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STUDIES ON EFFICACY OF BIOSTIMULANTS ON GROWTH AND FLOWERING OF CALENDULA (*Calendula officinalis* L.) CV. BON BON ORANGE

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ABSTRACT

Calendula (*Calendula officinalis* L.) is an important ornamental flowering crop valued for its attractive flowers, prolonged flowering period and diverse uses. Biostimulants have emerged as an important tool for improving plant growth and flowering by stimulating physiological and biochemical processes. The present investigation was conducted during the Rabi season of 2025–2026 at the Post Graduate Institute for Horticultural Sciences, Sri Konda Laxman Telangana Horticultural University, Mulugu, Siddipet, Telangana, to evaluate the effect of different biostimulants on growth and flowering of calendula cv. Bon Bon Orange. The experiment was laid out in a Randomized Block Design with thirteen treatments and three replications. The treatments comprised seaweed extract, humic acid, Panchagavya, fulvic acid, protein hydrolysate and Spirulina extract at different concentrations along with an untreated control. Foliar application was carried out at 20, 40 and 60 days after transplanting. Growth parameters were recorded at 30, 60 and 90 days after transplanting and flowering parameters were recorded at the respective phenological stages. Among the treatments, T₂ (seaweed extract @ 0.8%) recorded superior performance for most of the growth and flowering parameters. At 90 days after transplanting, T₂ recorded maximum plant height (29.07 cm), stem diameter (1.89 cm), plant spread in East–West (40.77 cm) and North–South directions (41.70 cm), number of branches per plant (25.67), number of leaves per plant (227.47), chlorophyll content (35.23 SPAD) and leaf area (26.20 cm²). T₂ also recorded the earlier flower bud initiation (24.60 days), 50 per cent flowering (57.87 days) and minimum duration from bud initiation to full bloom (8.47 days). The highest number of flowers per plant (75.20) and longest flowering duration (93.53 days), maximum stalk length (14.25 cm) and flower weight (13.43 g). T₄ (Humic acid @ 0.8%) was statistically comparable with T₂ (seaweed extract @ 0.8%) for several growth and flowering parameters. The untreated T₁₃ (control) recorded the lowest performance for most characters. Hence, foliar application of seaweed extract @ 0.8% was found to be the most effective treatment for improving growth and flowering of calendula cv. Bon Bon Orange under the agro-climatic conditions of Telangana.

Key words: Calendula, biostimulants, seaweed extract, humic acid, Panchagavya, fulvic acid, protein hydrolysate, Spirulina extract.

Introduction

Calendula officinalis L., belongs to the family Asteraceae (Compositae), is an important herbaceous flowering species commonly known as pot marigold. The

genus *Calendula* comprises approximately 20 species and the crop is extensively cultivated for ornamental, medicinal and industrial purposes (Dinda and Craker, 1998; Sampath Kumar *et al.*, 2010). It is considered to be native of

Southern Europe and has successfully adapted to warm temperate regions due to its attractive floral characteristics and diverse utility (Cromack and Smith, 1998). *Calendula* flowers are widely used for garlands, bouquets and floral arrangements. The flowers are rich in carotenoid pigments, particularly xanthophylls and lutein, which are utilized as natural colourants in food products, cosmetics and poultry feed industries (Crabas *et al.*, 2003). The crop is also valued for its anti-inflammatory, antimicrobial, antifungal and wound-healing properties (Moghaddasi Mohammad *et al.*, 2012).

Biostimulants are substances or biological agents that enhance plant growth and productivity by stimulating inherent physiological processes, improving nutrient use efficiency and enhancing tolerance to abiotic stresses (Traon *et al.*, 2014). Among the different biostimulants, seaweed extracts derived from *Ascophyllum nodosum* are rich in bioactive compounds and promote plant growth and productivity (Kingman and Moore, 1982). Humic acids enhance antioxidant activity and help plants to mitigate stresses caused by drought, heat, ultraviolet radiation and chemical exposure (Syedabadi and Armin, 2014).

Panchagavya is an organic biostimulant containing essential nutrients and plant growth regulators such as IAA and gibberellic acid, which contribute to improved plant growth and productivity (Devdhara and Polara, 2024). Fulvic acids facilitate nutrient uptake, root development and plant growth (Calvo *et al.*, 2014). Protein hydrolysates, mainly consisting of amino acids and peptides, enhance nutrient assimilation, metabolic activity and tolerance to abiotic stress, whereas *Spirulina platensis* has gained attention as a natural biostimulant due to its rich nutritional composition and beneficial effects on plant growth and productivity (Jowkar and Bashiri, 2017).

In view of its potential importance and the scanty literature available on *Calendula*, very little research has been conducted on the use of different biostimulants in this crop. Therefore, the present investigation was undertaken to evaluate the effect of different biostimulants on growth and flowering of *calendula* (*Calendula officinalis* L.) cv. Bon Bon Orange.

Materials and Methods

The investigation entitled “Studies on efficacy of biostimulants on growth and flowering of *calendula* (*Calendula officinalis* L.) cv. Bon Bon Orange” was conducted during Rabi season 2025–2026 at the Post Graduate Institute for Horticultural Sciences, Sri Konda Laxman Telangana Horticultural University, Mulugu, Siddipet, Telangana, located at 17.721372° N latitude,

78.625627° E longitude and 451 m above mean sea level.

Healthy, disease-free, one-month-old seedlings of *calendula* cv. Bon Bon Orange were procured from Sneha Nursery, Ibrahimpatnam, Hyderabad, Telangana. The experiment was laid out in a Randomized Block Design (RBD) with 13 treatments and three replications. Each plot measured 2 × 2 m, accommodating 12 plants at a spacing of 60 × 45 cm. The treatments comprised two concentrations each of seaweed extract (*Ascophyllum nodosum*) @ 0.5 and 0.8%, humic acid @ 0.5 and 0.8%, Panchagavya @ 3 and 5%, fulvic acid @ 0.2 and 0.4%, protein hydrolysate @ 0.2 and 0.4%, and *Spirulina* extract @ 0.2 and 0.4%, along with an untreated control.

Farmyard manure @ 25 t ha⁻¹, vermicompost @ 3 t ha⁻¹ and neem cake @ 320 kg ha⁻¹ were applied uniformly. The recommended dose of fertilizers (120:180:60 kg ha⁻¹ N:P₂O₅:K₂O) was applied through urea, single super phosphate and muriate of potash. Thirty-day-old seedlings were transplanted on 18 October 2025. Irrigation was provided at weekly intervals, while hand weeding was carried out at 20 and 50 days after transplanting (DAT). Disbudding was performed at 20 DAT.

The respective biostimulants were applied as foliar sprays at 20, 40 and 60 DAT using a 2-L hand sprayer. Five representative plants were randomly selected and tagged in each plot for recording observations. Growth parameters viz., plant height, stem diameter, plant spread, number of branches, number of leaves, chlorophyll content and leaf area were recorded at 30, 60 and 90 DAT. Flowering parameters viz., days to flower bud initiation, days to 50 per cent flowering, days from bud initiation to full bloom, number of flowers per plant, flowering duration, stalk length and flower weight. The data were analysed statistically using Randomized Block Design. Treatment differences were tested using the F-test, and standard error of mean (SEm) and critical difference (CD) at 5 per cent significance level were calculated for significant treatment effects following Panse and Sukhatme (1985).

Results and Discussion

Growth parameters

Plant height (cm):

Plant height was significantly influenced by different biostimulant treatments at all stages of observation. T₂ (seaweed extract @ 0.8%) recorded the maximum plant height at 30 DAT (16.53 cm), 60 DAT (25.33 cm) and 90 DAT (29.07 cm), followed by T₄ (humic acid @ 0.8%) with 15.10, 23.37 and 26.87 cm, respectively. The minimum plant height was recorded in T₁₃ (control) with

9.50, 15.93 and 19.20 cm, respectively. Similar findings were reported by Sridhar and Rengasamy (2010) in marigold, Hegde *et al.*, (2016) in chrysanthemum and Tartil *et al.*, (2016) in pot marigold.

Stem diameter (cm):

Significant variation in stem diameter was observed among the treatments. T_2 (seaweed extract @ 0.8%) recorded the maximum stem diameter at 30 DAT (0.83 cm), 60 DAT (1.33 cm) and 90 DAT (1.89 cm), followed by T_4 (humic acid @ 0.8%) (0.75, 1.22 and 1.74 cm, respectively), whereas T_{13} (control) recorded the minimum values of 0.52, 0.91 and 1.40 cm, respectively. Similar results were reported by Pruthvi *et al.*, (2017) and Bhargavi *et al.*, (2018) in chrysanthemum and Praveen *et al.*, (2021) in rose.

Plant spread (East–West direction):

Plant spread in the East–West direction was significantly influenced by the treatments. T_2 (seaweed extract @ 0.8%) recorded the maximum plant spread of 25.73, 31.33 and 40.77 cm at 30, 60 and 90 DAT, respectively, and was statistically on par with T_4 (humic acid @ 0.8%), which recorded 25.47, 31.13 and 40.63 cm, respectively. The minimum values were recorded in T_{13} (control) with 15.47, 18.77 and 27.33 cm, respectively. Similar findings were reported by Sridhar and Rengasamy (2010) in marigold, Praveen *et al.*, (2021) in rose and Suchitha *et al.*, (2023) in chrysanthemum.

Plant spread (North–South direction):

Plant spread in the North–South direction also differed significantly among the treatments. T_2 (seaweed extract @ 0.8%) recorded the maximum values of 25.70, 30.77 and 41.70 cm at 30, 60 and 90 DAT, respectively, and was statistically on par with T_4 (humic acid @ 0.8%), which recorded 24.83, 29.87 and 40.77 cm, respectively.

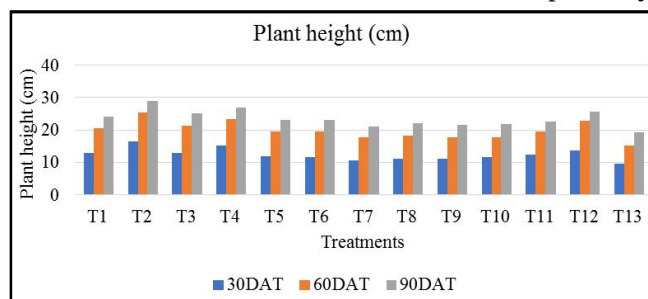


Fig. 1: Effect of biostimulants on plant height (cm) of Calendula cv. Bon Bon Orange. T_1 - Seaweed extract @0.5%, T_2 - Seaweed extract @0.8%, T_3 - Humic acid @0.5%, T_4 - Humic acid @0.8%, T_5 - Panchagavya@3%, T_6 - Panchagavya@5%, T_7 -Fulvic acid@0.2%, T_8 - Fulvic acid@0.4%, T_9 -Protein hydrolysate@0.2%, T_{10} -Protein hydrolysate@0.4%, T_{11} -Spirulina extract@0.2%, T_{12} -Spirulina extract@0.4%, T_{13} -Control.

The minimum plant spread was recorded in T_{13} (control) with 15.33, 18.60 and 26.27 cm, respectively. Similar observations were reported by Sridhar and Rengasamy (2010) in marigold, Praveen *et al.*, (2021) in rose and Suchitha *et al.*, (2023) in chrysanthemum.

Number of branches per plant:

The number of branches per plant was significantly influenced by the treatments. T_2 (seaweed extract @ 0.8%) recorded the highest number of branches at 30, 60 and 90 DAT (9.23, 15.63 and 25.67, respectively), followed by T_4 (humic acid @ 0.8%) with 8.37, 14.37 and 23.30 branches, respectively. The lowest number of branches was recorded in T_{13} (control) with 4.83, 9.50 and 16.47, respectively. Similar findings were reported by Sridhar and Rengasamy (2010) in marigold and Tartil *et al.*, (2016) in pot marigold.

Number of leaves per plant:

The treatments significantly influenced the number of leaves per plant. T_2 (seaweed extract @ 0.8%) recorded the highest number of leaves at 30, 60 and 90 DAT (55.33, 142.83 and 227.47, respectively). It was statistically on par with T_4 (humic acid @ 0.8%) at 30 DAT (53.73) and 90 DAT (226.47) and with T_4 and T_{12} (Spirulina extract @ 0.4%) at 90 DAT. The lowest values were recorded in T_{13} (control) with 24.67, 61.00 and 160.20 leaves, respectively. Similar results were reported by Sridhar and Rengasamy (2010) in marigold and Hegde *et al.*, (2016) in chrysanthemum.

Chlorophyll content:

Chlorophyll content showed significant variation among the treatments. T_2 (seaweed extract @ 0.8%) recorded the highest chlorophyll content of 21.96, 27.50 and 35.23 SPAD at 30, 60 and 90 DAT, respectively. It was statistically on par with T_4 (humic acid @ 0.8%) at

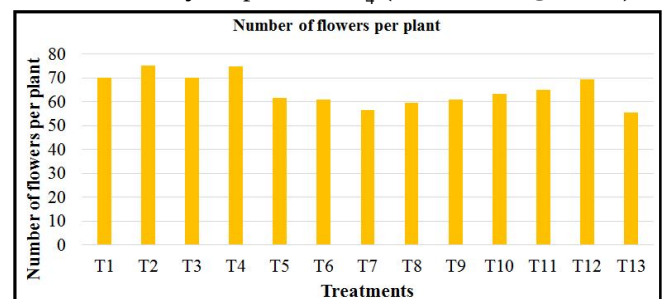


Fig. 2: Effect of biostimulants on number of flowers per plant of Calendula cv. Bon Bon Orange. T_1 - Seaweed extract @0.5%, T_2 - Seaweed extract @0.8%, T_3 - Humic acid @0.5%, T_4 - Humic acid @0.8%, T_5 - Panchagavya@3%, T_6 - Panchagavya@5%, T_7 -Fulvic acid@0.2%, T_8 - Fulvic acid@0.4%, T_9 -Protein hydrolysate@0.2%, T_{10} -Protein hydrolysate@0.4%, T_{11} -Spirulina extract@0.2%, T_{12} -Spirulina extract@0.4%, T_{13} -Control.

Table 1: Effect of biostimulants on growth and flowering parameters of Calendula cv. Bon Bon Orange.

Treatment	PH	SD	PS		NB	NL	CC	LA	DTB	DTF	DBB	NFP	DF	SL	WF
			EW	NS											
T ₁	24.20 ^{cd}	1.59 ^c	37.33 ^b	36.70 ^{bc}	22.53 ^{bc}	212.80 ^{ab}	32.92 ^{ab}	22.57 ^b	26.80 ^{fg}	60.07 ^{fg}	9.27 ^{ef}	70.17 ^{ab}	90.73 ^{ab}	12.26 ^{bc}	12.41 ^{bc}
T ₂	29.07 ^a	1.89 ^a	40.77 ^a	41.70 ^a	25.67 ^a	227.47 ^a	35.23 ^a	26.20 ^a	24.60 ^h	57.87 ^a	8.47 ^a	75.20 ^a	93.53 ^a	14.25 ^a	13.43 ^a
T ₃	25.13 ^{bc}	1.59 ^c	34.07 ^c	35.53 ^{bc}	22.47 ^{bc}	212.13 ^{ab}	30.47 ^{bc}	21.57 ^{bc}	27.27 ^{fg}	60.27 ^{fg}	9.40 ^{ef}	69.97 ^{ab}	90.27 ^{bc}	12.06 ^{bc}	11.66 ^{de}
T ₄	26.87 ^b	1.74 ^b	40.63 ^a	40.77 ^a	23.30 ^b	226.47 ^a	34.83 ^a	25.25 ^a	26.40 ^g	59.60 ^{fg}	9.13 ^f	74.93 ^a	92.20 ^{ab}	13.67 ^a	12.65 ^b
T ₅	23.00 ^{de}	1.58 ^c	34.07 ^c	32.67 ^{de}	21.47 ^{bc}	199.13 ^{bc}	28.44 ^{cd}	21.51 ^{bc}	29.53 ^{bc}	64.53 ^{cd}	10.83 ^{ab}	61.53 ^{cd}	86.27 ^d	11.41 ^{cd}	11.23 ^{de}
T ₆	23.07 ^{de}	1.64 ^{bc}	33.13 ^{cd}	33.47 ^{cd}	22.40 ^{bc}	211.47 ^{ab}	29.27 ^{cd}	21.49 ^{bc}	28.13 ^{de}	64.47 ^{cd}	10.53 ^{bc}	61.00 ^{cd}	87.93 ^{cd}	12.23 ^{bc}	11.29 ^{de}
T ₇	20.97 ^{fg}	1.55 ^c	30.67 ^d	29.27 ^f	18.97 ^e	178.50 ^d	26.75 ^{ef}	19.04 ^{de}	31.17 ^{ab}	69.87 ^{ab}	11.27 ^a	56.40 ^d	79.40 ^e	10.59 ^f	9.90 ^h
T ₈	22.10 ^{ef}	1.59 ^c	32.20 ^{cd}	31.73 ^{ef}	20.87 ^{cd}	179.40 ^d	26.95 ^{ef}	19.13 ^{cd}	30.60 ^{ab}	69.80 ^b	11.00 ^{ab}	59.73 ^{cd}	81.73 ^e	11.47 ^{cd}	9.99 ^{gh}
T ₉	21.53 ^f	1.59 ^c	33.40 ^{cd}	32.93 ^{cd}	20.80 ^{de}	183.23 ^{cd}	27.09 ^{ef}	20.86 ^{bc}	29.93 ^{ab}	67.67 ^{bc}	11.07 ^{ab}	61.00 ^{cd}	81.47 ^e	10.64 ^{ef}	10.66 ^{fg}
T ₁₀	21.90 ^f	1.61 ^{bc}	32.60 ^{cd}	33.20 ^{cd}	22.13 ^{bc}	198.07 ^{bc}	28.90 ^{cd}	20.90 ^{bc}	29.70 ^{bc}	65.73 ^{cd}	11.00 ^{ab}	63.47 ^{bc}	81.93 ^e	10.81 ^{de}	10.85 ^f
T ₁₁	22.53 ^{ef}	1.61 ^{bc}	33.20 ^{cd}	35.70 ^{bc}	22.40 ^{bc}	211.67 ^{ab}	30.32 ^{bc}	22.12 ^b	28.33 ^{cd}	63.53 ^{de}	10.20 ^{cd}	65.07 ^{bc}	88.73 ^{cd}	12.67 ^{bc}	11.14 ^{ef}
T ₁₂	25.67 ^{bc}	1.63 ^{bc}	34.20 ^{cd}	37.47 ^b	23.00 ^{bc}	213.07 ^{ab}	30.76 ^{bc}	22.39 ^b	27.83 ^{ef}	61.73 ^{ef}	9.83 ^{de}	69.47 ^{ab}	90.57 ^{ab}	12.70 ^{bc}	11.90 ^{cd}
T ₁₃	19.20 ^g	1.40 ^d	27.33 ^c	26.27 ^g	16.47 ^f	160.20 ^e	25.13 ^f	16.77 ^e	31.67 ^a	73.10 ^a	11.40 ^a	55.40 ^d	74.27 ^f	9.14 ^g	8.40 ⁱ
SEM±	0.82	0.05	1.11	1.06	0.74	6.01	1.04	0.86	0.61	1.12	0.20	2.38	1.07	0.49	0.25
CD@5%	2.40	0.14	3.24	3.09	2.15	17.55	1.72	2.50	1.71	3.26	0.57	6.96	3.14	1.42	0.73

PH: Plant height (cm); SD: Stem diameter (cm); PS: Plant spread (cm); NB: Number of branches; NL: Number of leaves; CC: Chlorophyll content (SPAD); LA: Leaf area (cm²); DTB: Days taken for bud initiation; DTF: Days taken for 50% flowering; DBB: Days taken from bud initiation to full bloom;

NFP: Number of flowers per plant; DF: Duration of flowering; SL: Stalk length (cm); WF: Weight of flower (g)

all stages and also with T₁₂ (Spirulina extract @ 0.4%) at 60 DAT. The lowest chlorophyll content was recorded in T₁₃ (control) with 15.42, 17.05 and 25.13 SPAD, respectively. Comparable results were reported by Majeed Khadim Al-Hamzawi (2019) in *Dianthus chinensis* and *Gazania splendens*.

Leaf area:

Leaf area was significantly affected by different biostimulant treatments. T₂ (seaweed extract @ 0.8%) recorded the maximum leaf area of 14.81, 21.32 and 26.20 cm² at 30, 60 and 90 DAT, respectively, and remained statistically on par with T₄ (humic acid @ 0.8%), which recorded 14.17, 20.89 and 25.25 cm², respectively. The minimum leaf area was recorded in T₁₃ (control) with 10.29, 14.63 and 16.77 cm², respectively. These results are consistent with the findings of Bhargavi *et al.*, (2018) in chrysanthemum, Praveen *et al.*, (2021) in rose and Archana *et al.*, (2023) in Asiatic lily.

The superior growth performance of calendula under T₂ (seaweed extract @ 0.8%) may be attributed to the presence of naturally occurring growth-promoting substances, minerals, amino acids and other bioactive compounds in seaweed extract. These components enhance nutrient uptake, photosynthetic activity, cell division and cell elongation, thereby promoting overall vegetative growth. The enhanced vegetative growth was reflected in higher plant height, stem diameter, plant spread, number of branches, number of leaves, chlorophyll content and leaf area. (Khan *et al.*, 2009; Craigie, 2011).

Flowering attributes

Days to flower bud initiation:

The number of days taken for flower bud initiation differed significantly among the treatments. T₂ (seaweed extract @ 0.8%) recorded the minimum number of days (24.60 days), followed by T₄ (humic acid @ 0.8%) (26.40 days), whereas the maximum number of days was recorded in T₁₃ (control) (31.67 days). Similar findings have been reported by Suchitha *et al.*, (2023) in chrysanthemum and Veeresh *et al.*, (2024) in china aster.

Days to 50 per cent flowering:

Days to 50 per cent flowering differed significantly among the treatments. T₂ (seaweed extract @ 0.8%) recorded the earliest 50 per cent flowering (57.87 days), which was statistically on par with T₄ (humic acid @ 0.8%) (59.60 days). The maximum number of days was recorded in T₁₃ (control) (73.10 days). These results are in agreement with the findings of Pruthvi *et*

al., (2017) in chrysanthemum and Veeresh *et al.*, (2024) in china aster.

Days taken from bud initiation to full bloom:

Days taken from bud initiation to full bloom showed significant variation among the treatments. The minimum number of days taken from bud initiation to full bloom was recorded in T₂ (Seaweed extract @ 0.8%) (8.47 days), followed by T₄ (Humic acid @ 0.8%) (9.13 days). The maximum duration was observed in T₁₃ (Control) (11.40 days).

Number of flowers per plant:

The number of flowers per plant was significantly influenced by the treatments. T₂ (seaweed extract @ 0.8%) recorded the highest number of flowers (75.20), which was statistically on par with T₄ (humic acid @ 0.8%) (74.93). The lowest number of flowers was recorded in T₁₃ (control) (55.40). The present results are supported by the findings of Sridhar and Rengasamy (2010) in marigold, Hegde *et al.*, (2016) in chrysanthemum, Tartil *et al.*, (2016) in pot marigold.

Duration of flowering:

The longest flowering duration was differed significantly among treatments. T₂ (seaweed extract @ 0.8%) (93.53 days), which was statistically on par with T₄ (humic acid @ 0.8%) (92.20 days) and T₁₂ (Spirulina extract @ 0.4%) (90.57 days). The shortest flowering duration was recorded in T₁₃ (control) (74.27 days). These findings are in accordance with the reports of Sridhar and Rengasamy (2010) in marigold, Lingwal *et al.*, (2019) in strawberry, Suchitha *et al.*, (2023) in chrysanthem and Veeresh *et al.*, (2024) in china aster.

Stalk length:

Stalk length showed significant variation among the treatments. T₂ (seaweed extract @ 0.8%) recorded the maximum stalk length (14.25 cm), which was statistically on par with T₄ (humic acid @ 0.8%) (13.67 cm). The minimum stalk length was recorded in T₁₃ (control) (9.14 cm). The present findings are in agreement with earlier reports of Hegde *et al.*, (2016) in chrysanthemum and Majeed Khadim Al-Hamzawi (2019) in *Dianthus chinensis* and *Gazania splendens*.

Flower weight:

Flower weight was significantly influenced by the treatments. The highest flower weight was recorded in T₂ (seaweed extract @ 0.8%) (13.43 g), followed by T₄ (humic acid @ 0.8%) (12.65 g). The lowest flower weight was recorded in T₁₃ (control) (8.40 g). Similar findings have been reported by Hegde *et al.*, (2016) in chrysanthemum. Suchitha *et al.*, (2023) in

chrysanthemum and Veeresh *et al.*, (2024) in china aster.

The improved flowering performance of T₂ (seaweed extract @ 0.8%) may be attributed to the better vegetative growth and enhanced photosynthetic activity, which increased the production and translocation of assimilates towards reproductive organs. The growth-promoting compounds and nutrients present in seaweed extract may have further supported floral initiation, development and maintenance, resulting in early flowering, higher number of flowers per plant, longer flowering duration, longer flower stalks and greater flower weight. (Khan *et al.*, 2009; Craigie, 2011).

Conclusion

The present investigation demonstrated that the application of different biostimulants significantly influenced the growth and flowering of calendula (*Calendula officinalis* L.) cv. Bon Bon Orange. Among the treatments, T₂ (seaweed extract @ 0.8%) was the most effective treatment, recording superior performance for plant height, stem diameter, plant spread, number of branches, number of leaves, chlorophyll content, leaf area and flowering attributes. The treatment also recorded early flower bud initiation and 50 per cent flowering, higher number of flowers per plant, longer flowering duration, stalk length and flower weight, and was statistically on par with T₄ (humic acid @ 0.8%) for several parameters. The T₁₃ (control) recorded the lowest performance for most of the growth and flowering parameters. Thus, foliar application of T₂ (seaweed extract @ 0.8%) showed potential for improving growth and flowering of calendula cv. Bon Bon Orange under the present study conditions.

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