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Plant Growth Dynamics of Statice (*Limonium sinuatum* L.) Influenced by Fertilization and 6-Benzylaminopurine Application

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Authors' contributions

This work was carried out in collaboration among all authors. Authors AS and NL designed the study. Author HP prepared the Manuscript and wrote the first draft. Authors SG, RM and SP provided assistance with the research work and manuscript preparation. All authors read and approved the final manuscript.

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Abstract

The present investigation was conducted at the Experimental Farm, Division of Floriculture and Landscaping, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Main Campus, Chatha, Jammu and Kashmir, during 2024–2025. The experiment was laid out in a factorial randomized complete block design (RCBD) comprising 16 treatment combinations, each replicated thrice. The treatments consisted of four fertilization regimes: F_1, 100% recommended dose of fertilizers (RDF; 150:125:75 kg NPK ha^{-1}); F_2, 75% RDF + humic acid (HA) at 5 g m^{-2}; F_3, 50% RDF + HA at 10 g m^{-2}; and F_4, 25% RDF + HA at 15 g m^{-2}, along with four concentrations of 6-benzylaminopurine (BAP): B_1, control (no application); B_2, 50 ppm; B_3, 100 ppm; and B_4, 150 ppm. The results revealed that the application of 75% RDF supplemented with HA at 5 g m^{-2} resulted in the maximum plant height (67.25 cm), plant spread (75.08 cm), shoot fresh weight (260.80 g), root fresh weight (26.85 g) and root: shoot ratio (0.27). In contrast, 100% RDF recorded the highest leaf area (79.55 cm^2), chlorophyll content, number of leaves per plant (70.82) and shoot dry weight (66.80 g). Among the BAP treatments, foliar application at 150 ppm was the most effective in improving vegetative

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growth. Overall, the combination of 75% RDF + HA at 5 g m^{-2} and 150 ppm BAP emerged as the most promising treatment combination for enhancing vegetative growth in statice, indicating the potential to reduce mineral fertilizer application while improving plant growth through the integrated use of humic acid and BAP.

Keywords: Statice; growth; flowering; benzyl adenine; humic acid.

1. Introduction

Statice is an excellent cut flower widely used as a filler in both fresh and dried floral arrangements, making it a favourite choice for weddings and special occasions (Fisher, 2024; Laishram *et al*., 2024). It belongs to the family Plumbaginaceae and genus *Limonium* (Nataraj *et al*., 2009). Beyond its commercial utility in the cut and dried flower industry, statice is well-suited for flower beds, borders and rock gardens (Kumar *et al*., 2022). Its commercial cultivation is highly profitable due to the wide spectrum of vibrant floral colours available—including white, purple, apricot, yellow, pink, and blue (Galage *et al*., 2021). Furthermore, statice plants exhibit strong salinity tolerance, rendering them an ideal choice for coastal environments (Ibrahim *et al*., 2016).

The genus *Limonium* consists of both annual and perennial species. The primary annual species include *Limonium sinuatum* and *Limonium suworowii*, whereas *Limonium dumosum*, *Limonium altaica*, *Limonium perezii*, *Limonium latifolium*, *Limonium caspia*, *Limonium vulgare*, and *Limonium speciosum* are prominent perennials (Galage *et al*., 2021). Among these, *Limonium sinuatum* represents the most commonly cultivated and globally recognized commercial cut flower species (Mellesse *et al*., 2013). High-performing annual cultivars include 'Midnight Blue', 'Twilight', 'Lavender', 'Blue Bonnet', 'Iceberg', 'Gold Coast', 'Amazon Bird', 'Giant Blue Bird', and 'Yellow Sun Bird' (Mellesse *et al*., 2013; Galage *et al*., 2021).

Humic acid has emerged as a promising organic amendment with documented positive effects across various ornamental crops including gerbera, petunia, freesia, tuberose, gazania, African marigold and rose (Yazdani *et al*., 2014; Ibrahim *et al*., 2016; Babarabie *et al*., 2020; Bhiah and Al-Zurfi 2020; Khudair and Albbas, 2021; Nazarova *et al*., 2022; El-Naggar and Imhmd, 2023). However, humic acid cannot entirely replace mineral nutrition and must be integrated with chemical fertilizers to maximize nutrient use efficiency. Crop response to humic acid application depends heavily on the source, plant species, developmental stage, application method and dosage, often yielding variable results (Olanrewaju *et al*., 2017).

Studies in ornamental plants have reported improvements in vegetative and flowering characteristics following humic acid application, including African marigold and anthurium, although treatment composition and application methods differed (Azam *et al*., 2022; Thomas *et al*., 2024).

A recent field study on African marigold reported changes in vegetative growth and plant nutrient status following foliar benzyladenine application, providing a related ornamental-crop context rather than direct evidence for statice (Hassan *et al*., 2026).

Recent evidence also indicates that humic substances can influence nutrient acquisition and plant responses, with effects that depend on the material and growing conditions (Rathor *et al*., 2024; Canellas *et al*., 2024).

Synthetic plant growth regulators such as 6-benzylaminopurine (6-BAP or benzyl adenine)—a synthetic cytokinin—triggers cell division and structural development. Furthermore, 6-BAP prolongs post-harvest floral longevity by inhibiting respiratory kinase activity. Cytokinins play a vital role in stimulating cell division, apical dominance, and morphogenesis. The stimulatory effects of exogenous applications of 6-benzylaminopurine on vegetative growth and flowering have been widely demonstrated in various ornamentals, including *Gladiolus* (Khan *et al*., 2013), *Alstroemeria* (Kaviya *et al*., 2021), *Ixora* (Guddad *et al*., 2022), *Chrysanthemum* (Ara *et al*., 2023), *Pelargonium* (El-Sayed *et al*., 2023), *Oxalis* (Khushaba *et al*., 2022), *Rosa* (Alzuhairi and Al-Sheikly 2022), and *Gypsophila* (Akshitha *et al*., 2023), and Liatris (Pogroszewska & Sadkowska, 2008).

Despite its high economic potential and market popularity, statice remains an underutilized specialty cut flower crop in northern India, where local farming communities lack standardized production protocols. To date, no systematic research has evaluated the scientific cultivation and growth dynamics of statice in the agro-climatic conditions of Jammu and Kashmir. In particular, the combined effects of reduced mineral fertilization, humic acid soil application and foliar 6-benzylaminopurine on statice vegetative traits under the study conditions remain insufficiently documented. Therefore, the objective of this study was to evaluate the combined influence of inorganic fertilizer doses, humic acid, and 6-benzylaminopurine on the growth parameters of statice, and to identify the most economically viable treatment combination for regional adoption.

2. Materials and Methods

The investigation was carried out at the Experimental Farm, Division of Floriculture and Landscaping, Sher-e-Kashmir University of Agricultural Sciences and Technology, Main Campus, Chatha, Jammu, J&K 180009, India, at an elevation 296 meters above mean sea level (MSL), latitude of 33°55’ North, longitude of 74°58’ East, average total rainfall of 1000 to 1200 mm, average annual maximum temperature 45–46°C during summer and minimum temperature of 4–6°C during winter).

The experiment was laid out in randomised complete block design (RCBD Factorial) with three replications and two factors viz, Factor 1 comprised four levels of fertilization and Factor 2 comprised four levels of Benzyl adenine foliar application with three replications. In total, there were sixteen treatment combinations. Humic acid was applied as a soil drench after 30 and 60 DAT. Two foliar sprays of benzyl adenine were given after 30 and 60 days after transplanting (DAT). Humic acid was dissolved in water as per the treatment schedule and applied as a drench. Approximately 5 litres of water were used per plot measuring 1.50 × 1.20 m.

Experimental Details:

- **A.** Crop: Statice (*Limonium sinuatum* L.)
- **B.** Variety: QIS white
- **C.** Design: Randomized Completely Block Design (RCBD) Factorial
- **D.** Number of factors: 02
- **E.** Total number of treatments: 16
- **F.** Total number of replications: 03
- **G.** Plot size: 1.5m x 1.2m
- **H.** Spacing: 30 x 30 cm
- **I.** Total no. of plants:20
- **J.** **Treatment details**

Factor 1: Fertilizers Doses (4 Levels):

1. F_1: 100 % RDF (150:125:75 kg NPK/ha, Control)
2. F_2: 75 % RDF + 5 gm/m^2 Humic acid (HA) soil application
3. F_3:50% % RDF + 10 gm/m^2 Humic acid (HA) soil application
4. F_4:25 % RDF + 15 gm/m^2 Humic acid (HA) soil application

The full dose of P and K and half the dose of N were applied as a basal dose. The remaining half-dose of N was applied at 30 DAT. Humic acid was applied as a soil drench after 30 and 60 DAT.

Factor 2: Benzyl adenine doses (4 Levels):

1. B_1: No application (Control)
2. B_2:50 ppm Benzyl Adenine (BA)
3. B_3:100 ppm Benzyl Adenine (BA)
4. B_4:150 ppm Benzyl Adenine (BA)

Two foliar sprays of benzyl adenine were given after 30 and 60 days after transplanting (DAT).

2.1 Plant Material and Nursery Management

Limonium sinuatum [L.] Mill. cv. Qis White was procured for the experiment from Pan America, India. After proper hoeing and weeding, a bed size of 1.0 m × 3.0 m was prepared. The bed was kept raised 15 cm above the ground level so as to provide proper drainage of excess water. Well-rotted FYM was mixed in the nursery bed and seeds were sown on October 5, 2024. Line-to-line sowing of the seed was practised in the nursery bed with lines 5 cm apart and 3–4 cm deep. The opened rows were closed with the mixture of FYM, soil and sand (2:1:1). The surface was covered with the mulching material and then watered with a fine rose-can. After seed germination, the mulch cover was removed.

2.2 Field Preparation, Transplanting and After Care

The field was prepared to a fine tilth by two to three ploughings and finally the field was levelled by planking after removing the plant residues and weeds. The beds of the required dimension were then made according to the layout plan. The levelled experimental area was split into 48 equal plots of 1.5 m × 1.2 m raised beds.

Healthy seedlings having four fully developed leaves were transplanted in the main field 30 days after sowing, i.e., on November 8, 2024 at a spacing of 30 cm x 30 cm thereby accommodating 20 seedlings per bed size of 1.50 m × 1.20 m. Transplanting was done during the evening when the temperature was low to minimise transplanting shock. Light irrigation was given immediately after transplanting. To ensure a full plant population in each plot until ten days after transplanting, fresh seedlings were used to replace mortality. Irrigation was carried out as and when required throughout the growth period of the crop. No fertilization, disease and pest control schedule was included during the cultivation period. Gap filling was done with fresh seedlings in order to maintain cent percent plant population in each plot till ten days after transplanting. Irrigations were given as and when required during the crop growth. No incidence of insect pests or diseases was observed during the experiment.

Fertilisers were applied to each plot as per the experimental treatments. Urea, diammonium phosphate (DAP) and muriate of potash (MOP) were used to supply the elements of nitrogen, phosphorus and potassium respectively. Humic acid was applied as soil drench after 30 and 60 days after transplanting (DAT) as per the treatment details.

3. Results and Discussion

3.1 Influence of Fertilization and 6-benzylaminopurine Application on Vegetative Growth

Integrating humic acid (HA) with NPK fertilization markedly increased vegetative parameters in the present study, improving plant height, plant spread, leaf number, and leaf area compared to NPK alone, with peak responses observed under 75% RDF + 5 g m^{-2} HA. Maximum plant height and plant spread were recorded with 75% RDF + 5 g m^{-2} HA. Different doses of benzyl adenine (BA)

did not show any significant effect on plant height; however, the maximum plant spread was observed with 150 ppm BA foliar spray. Maximum leaf number and leaf area were recorded with the application of 100% RDF. The effect of different BA doses on the number of leaves per plant was non-significant; however, the maximum leaf area was observed with 150 ppm BA foliar spray.

The improvement in vegetative growth under HA application may be attributed to enhanced nutrient availability, increased root growth, and improved uptake of macro- and micronutrients. Humic substances stimulate plasma membrane H^+-ATPase activity, improve nutrient mobility, and exhibit auxin-like effects that promote cell elongation and root proliferation (Nofal, 2005; Ichwan *et al*., 2022). Enhanced nutrient uptake increases photosynthetic efficiency, resulting in greater leaf production and overall plant vigour. BA, a synthetic cytokinin, promotes cell division and leaf expansion by regulating cytokinin-mediated signalling pathways, thereby increasing canopy development without causing phytotoxicity (Barrôco *et al*., 2005; Werner and Schmülling, 2009; Cheruvathur and Thomas, 2014). Similar findings have been reported in calendula (El-Nashar, 2021), marigold (Hasan, 2019; Nazarova *et al*., 2022), gerbera (Nikbakht *et al*., 2008), gladiolus (Ahmad *et al*., 2013), and tuberose (Babarabie *et al*., 2020).

3.2 Influence of Fertilization and 6-benzylaminopurine Application on Chlorophyll Content (SPAD Values at 30, 60 and 90 DAT)

Among the various fertilization treatments, the maximum chlorophyll content (44.58 and 76.85 SPAD values) was recorded with the application of 100% RDF at 30 and 90 days after transplanting (DAT), respectively. However, at 60 DAT, the maximum chlorophyll content (70.61 SPAD) was observed with 75% RDF + 5 g m^{-2} HA, which was statistically comparable with 100% RDF (70.46 SPAD). Among the benzyl adenine (BA) doses, the highest chlorophyll content was recorded with 150 ppm BA foliar spray, registering 41.90, 71.01, and 75.29 SPAD values at 30, 60, and 90 DAT, respectively. The interaction effect of fertilization and BA showed the maximum chlorophyll content of 48.79 and 79.17 SPAD values with the F_1B_4 treatment at 30 and 90 DAT, respectively, whereas the highest SPAD value at 60 DAT (73.38) was recorded with F_2B_4.

The increased chlorophyll content with HA and BA treatments may be attributed to improved nutrient uptake, particularly nitrogen, magnesium, and iron, which are essential for chlorophyll biosynthesis. Cytokinins delay chlorophyll degradation by suppressing chlorophyllase activity and maintaining thylakoid membrane integrity, thereby prolonging photosynthetic activity and delaying leaf senescence (Laugier *et al*., 2010; Zhiponova *et al*., 2013). Similar observations have been reported in several ornamental crops following cytokinin application.

3.3 Influence of Fertilization and 6-benzylaminopurine Application on Shoot Biomass

Fresh and dry shoot biomass varied significantly across fertilization treatments, plant growth regulator (PGR) concentrations, and their interaction effects. Among the fertilization treatments, the application of 75% recommended dose of fertiliser (RDF) + 5 g m^{-2} humic acid (HA) recorded the highest shoot fresh weight (260.80 g) and shoot dry weight (68.10 g), which were statistically comparable with the 100% RDF treatment and 50% RDF + 10 g m^{-2} HA. Among the foliar application treatments of 6-benzyladenine (BA), the maximum shoot fresh weight (260.90 g) and shoot dry weight (70.82 g) were recorded with 100 ppm BA, showing no statistically significant difference from 150 ppm BA. Among the interaction effects, the F_2B_1 treatment combination recorded the highest shoot fresh weight (296.60 g), which was statistically comparable with F_1B_4, F_2B_4, and F_3B_2. Conversely, the maximum shoot dry weight (76.66 g) was observed under the F_3B_3 interaction, which did not differ significantly from F_1B_3, F_2B_2, F_2B_3, and F_4B_4.

Humic substances have been reported to promote plant growth by stimulating root architecture and plasma membrane H^+-ATPase activity, thereby improving nutrient acquisition (Canellas and Olivares, 2014). The increased shoot biomass observed with 100 ppm BA may be associated with the role of cytokinins in promoting cell division and shoot growth and development (Werner and Schmülling, 2009). Similar improvements in shoot growth following humic acid application have been reported in gerbera (Nikbakht *et al*., 2008) and gladiolus (Ahmad *et al*., 2013).

3.4 Influence of Fertilization and 6-benzylaminopurine Application on Root Biomass

Root fresh and dry weight accumulation exhibited distinct responses to the applied amendments. The 100% RDF treatment registered the highest root fresh weight (26.87 g), which was statistically comparable to 75% RDF + 5 g/m^2 HA (26.85 g). However, for root dry matter accumulation, the 75% RDF + 5 g/m^2 HA treatment proved to be statistically superior to all other fertilization treatments, achieving a maximum root dry weight of 14.84 g. Foliar application of 100 ppm BA (B_3) optimized root biomass, recording the maximum root fresh weight (29.03 g, statistically at par with 150 ppm BA at 28.57 g) and root dry weight (14.37 g). The interactive effect of fertilizer and cytokinin was most prominent in the F_2B_3 treatment combination, which achieved the peak values for both root fresh weight (32.02 g, statistically comparable with F_1B_4, F_2B_4, and F_3B_3) and root dry weight (19.99 g).

The increased shoot biomass under integrated application of humic acid (HA) and NPK may be attributed to improved nutrient uptake, enhanced root growth, and greater photosynthetic efficiency. Humic substances stimulate root architecture and plasma membrane H^+-ATPase activity, thereby enhancing nutrient absorption and plant growth (Canellas and Olivares, 2014). Foliar application of 6-benzyladenine (BA) may have further increased shoot biomass by promoting cell division and delaying leaf senescence, thereby maintaining photosynthetically active leaves (Werner and Schmülling, 2009).

Table 1. Effect of benzyl adenine and humic acid on vegetative parameters (Plant height and Plant spread) of Statice (*Limonium sinuatum* L.)

Fertilizer doses	Plant height (cm)				Plant spread (cm)			
	6-Benzyladenine (ppm)				6-Benzyladenine (ppm)			
	B_1(control)	B_2(50 ppm)	B_3 (100 ppm)	B_4 (150 ppm)	B_1(control)	B_2(50 ppm)	B_3 (100 ppm)	B_4 (150 ppm)
F_1-100 % RDF (150:125:75 kg NPK/ha)	64.71 ± 2.01	62.90 ± 0.17	71.41 ± 2.45	63.93 ± 1.09	69.00 ± 0.70	61.00 ± 1.98	64.00 ± 2.19	67.00 ± 0.48
F_2-75 % RDF + 5 gm/m^2 Humic acid soil drench	68.56 ± 0.99	65.35 ± 2.00	65.26 ± 0.24	69.81 ± 2.77	71.00 ± 0.25	73.67 ± 2.19	76.67 ± 3.39	79.00 ± 0.00
F_3-50% % RDF + 10 gm/m^2 Humic acid soil drench	66.56 ± 2.16	66.61 ± 2.76	67.48 ± 2.31	66.63 ± 2.23	70.00 ± 1.83	67.00 ± 0.84	71.00 ± 1.73	75.00 ± 2.44
F_4-25 % RDF + 15 gm/m^2 Humic acid soil drench	62.13 ± 1.90	62.53 ± 1.86	62.91 ± 0.79	65.65 ± 2.13	60.00 ± 1.84	61.00 ± 0.06	62.00 ± 0.61	65.00 ± 1.46

Table 2. Effect of benzyl adenine and humic acid on vegetative parameters (Leaf area and Chlorophyll content) of Statice (*Limonium sinuatum* L.)

Fertilizer doses	Leaf area (cm^2)				Chlorophyll content (SPAD values at 30 DAT)			
	6-Benzyladenine (ppm)				6-Benzyladenine (ppm)			
	B_1(control)	B_2(50 ppm)	B_3 (100 ppm)	B_4 (150 ppm)	B_1(control)	B_2(50 ppm)	B_3 (100 ppm)	B_4 (150 ppm)
F_1-100 % RDF (150:125:75 kg NPK/ha)	79.05 ± 2.97	79.70 ± 2.37	79.44 ± 0.29	80.03 ± 0.43	43.24 ± 0.01	42.34 ± 0.14	43.95 ± 0.12	48.79 ± 0.97
F_2-75 % RDF + 5 gm/m^2 Humic acid soil drench	77.72 ± 2.87	78.40 ± 0.42	78.07 ± 2.18	78.75 ± 1.49	38.08 ± 0.38	40.64 ± 0.58	39.05 ± 0.77	43.05 ± 1.55
F_3-50% % RDF + 10 gm/m^2 Humic acid soil drench	76.54 ± 0.90	77.17 ± 3.06	76.84 ± 0.76	77.46 ± 0.77	37.02 ± 0.20	38.54 ± 0.45	36.95 ± 0.60	38.19 ± 1.07
F_4-25 % RDF + 15 gm/m^2 Humic acid soil drench	75.35 ± 1.63	75.96 ± 1.24	75.66 ± 3.27	76.20 ± 2.06	37.39 ± 0.27	38.61 ± 0.46	35.89 ± 0.58	37.58 ± 0.88

Table 3. Effect of benzyl adenine and humic acid on vegetative parameters (Chlorophyll content) of Statice (*Limonium sinuatum* L.)

Fertilizer doses	Chlorophyll content (SPAD values at 60 DAT)				Chlorophyll content (SPAD values at 90 DAT)			
	6-Benzyladenine (ppm)				6-Benzyladenine (ppm)			
	B_1(control)	B_2(50 ppm)	B_3 (100 ppm)	B_4 (150 ppm)	B_1(control)	B_2(50 ppm)	B_3 (100 ppm)	B_4 (150 ppm)
F_1-100 % RDF (150:125:75 kg NPK/ha)	68.76 ± 2.45	70.30 ± 1.90	70.58 ± 0.31	72.19 ± 2.41	74.26 ± 0.87	76.38 ± 1.72	77.58 ± 0.07	79.17 ± 0.43
F_2-75 % RDF + 5 gm/m^2 Humic acid soil drench	67.85 ± 2.63	69.69 ± 1.57	71.53 ± 3.10	73.38 ± 0.86	72.83 ± 2.24	74.62 ± 2.08	74.53 ± 1.48	77.32 ± 0.91
F_3-50% % RDF + 10 gm/m^2 Humic acid soil drench	66.53 ± 2.70	68.61 ± 0.43	69.62 ± 1.76	69.61 ± 0.63	70.42 ± 2.86	71.45 ± 0.13	72.76 ± 2.36	72.83 ± 0.72
F_4-25 % RDF + 15 gm/m^2 Humic acid soil drench	65.77 ± 0.53	67.34 ± 2.25	68.76 ± 1.98	68.84 ± 1.12	69.71 ± 2.96	70.34 ± 1.40	71.76 ± 0.20	71.84 ± 0.58

Table 4. Effect of benzyl adenine and humic acid on vegetative parameters (Leaf per plant and Shoot fresh weight) of Statice (*Limonium sinuatum* L.)

Fertilizer doses	Leaf per plant				Shoot fresh weight (g)			
	6-Benzyladenine (ppm)				6-Benzyladenine (ppm)			
	B_1(control)	B_2(50 ppm)	B_3 (100 ppm)	B_4 (150 ppm)	B_1(control)	B_2(50 ppm)	B_3 (100 ppm)	B_4 (150 ppm)
F_1-100 % RDF (150:125:75 kg NPK/ha)	69.42 ± 0.17	71.22 ± 1.67	71.22 ± 1.22	71.42 ± 1.29	243.30 ± 0.86	220.00 ± 9.72	252.00 ± 6.36	272.90 ± 8.36
F_2-75 % RDF + 5 gm/m^2 Humic acid soil drench	64.93 ± 0.70	66.37 ± 2.63	66.00 ± 0.06	68.64 ± 1.42	243.30 ± 1.10	213.30 ± 2.50	296.60 ± 0.27	290.00 ± 10.19
F_3-50% % RDF + 10 gm/m^2 Humic acid soil drench	63.72 ± 0.87	64.72 ± 1.93	63.99 ± 2.54	64.78 ± 0.64	225.00 ± 3.45	290.00 ± 4.97	255.00 ± 4.37	236.66 ± 9.38
F_4-25 % RDF + 15 gm/m^2 Humic acid soil drench	60.42 ± 0.43	62.25 ± 0.90	62.15 ± 1.90	62.50 ± 0.06	236.60 ± 6.61	233.99 ± 5.90	239.99 ± 4.98	230.32 ± 8.30

Table 5. Effect of benzyl adenine and humic acid on vegetative parameters (Root fresh weight and Dry weight shoot) of Statice (*Limonium sinuatum* L.)

Fertilizer doses	Root fresh weight (g)				Dry weight shoot (g)			
	6-Benzyladenine (ppm)				6-Benzyladenine (ppm)			
	B_1(control)	B_2(50 ppm)	B_3 (100 ppm)	B_4 (150 ppm)	B_1(control)	B_2(50 ppm)	B_3 (100 ppm)	B_4 (150 ppm)
F_1-100 % RDF (150:125:75 kg NPK/ha)	22.93 ± 0.79	25.26 ± 0.71	29.74 ± 0.32	29.53 ± 1.04	65.00 ± 0.83	63.30 ± 2.06	73.30 ± 2.71	65.59 ± 2.78
F_2-75 % RDF + 5 gm/m^2 Humic acid soil drench	20.90 ± 0.21	23.69 ± 0.41	32.02 ± 1.27	30.77 ± 0.11	62.50 ± 0.06	69.99 ± 0.44	73.30 ± 0.93	66.60 ± 0.24
F_3-50% % RDF + 10 gm/m^2 Humic acid soil drench	18.11 ± 0.28	22.63 ± 0.39	30.00 ± 1.25	27.20 ± 0.22	63.30 ± 2.39	65.00 ± 2.87	76.66 ± 3.32	66.66 ± 2.70
F_4-25 % RDF + 15 gm/m^2 Humic acid soil drench	17.78 ± 0.45	20.67 ± 0.07	24.37 ± 0.96	26.77 ± 0.26	60.00 ± 2.32	60.05 ± 2.54	60.03 ± 0.11	70.50 ± 0.06

Table 6. Effect of benzyl adenine and humic acid on vegetative parameters (Dry weight root and Root: shoot ratio) of Statice (*Limonium sinuatum* L.)

Fertilizer doses	Dry weight root (g)				Root: shoot ratio			
	6-Benzyladenine (ppm)				6-Benzyladenine (ppm)			
	B_1(control)	B_2(50 ppm)	B_3 (100 ppm)	B_4 (150 ppm)	B_1(control)	B_2(50 ppm)	B_3 (100 ppm)	B_4 (150 ppm)
F_1-100 % RDF (150:125:75 kg NPK/ha)	9.95 ± 0.39	13.33 ± 0.15	15.00 ± 0.66	10.09 ± 0.29	0.15 ± 0.00	0.21 ± 0.00	0.20 ± 0.00	0.15 ± 0.00
F_2-75 % RDF + 5 gm/m^2 Humic acid soil drench	13.66 ± 0.50	10.01 ± 0.13	19.99 ± 0.69	15.67 ± 0.48	0.22 ± 0.01	0.14 ± 0.00	0.27 ± 0.01	0.24 ± 0.00
F_3-50% % RDF + 10 gm/m^2 Humic acid soil drench	10.05 ± 0.06	14.95 ± 0.25	12.50 ± 0.46	13.29 ± 0.30	0.16 ± 0.00	0.23 ± 0.00	0.16 ± 0.01	0.20 ± 0.01
F_4-25 % RDF + 15 gm/m^2 Humic acid soil drench	13.3 ± 0.54	13.42 ± 0.41	10.00 ± 0.02	13.32 ± 0.32	0.22 ± 0.00	0.22 ± 0.01	0.17 ± 0.00	0.19 ± 0.00

3.5 Influence of Fertilization and 6-benzylaminopurine Application on Root to Shoot Ratio

The partitioning of dry matter between below-ground and above-ground tissues, expressed via the root to shoot (R:S) ratio, was noticeably influenced by nutrient-humic supplementation and growth regulator levels. The highest R:S ratio among fertilization levels (0.22) was recorded under 75% RDF + 5 g/m^2 HA. Among the BA treatments, the 50 ppm and 100 ppm BA foliar sprays co-recorded the maximum R:S ratio of 0.20. Overall, the F_2B_3 interaction produced the absolute maximum R:S ratio (0.27).

The higher root-to-shoot ratio observed under integrated nutrient management indicates improved dry matter partitioning towards the root system, resulting in enhanced nutrient and water uptake. BA also delayed leaf senescence by suppressing cytokinin oxidase/dehydrogenase activity and senescence-associated genes, thereby maintaining photosynthetic activity and improving assimilate allocation, ultimately contributing to greater biomass production (Synková *et al*., 2012).

4. Conclusion

The investigation demonstrated that mineral fertilisation, humic acid application and foliar benzyladenine influenced the vegetative growth characteristics of statice (Limonium sinuatum L.) under the agro-climatic conditions of Jammu. Among the fertilisation treatments, the application of 75% recommended dose of fertilisers (RDF) supplemented with humic acid at 5 g m^{-2} produced favourable responses in plant height, plant spread and shoot fresh weight. However, the application of 100% RDF resulted in the highest leaf area and number of leaves per plant, indicating that individual growth parameters responded differently to fertilisation regimes. Foliar application of benzyladenine also influenced vegetative growth, with treatment responses varying according to the measured characteristics. These observations suggest that combining humic acid with a reduced mineral fertiliser dose may represent a potentially useful approach to managing vegetative growth in statice. Nevertheless, the findings do not establish a single treatment as superior for all growth characteristics. Further evaluation under different growing conditions would help determine the consistency and practical applicability of the observed responses.

5. Limitations

The investigation was conducted at a single experimental location during the 2024–2025 growing season using one statice cultivar. Consequently, the findings may not be directly applicable to other cultivars or agro-climatic conditions. The assessment focused primarily on vegetative growth characteristics under the specified fertilisation and benzyladenine treatments. Although differences among treatments were observed, the available results do not establish their consistency across multiple growing seasons. Further multi-location and multi-season investigations are required to evaluate the reproducibility of the responses and identify suitable management recommendations.

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Declaration of AI Use

This manuscript was prepared through the intellectual contributions of the author(s) to the study design, data analysis, interpretation of results, and scholarly content. The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing Interests

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper. All authors contribute equally in the preparation of the manuscript.

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