality. By systematically testing various biostimulants, growers can identify the most effective and economically viable option for

anthurium. This knowledge not only leads to increased productivity and quality of anthurium, but also contributes to sustainable agricultural practices by minimizing environmental impacts.

Considering all these aspects, the current research was carried out to examine the impact of various biostimulants on the growth, yield, and quality parameters of *Anthurium andreaenum* cv. Dora.

2. MATERIALS AND METHODS

The study was conducted in a naturally ventilated polyhouse in the Department of Floriculture and Landscaping, College of Agriculture, Vellayani under Kerala Agricultural University, during 2022-23. The design used was completely randomized design with ten replications and 15 treatments as shown in Table 1.

Table 1. Treatments used in the experiment

Sl. No.	Treatments	Treatment particulars
1.	T ₁ (Control)	Fertilizers and manures as per Package of Practices of KAU 2016 (cow dung supernatant + 19:19:19 (2 g L ⁻¹) weekly once)
2.	T ₂	T ₁ + 0.2% humic acid at fortnightly intervals
3.	T ₃	T ₁ + 0.2% humic acid at monthly intervals
4.	T ₄	T ₁ + 2% humic acid - fulvic acid mixture at fortnightly intervals
5.	T ₅	T ₁ + 2% humic acid - fulvic acid mixture at monthly intervals
6.	T ₆	T ₁ + 100 mg L ⁻¹ salicylic acid at fortnightly intervals
7.	T ₇	T ₁ + 100 mg L ⁻¹ salicylic acid at monthly intervals
8.	T ₈	T ₁ + 2% humic acid - fulvic acid mixture+ 100 mg L ⁻¹ salicylic acid at fortnightly intervals
9.	T ₉	T ₁ + 2% humic acid - fulvic acid mixture + 100 mg L ⁻¹ salicylic acid at monthly intervals
10.	T ₁₀	T ₁ + 0.5% seaweed extract at fortnightly intervals
11.	T ₁₁	T ₁ + 0.5% seaweed extract at monthly intervals
12.	T ₁₂	T ₁ + 0.2% humic acid + 0.5% seaweed extract at fortnightly intervals
13.	T ₁₃	T ₁ + 0.2% humic acid + 0.5% seaweed extract at monthly intervals
14.	T ₁₄	T ₁ + 2% humic acid - fulvic acid mixture + 0.5% seaweed extract at fortnightly intervals
15.	T ₁₅	T ₁ + 2% humic acid - fulvic acid mixture + 0.5% seaweed extract at monthly intervals



Plate 1. General view of the experimental site

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height

The recorded observations on plant height are presented in Table 2. Among the different treatments, in T₁₂ exhibited significantly higher plant height at various stages of plant growth, with measurements of 17.70 cm at 30 DAP, 24.67 cm at 150 DAP, 28.81 cm at 210 DAP, 29.10 cm at 270 DAP, and 29.30 cm at 330 DAP. At 90 DAP, T₁₃ displayed the highest plant height (21.08 cm). At 330 DAP, the plant height of T₁₂ (29.30 cm) was comparable to that of T₅, T₆, T₈, T₁₀, T₁₁, T₁₃, and T₁₄, which registered measurements of 26.85 cm, 28.20 cm, 28.75 cm, 28.02 cm, 27.22 cm, 26.78 cm, and 28.65 cm, respectively. The lowest plant height was observed in T₉ at 30 DAP and 90 DAP, and from that point onwards until 330 DAP, T₁ consistently displayed the minimum plant height. The increase in plant height can be attributed to the capacity of humic acid to improve nutrient absorption in plants. By facilitating the movement of micronutrients across the leaf surface and into the plant's vascular system, humic acid enhances nutrient availability and uptake, ultimately fostering plant growth and development. This, in turn, results in an increase in plant height. Similar findings were observed by [5] and [6] in the context of marigold. Whereas, seaweed extract function as regulators of plant growth, exerting stimulating effects via growth

substances like cytokinins, auxins, and abscisic acid. Consequently, they influence cellular metabolism in treated plants, ultimately contributing to heightened plant height. This observation aligns with the results reported by [7].

3.1.2 Stem girth

Until 90 DAP, there were no significant differences in stem girth among the various treatments. However, from 150 DAP to 330 DAP, the treatment T₈, exhibited the maximum stem girth value. At 330 DAP, T₈ recorded the highest stem girth value at 1.45 cm, and this was comparable to T₂, T₄, and T₉, which displayed stem girths of 1.34 cm, 1.34 cm, and 1.44 cm, respectively. In contrast, T₁₃ exhibited the lowest stem girth from 150 DAP onwards (Table- 3). The increase in stem girth can be attributed to the ability of humic substances to chelate or bind with nutrients, thereby improving their accessibility to plants and subsequently enhancing nutrient uptake. As a result, this facilitates plant growth and development, contributing to the increase in stem girth. Similar findings were observed in research conducted by [5], [6] and [8] in African marigold. In addition to that salicylic acid (SA) enhances plant performance by promoting the formation of specific enzymes, which in turn stimulates chlorophyll synthesis and boosts photosynthetic activities. This ultimately leads to the advancement of plant growth, as observed in the study by [9].

Table 2. Effect of different biostimulants on plant height (cm) of *Anthurium andreanum* cv. Dora

Treatments	30 DAP	90 DAP	150 DAP	210 DAP	270 DAP	330 DAP
T ₁	15.10	18.52	19.53	22.39	22.51	23.01
T ₂	17.44	21.01	23.37	25.39	25.46	25.82
T ₃	13.40	18.00	22.37	24.58	25.49	25.41
T ₄	16.00	20.80	24.59	25.58	25.86	26.06
T ₅	16.00	21.06	24.60	26.23	26.53	26.85
T ₆	13.70	21.06	22.21	25.52	26.89	28.20
T ₇	15.90	18.00	22.21	25.75	26.03	26.34
T ₈	15.00	19.46	23.27	27.76	28.10	28.75
T ₉	11.10	16.21	19.94	23.17	23.96	24.71
T ₁₀	13.20	17.28	22.89	26.18	26.73	28.02
T ₁₁	13.70	18.20	22.67	24.18	25.26	27.22
T ₁₂	17.70	21.06	24.67	28.81	29.10	29.30
T ₁₃	16.90	21.08	23.24	25.26	25.50	26.78
T ₁₄	16.80	19.35	22.85	25.49	27.82	28.65
T ₁₅	12.00	18.30	21.90	22.92	24.62	25.45
SE(m)	1.177	1.24	1.038	1.071	1.058	1.036
CD (0.05)	3.29	3.47	2.90	2.98	2.96	2.89

Table 3. Effect of different biostimulants on stem girth (cm) of *Anthurium andreanum* cv. Dora

Treatments	30 DAP	90 DAP	150 DAP	210 DAP	270 DAP	330 DAP
T ₁	0.38	0.58	0.70	0.93	0.96	1.18
T ₂	0.38	0.58	0.74	1.14	1.31	1.34
T ₃	0.33	0.60	0.85	1.12	1.29	1.29
T ₄	0.35	0.72	0.84	1.09	1.29	1.34
T ₅	0.39	0.62	0.70	1.09	1.17	1.23
T ₆	0.36	0.55	0.82	0.98	1.12	1.24
T ₇	0.35	0.60	0.76	0.96	1.20	1.28
T ₈	0.36	0.60	1.10	1.20	1.32	1.45
T ₉	0.40	0.64	0.93	1.14	1.24	1.44
T ₁₀	0.35	0.67	0.80	1.03	1.18	1.22
T ₁₁	0.36	0.69	0.83	0.88	0.95	1.20
T ₁₂	0.37	0.66	0.79	0.84	0.92	1.11
T ₁₃	0.37	0.62	0.67	0.80	0.81	1.04
T ₁₄	0.32	0.58	0.69	0.82	1.02	1.09
T ₁₅	0.26	0.68	0.89	0.82	0.99	1.16
SE(m)	0.03	0.05	0.05	0.06	0.05	0.05
CD (0.05)	NS	NS	0.15	0.16	0.14	0.13

3.1.3 Leaf length and Leaf width

Leaf length measurements were recorded at bimonthly intervals, commencing from one month after planting as shown in Table 4. However, significant variations were observed among the treatments only from 150 DAP. Among the various treatments, T₈ consistently demonstrated the highest leaf length, measuring 10.05 cm at 150 DAP, 12.50 cm at 210 DAP, 13.48 cm at 270 DAP, and 13.90 cm at 330 DAP. Leaf length ranged from 8.41 cm to 13.90 cm at 330 DAP, when T₈ was on par with T₉ (13.37 cm) and it was followed by T₁₀ which recorded a leaf length of 10.27 cm. Throughout

the period from 150 DAP to 330 DAP, T₃ consistently displayed the shortest leaf length among the treatments. A steady and gradual rise in leaf breadth was observed across all the treatments during the experiment from 150 DAP to 330 DAP (Table 5.). The maximum leaf breadth, measuring 9.84 cm, was observed in T₈ at 150 DAP. T₈ consistently displayed the highest leaf breadth throughout the experiment, with values of 11.10 cm at 210 DAP, 11.45 cm at 270 DAP, and 11.99 cm at 330 DAP. Conversely, from 150 DAP to 270 DAP, T₄ consistently exhibited the smallest leaf breadth. However, at 330 DAP, the treatment T₃ recorded the minimum leaf breadth.

Table 4. Effect of different biostimulants on length of leaves (cm) of *Anthurium andreanum* cv. Dora

Treatments	30 DAP	90 DAP	150 DAP	210 DAP	270 DAP	330 DAP
T ₁	7.35	8.58	8.60	9.40	9.52	9.35
T ₂	8.00	8.23	8.55	9.12	9.14	9.35
T ₃	7.35	7.51	7.90	8.03	8.06	8.41
T ₄	6.65	7.57	7.73	8.04	8.47	8.47
T ₅	7.80	8.41	8.96	9.17	9.22	9.41
T ₆	8.20	9.27	8.23	9.19	9.21	9.42
T ₇	7.80	8.35	9.02	9.61	9.66	9.65
T ₈	8.10	8.75	10.05	12.50	13.48	13.90
T ₉	6.80	8.60	9.30	11.36	11.90	13.37
T ₁₀	7.70	9.08	9.10	9.59	9.79	10.27
T ₁₁	7.40	8.30	7.81	8.97	8.97	9.06
T ₁₂	7.00	8.70	8.10	8.80	8.80	8.57
T ₁₃	7.40	7.40	7.95	9.54	9.55	8.77
T ₁₄	7.40	8.25	8.90	8.73	8.83	9.17
T ₁₅	6.40	8.30	8.51	9.92	9.92	9.35
SE(m)	0.51	0.49	0.45	0.39	0.38	0.26
CD (0.05)	NS	NS	1.27	1.10	1.07	0.73

The plant growth-regulating effect of humic substances may arise from both the direct impact of soluble humic complexes and an elevation in the concentration of endogenous hormones in tissues. This elevation is a result of the inhibition of specific catabolic enzymes, such as IAA oxidase, by soluble humic complexes, as proposed by [10]. The elongation and widening of leaves can be attributed to the existence of precursor substances for growth, such as indole-3-acetic acid (IAA), in humic-fulvic acid. These

precursors likely played a role in the expansion of leaves. The present results align with the observations reported by [11]. As per [12], salicylic acid demonstrates a synergistic interaction with auxin and gibberellin. Salicylic acid stimulates the synthesis of these hormones, leading to an augmentation in both leaf length and breadth. It encourages the elongation of cells, triggers cell division, facilitates protein synthesis, and regulates the interaction between sink and source in the plant.

Table 5. Effect of different biostimulants on width of leaves (cm) of *Anthurium andreaeanum* cv. Dora

Treatments	30 DAP	90 DAP	150 DAP	210 DAP	270 DAP	330 DAP
T ₁	5.80	5.85	6.41	6.72	7.24	7.30
T ₂	5.55	6.12	6.72	7.31	7.39	7.76
T ₃	5.20	5.31	6.25	6.27	6.34	6.41
T ₄	5.15	5.22	5.61	5.93	6.11	6.49
T ₅	5.55	6.31	6.97	7.16	7.22	7.49
T ₆	6.20	6.31	6.72	7.22	7.24	7.25
T ₇	5.10	6.38	7.43	7.59	7.62	7.84
T ₈	5.30	6.05	9.84	11.10	11.45	11.99
T ₉	4.30	5.94	9.34	9.47	9.57	10.39
T ₁₀	5.55	6.51	6.95	7.43	7.66	8.28
T ₁₁	4.80	6.10	6.62	6.97	6.99	7.14
T ₁₂	5.35	6.91	6.93	7.65	7.80	7.82
T ₁₃	5.51	6.35	6.64	7.50	7.54	7.80
T ₁₄	5.30	5.94	7.31	6.80	7.01	7.74
T ₁₅	6.11	6.51	7.31	7.73	7.84	8.11
SE(m)	0.37	0.39	0.399	0.377	0.367	0.290
CD (0.05)	NS	NS	1.11	1.05	1.02	0.81

Table 6. Effect of different biostimulants on flowering and post-harvest parameters in *Anthurium andreaeanum* cv. Dora

Treatment	flower bud initiation (days)	Stalk length (cm)	Flower longevity (days)	Number of flowers/ plant	Vase life (days)
T ₁	321.1	18.69	15.1	0.27	8.1
T ₂	316.8	19.09	19.1	0.28	8.3
T ₃	312.0	19.09	16.0	0.28	9.1
T ₄	302.5	20.53	21.4	0.40	9.0
T ₅	317.1	21.11	21.9	0.34	9.3
T ₆	268.9	20.69	20.5	0.58	10.5
T ₇	246.8	20.47	17.4	0.56	9.6
T ₈	215.8	23.04	31.4	1.05	12.7
T ₉	214.1	22.73	28.0	0.77	12.5
T ₁₀	285.9	21.58	21.2	0.77	9.7
T ₁₁	275.0	21.09	22.7	0.53	8.8
T ₁₂	293.1	21.32	19.9	0.36	8.8
T ₁₃	311.2	20.59	23.7	0.41	9.0
T ₁₄	297.0	20.40	19.4	0.36	9.0
T ₁₅	287.2	20.41	21.3	0.42	8.7
SE(m)	12.26	0.46	2.85	0.14	0.43
CD (0.05)	34.28	1.29	7.96	0.40	1.21

3.2 Floral Parameters

3.2.1 Days to flower bud initiation

The Table-6 provides information on the impact of different biostimulants on the duration required for the initiation of flower buds. T₉ demonstrated the briefest timeframe (214.1 days) for the initiation of flower buds. Following closely behind T₉ were T₈ (215.8 days) and T₇ (246.8 days), which exhibited a similar duration. In contrast, T₁ required the maximum number of days (321.1) for the initiation of flower buds. An increased production of auxin and growth substances by humic acid during the initial growth phase likely played a role in promoting early flowering. The early emergence of flower buds can be linked to the initiation of metabolic activity and a decrease in the C:N ratio, attributed to the significant accumulation of carbohydrates. Similar observations regarding the influence of humic acid on the early appearance of flower buds were reported by [13] in gerbera. Additionally, SA has showcased its capacity to trigger flowering in different species, such as oncidium orchids and *Impatiens balsamina*, as noted by [14]. This aligns with the conclusions drawn in the present study.

3.2.2 Stalk length

T₈ showcased the highest peduncle length at 23.04 cm, which was comparable to T₉ at 22.73 cm. In contrast, the control group T₁ exhibited the shortest peduncle length at 18.69 cm (Table – 6). It is conceivable that the extended release of nutrients from the soil resulted in elevated nutrient uptake, ultimately contributing to the increased length of the stalk. Humic substances may have aided in the mobilization of stored food materials to the sink by enhancing the activity of

hydrolysing and oxidizing enzymes. This mechanism likely enhanced the availability and utilization of nutrients. The findings presented by [15] in gerbera align with the influence of humic substances in improving stalk length. Salicylic acid, recognized for its growth-promoting characteristics [16], seems to positively influence growth parameters by expediting both cell divisions and cell elongation in the apical section of the stalk. [17] found that applying salicylic acid through foliar spray resulted in a notable enhancement in stalk length and overall quality of cut roses.

3.2.3 Spathe length and width

In the concluding phase of the experiment, at 330 DAP, T₈ registered the maximum spathe length and width at 7.19 cm and 6.21 cm respectively. Spathe length at T₈ was comparable to T₉ at 6.97 cm and T₁₄ at 6.51 cm. whereas, spathe width at T₈ was comparable to T₉, T₁₄ and T₁₅ at 6.13 cm, 6.01 cm and 5.52 cm respectively. Conversely, the control group T₁ exhibited the smallest spathe length and width at 4.30 cm and 3.83 cm respectively, distinct from all other treatments (Figs 1 & 2). The augmentation in spathe length and breadth prompted by humic substances could be attributed to their influence on continuous cell elongation. Furthermore, the gibberellin-like activity exhibited by humic acid plays a role in the elongation of the spathe. The mechanism elucidated by [18] regarding the impact of humic acid on enhanced floret length might be applicable in this context. On the other hand, concerning spathe breadth, cytokinin inhibits the longitudinal growth of the floret while concurrently promoting an expansion in its diameter. The results obtained in the present study closely match the observations

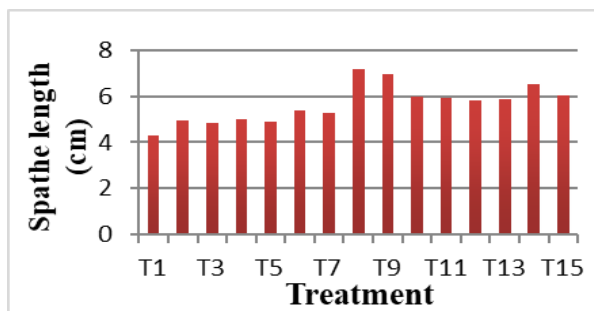


Fig 1. Effect of biostimulants on Spathe length of anthurium

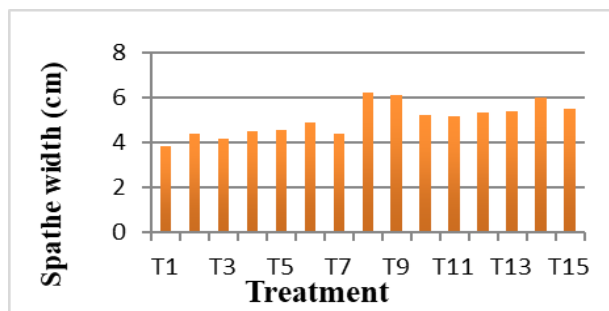


Fig 2. Effect of biostimulants on Spathe width of anthurium

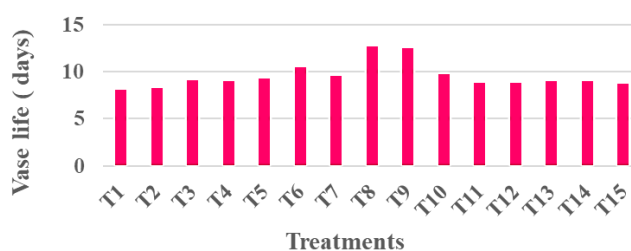


Fig 3. Effect of biostimulants on vase life of anthurium

documented by [19] in the case of anthurium. The use of salicylic acid (SA) has the potential to elevate auxin levels, consequently promoting flower growth, as suggested by studies such as those conducted by [20]. The current findings are consistent with the results reported by [21] in *Calendula officinalis*. Seaweed extracts display growth-stimulating effects, primarily due to their substantial influence on promoting cell division. This viewpoint is substantiated by research conducted by [22]. Consequently, the combination of a humic-fulvic acid mixture and seaweed extract also influenced the length and width of the spathe.

3.2.4 Number of flowers per plant

The information presented in Table 6. signifies a noteworthy disparity in the count of flowers per plant at 330 days after planting (DAP), attributed to the foliar application of biostimulants. Among the various treatments, T₈, displayed the greatest number of flowers at 330 DAP, reaching 1.05. This was statistically equivalent to the flower counts of T₉ and T₁₀, both recording 0.77 flowers per plant. In contrast, the control group, T₁, exhibited the lowest number of flowers per plant at 0.27, indicating a less favorable performance compared to all other treatments. Additionally, [23] found that the application of humic substances had a positive impact on the flower production of *Zinnia elegans* Jacq. and *Tagetes patula*. [24] noted that the improvement in plant growth and flower production was a consequence of the increased absorption of nutrients, including calcium, nitrogen, potassium, phosphorus, zinc, manganese, and iron, facilitated by the activities of fulvic and humic acids. This heightened effect is ascribed to a more potent stimulating function that hastens photosynthesis and enhances overall plant development. The increase in endogenous salicylic acid (SA) levels due to external application is linked to beneficial effects on both plant growth and flowering, as indicated by [25]. Salicylic acid (SA) has been reported to induce flowering in different plant species. [21] observed

that the foliar application of salicylic acid (SA) in marigold plants resulted in a higher number of flowers. The use of seaweed extract had a notable impact on the number of flowers as well. The increased yield was attributed to various concentrations of phytohormones present in the extracts, such as cytokinins, and the stimulation of the host's hormonal synthesis, as suggested by [26].

3.2.5 Flower longevity

The Table - 6 presents data showcasing the influence of biostimulants on the duration of flower longevity in *Anthurium andreanum* cv. Dora. The most extended period of flower longevity, lasting 31.4 days, was noted in T₈. This duration was similar to T₉ and T₁₃, where the flowers remained on the plants for 28.0 days and 23.7 days, respectively. In contrast, the briefest flower longevity was documented in T₁, with a duration of 15.1 days. The application of humic substances and salicylic acid on the leaves resulted in an extended natural lifespan of anthurium plants. It is hypothesized that humic acid could influence respiration by acting as a hydrogen acceptor, thereby altering the plant's carbohydrate metabolism and facilitating the accumulation of sugars, as proposed by [10]. With known cytokinins and auxins, humic acid might have contributed to increased antioxidant levels and improved resistance to senescence. This interpretation aligns with the findings of [27], supporting the prolonged spike longevity observed in gladiolus. Additionally, the use of salicylic acid resulted in an increase in the membrane stability index. Salicylic acid has been noted to contribute to alleviating plant stress responses and postponing senescence, as emphasized by [28].

3.3 Post Harvest Parameters

3.3.1 Vase life

The longest vase life was observed in T₈, resulted in a lasting duration of 12.7 days. This

performance was comparable to T₉, achieved a vase life of 12.5 days. In contrast, the control group T₁ recorded the shortest vase life at 8.1 days (Table – 6). The research showcases a significant improvement in the vase life of harvested anthurium flowers by using humic substances (HS). This prolonged lifespan is associated with an increased accumulation of calcium (Ca) in the flower stalks. [15] documented similar findings, indicating that humic substances played a role in extending the vase life of gerbera flowers. The brief vase life of cut flowers is attributed to unfavorable water relations, encompassing reduced water uptake possibly due to microbial growth and vascular blockage, coupled with elevated transpiration rates resulting in water loss. The beneficial effects of salicylic acid can be ascribed to its ability to diminish bacterial growth and vascular blockage, foster more favorable water uptake, and restrict water loss [29]. Additionally, salicylic acid has been found to reduce the transpiration rate [30] and impede ethylene action [19].

4. CONCLUSION

Anthurium is popular both as a cut flower and as a potted ornamental plant. Application of biostimulants significantly influenced the growth and floral attributes of *Anthurium andreaeanum* cv. Dora. Results of the present study revealed that fortnightly foliar application of 2 per cent humic acid - fulvic acid mixture in combination with 100 mg L⁻¹ salicylic acid along with weekly application of cow dung supernatant and 2 g L⁻¹ 19:19:19 exhibited the earliest flower bud initiation and also the highest values for stem girth, leaf length, leaf breadth, stalk length, spathe length, spathe width, number of flowers, flower longevity and vase life.

ACKNOWLEDGEMENT

Kerala Agricultural University for funding and facilities.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

- Prakash D, Sujatha K, Sangma. Anthurium. In: Advan. Orn. Hort. (Ed., Bhattacharjee, S.K.). Pointer Publishers, Jaipur. 2006;109-29.
- Kumar S, Nanda KK. Gibberellic acid-and salicylic acid-caused formation of new proteins associated with extension growth and flowering of *Impatiens balsamina*. *Biologia plantarum*. 1981;23(5):321-7.
- Tatte S, Chawla SL, Sudha P, Neelima P. Effect of growing media and primary nutrients on postharvest life of cut flowers of anthurium var. tropical. *Journal of Ornamental Horticulture*. 2017;20(1/2):75-9.
- Du Jardin P. Plant biostimulants: Definition, concept, main categories and regulation. *Sci hortic*. 2015;196:3-14.
- Jawaharlal M, Swapna C, Ganga M. Comparative analysis of conventional and precision farming systems for African marigold (*Tagetes erecta* L.). In International Conference on Quality Management in Supply Chains of Ornamentals QMSCO2012 970. 2012; 311-317.
- Azam MK, Jan I, Ghani A, Kamal A, Kalhoro AA, Aslam MZ, Nadeem S, Shah SWH, Aamer M, Zafar SN, Hussain A. Influence of humic acid on vegetative and reproductive attributes of African marigold (*Tagetes Erecta* L.). *Plant Cell Biotechnol Mol Biol*. 2022;58-67.
- Ibrahim ZR. Effect of foliar spray of ascorbic acid, Zn, seaweed extracts (Sea) force and biofertilizers (EM-1) on vegetative growth and root growth of olive (*Olea europaea* L.) transplants cv. HojBlanca. *Int J Pure Appl Sci Technol*. 2013;17(2):79.
- Sendhilnathan R, Rethinakumar M, Rajkumar M, Sureshkumar R. Effect of pinching and foliar application of organics on vegetative, floral attributes and quality of African marigold (*Tagetes erecta* L.). *Annals of Plant and Soil Research*. 2019;21(2):189-92.
- Hayat S, Ali B, Ahmad A. Salicylic acid: biosynthesis, metabolism and physiological role in plants. *Salicylic Acid: A Plant Hormone*. 2007:1-4.
- Cacco G. Plant growth regulator activity of soluble humic complex. *Can. J. Soil Sci*. 1984; 62:306-10.
- de Sanfilippo EC, Argüello JA, Abdala G, Orioli GA. Content of auxin-inhibitor-and gibberellin-like substances in humic acids. *Biologia Plantarum*. 1990;32:346-51.
- Datta KS, Nanda KK. Effect of some phenolic compounds and gibberellic acid on growth and development of Cheena millet (*Panicum miliaceus* L.).

- Indian J Plant Physiol. 1985; 28(3).
13. Kannan D, Rishu S, Bhatt SS, Abhay S. Fertigation studies on Gerbera (*Gerbera jamesonii* Bolus ex Hooker F.) for growth and yield under cover in southern hills (Shevaroy). Int J Trop Agric. 2015; 33(1):31-6.
 14. Raskin I. Role of salicylic acid in plants. Annu rev plant boil. 1992;43(1):439-63.
 15. Nikbakht A, Kafi M, Babalar M, Xia YP, Luo A, Etemadi NA. Effect of humic acid on plant growth, nutrient uptake, and postharvest life of gerbera. J Plant Nutr. 2008;31(12):2155-67.
 16. Ram M, Pal V, Singh MK, Kumar M. Response of different spacing and salicylic acid levels on growth and flowering of gladiolus (*Gladiolus grandiflora* L.). Hort Flora Research Spectrum. 2012;1(3):270-3.
 17. Mansouri M, Shoor M, Tehranifar A, Selahvarzi Y. Effect of foliar application of salicylic acid and thiamine on quantitative and qualitative characteristics of gerbera (*Gerbera jamesonii* L. cv. Pink Elegance). Journal of Science and Technology of Greenhouse Culture. 2015;6(23).
 18. Vaughan D. Effects of hydroxyproline on the growth and cell-wall protein metabolism of excised root segments of *Pisum sativum*. Planta. 1973;115:135-45.
 19. Muraleedharan A, Karuppaiah P, Joshi JL. Impact of humic acid along with growing media combination with azospirillum and fym on the growth, flowering and quality of Anthurium andraeanum plants. J Emerg Technol Innov Res. 2017;4(1).
 20. Zamani S, Kazemi M, Aran M. Postharvest life of cut rose flowers as affected by salicylic acid and glutamin. World Appl Sci J. 2011;12(9):1621-4.
 21. Pacheco AC, Cabral CD, Fermino ES, Aleman CC. Salicylic acid-induced changes to growth, flowering and flavonoids production in marigold plants. J. med. Plants res. 2013;7(42):3158-63.
 22. Soliman AI, Hussein MH, Dessouki SA, Torky Y. Production of phytohormones by using some blue green algae used as soil inoculants for rice fields in Egypt. J. Union Arab Biol., Cairo. (88): Physiology and Algae. 2000;83-102.
 23. Dudley JB, Pertuit AJ, Toler JE. Leonardite influences zinnia and marigold growth. Hort Science. 2004;39(2):251-5.
 24. Olaetxea M, De Hita D, Garcia CA, Fuentes M, Baigorri R, Mora V, Garnica M, Urrutia O, Erro J, Zamarreño AM, Berbara RL. Hypothetical framework integrating the main mechanisms involved in the promoting action of rhizospheric humic substances on plant root-and shoot-growth. Appl Soil Ecol. 2018;123:521-37.
 25. Kim YH, Hamayun M, Khan AL, Na CI, Kang SM, Han HH, Lee I. Exogenous application of plant growth regulators increased the total flavonoid content in *Taraxacum officinale* Wigg. Afr J Biotechnol. 2009;8(21).
 26. Kulkarni MG, Rengasamy KR, Pendota SC, Gruz J, Plačková L, Novák O, Doležal K, Van Staden J. Bioactive molecules derived from smoke and seaweed *Ecklonia maxima* showing phytohormone-like activity in *Spinacia oleracea* L. New biotechnol. 2019;48:83-9.
 27. Zhang X, Ervin EH. Cytokinin-containing seaweed and humic acid extracts associated with creeping bentgrass leaf cytokinins and drought resistance. Crop science. 2004;44(5):1737-45.
 28. Shi Q, Bao Z, Zhu Z, Ying Q, Qian Q. Effects of different treatments of salicylic acid on heat tolerance, chlorophyll fluorescence, and antioxidant enzyme activity in seedlings of *Cucumis sativa* L. Plant growth regul. 2006;48:127-35.
 29. Yazdani B, Nikbakht A, Etemadi N. Physiological effects of different combinations of humic and fulvic acid on Gerbera. Commun Soil Sci Plant Anal. 2014;45(10):1357-68.
 30. Mei-Hua F, Jian-Xin W, Ge S, Li-Na S, Ruofan L. Salicylic acid and 6-BA effects in shelf-life improvement of *Gerbera jamesonii* cut flowers. Northern Horticulture. 2008;8:117-20.