Research article

Biostimulants for promoting growth, yield and flower quality in *Anthurium andreanum* Lind.

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^{-1}19:19:19 weekly once) to all the treatments including the control (T_1). In addition, for treatments T_2 to T_{15}, 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 T_8 i.e., application of cow dung supernatant and 2 g L^{-1}19:19:19 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 T_8.

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℃ - 24℃, and relative humidity of 60% - 80% with low to medium light intensity of 20000 to 25000 Lux. Growth and yield an 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 andreanum* 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 T_{12} 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, T_{13} displayed the highest plant height (21.08 cm). At 330 DAP, the plant height of T_{12} (29.30 cm) was comparable to that of T_5, T_6, T_8, T_{10}, T_{11}, T_{13}, and T_{14}, 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 T_9 at 30 DAP and 90 DAP, and from that point onwards until 330 DAP, T_1 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 T_8, exhibited the maximum stem girth value. At 330 DAP, T_8 recorded the highest stem girth value at 1.45 cm, and this was comparable to T_2, T_4, and T_9, which displayed stem girths of 1.34 cm, 1.34 cm, and 1.44 cm, respectively. In contrast, T_{13} 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, T_8 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 T_8 was on par with T_9 (13.37 cm) and it was followed by T_{10} which recorded a leaf length of 10.27 cm. Throughout the period from 150 DAP to 330 DAP, T_3 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 T_8 at 150 DAP. T_8 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, T_4 consistently exhibited the smallest leaf breadth. However, at 330 DAP, the treatment T_3 recorded the minimum leaf breadth.

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 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

Table 5. Effect of different biostimulants on width of leaves (cm) of *Anthurium andreanum* 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 andreanum* 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

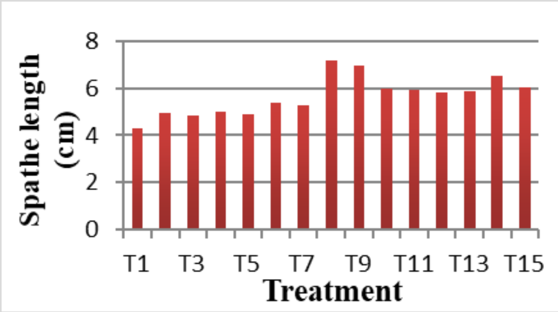

Fig 1. Effect of biostimulants on Spathe length of anthurium

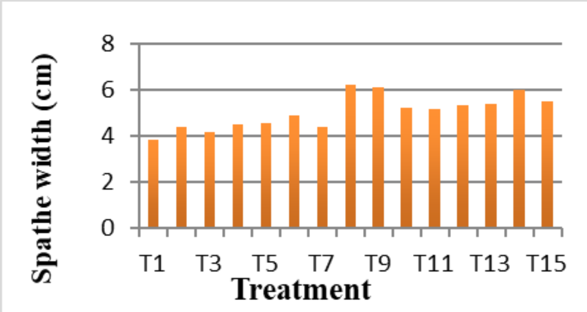

Fig 2. Effect of biostimulants on Spathe width of anthurium

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. T_9 demonstrated the briefest timeframe (214.1 days) for the initiation of flower buds. Following closely behind T_9 were T_8 (215.8 days) and T_7 (246.8 days), which exhibited a similar duration. In contrast, T_1 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

T_8 showcased the highest peduncle length at 23.04 cm, which was comparable to T_9 at 22.73 cm. In contrast, the control group T_1 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, T_8 registered the maximum spathe length and width at 7.19 cm and 6.21 cm respectively. Spathe length at T_8 was comparable to T_9 at 6.97 cm and T_{14} at 6.51 cm. whereas, spathe width at T8 was comparable to T_9, T_{14} and

T_{15} at 6.13 cm, 6.01 cm and 5.52 cm respectively. Conversely, the control group T_1 exhibited the smallest spathe length and width at 4.30 cm and 3.83 cm respectively, distinct from all other treatments (Fig 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 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, T_8, displayed the greatest number of flowers at 330 DAP, reaching 1.05. This was statistically equivalent to the flower counts of T_9 and T_{10}, both recording 0.77 flowers per plant. In contrast, the control group, T_1, 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 T_8. This duration was similar to T_9 and T_{13}, 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 T_1, 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 T_8, resulted in a lasting duration of 12.7 days. This performance was comparable to T_9, achieved a vase life of 12.5 days. In contrast, the control group T_1 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].

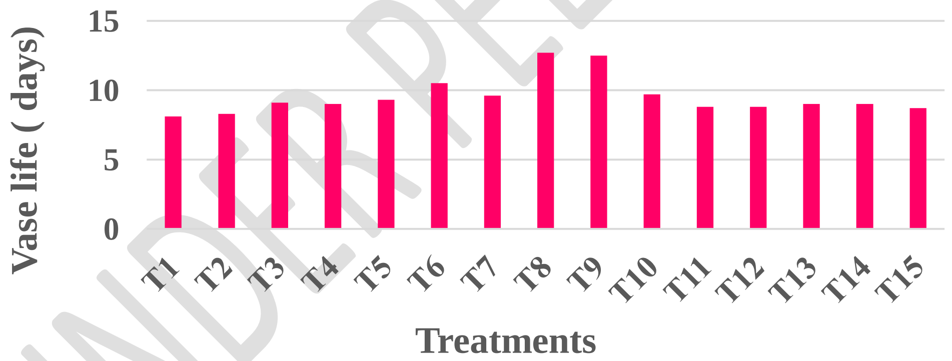

Fig 3. Effect of biostimulants on vase life of anthurium

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 andreanum* 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.

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