



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; SP-9(7): 227-230
Received: 24-05-2026
Accepted: 28-06-2026

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Agronomic and quality responses of bird's eye chilli to growth stimulant applications

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DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i7Sc.6031>

Abstract

Bird's eye chilli (*Capsicum frutescens* L.) is a promising spice crop known for its pungency, nutritional value, health-promoting properties, and rising demand in both domestic and international markets. However, scientific information on its systematic cultivation and crop management practices remains limited. Hence, the present study was undertaken to assess the influence of different plant growth stimulants on the growth, yield, and quality parameters of bird's eye chilli.

The experiment was carried out during 2023–24 at the College of Horticulture, Mudigere, employing a Randomized Complete Block Design (RCBD) with thirteen treatments. Among the treatments tested, foliar application of GA₃ @ 75 ppm (T₄) resulted in significantly superior growth and yield performance, recording the highest plant height (83.59 cm), number of primary branches (11.50 plant⁻¹), number of leaves (432.90 plant⁻¹), leaf area index (2.73), and fresh fruit yield (59.08 q ha⁻¹). With regard to quality attributes, foliar spray of humic acid @ 0.50% significantly increased total chlorophyll content (2.23 mg g⁻¹ fresh weight), ascorbic acid content (119.60 mg 100 g⁻¹), oleoresin content (8.83%) and capsaicin content (1.89%). Conversely, the maximum capsanthin content (17.29 g kg⁻¹) was observed with foliar application of NAA @ 50 ppm.

The results of the investigation revealed that foliar application of GA₃ @ 75 ppm effectively enhanced vegetative growth and fruit yield, while humic acid @ 0.50% applied at 60, 90 and 120 days after transplanting (DAT) markedly improved the quality characteristics of bird's eye chilli. Therefore, the application of these growth stimulants may be recommended for achieving higher productivity and superior fruit quality under hill-zone conditions.

Keywords: Bird's eye chilli, *Capsicum frutescens*, plant growth stimulants, GA₃, humic acid, fruit yield, quality attributes, capsaicin

Introduction

Bird's eye chilli (*Capsicum frutescens* L.) is an important and emerging spice crop widely cultivated in tropical and subtropical regions of the world. As both a vegetable and spice crop, it plays a significant role in human nutrition, culinary applications, and the spice trade. It belongs to the family *Solanaceae* and possesses a chromosome number of 2n = 24. The crop is native to Tropical America, with Guatemala recognized as its secondary centre of origin. Chilli was introduced into India by the Portuguese during the latter half of the sixteenth century. Peppers are considered among the earliest spices used by humans, and archaeological evidence indicates their utilization as early as 6000 years ago (Hill *et al.*, 2013) [6]. Bird's eye chilli is known by several common names, including African pepper, goat's pod, Mexican chilli, red pepper, Tabasco pepper, Zanzibar pepper, and Cayenne pepper. The name "bird's eye chilli" is derived from the preference of birds for its ripe fruits, which aid in seed dispersal.

Capsicum frutescens is regarded as one of the hottest pepper species and is rich in numerous bioactive compounds such as capsaicinoids, carotenoids, vitamins, proteins, fibre, minerals, and volatile oils. Owing to its high pungency, attractive colour, and medicinal properties, a major portion of the produce is processed for extraction of oleoresin and capsaicin, which are extensively utilized in food, pharmaceutical, cosmetic, and nutraceutical industries. Traditionally, bird's eye chilli has been used for the treatment of toothache, indigestion, flatulence, arthritis, and rheumatism. In addition, the fruits are recognized for their antioxidant properties and nutritional value, making them an important component of health-oriented diets.

The productivity and profitability of chilli cultivation largely depend on optimum vegetative growth, efficient flowering, fruit set, and superior fruit quality. Growth stimulants play a crucial role in regulating physiological and biochemical processes that influence plant growth and development. They enhance cell division, cell elongation, nutrient uptake, photosynthetic efficiency, and assimilate translocation, thereby improving vegetative growth parameters such as plant height, number of branches, leaf production, and leaf area. Improved vegetative growth subsequently contributes to higher fruit yield and better quality produce.

Several studies have demonstrated the beneficial effects of growth stimulants on growth, yield, and quality attributes in chilli and related crops. Karakurt *et al.* (2009) [7] reported that foliar application of humic acid (20 ml l⁻¹) significantly increased total chlorophyll content (1.06 µg mg⁻¹) in chilli compared to the control. Similar findings were reported by Dawa *et al.* (2012) [1] in sweet pepper. El-Sayed *et al.* (2019) [2] studied the effect of humic acid (0, 1, and 2 g l⁻¹) on sweet pepper cv. California Wonder and observed the highest vitamin C content (63.91 mg 100 g⁻¹), acidity (0.404%), and oleoresin content (6.48%) with foliar application of humic acid at 2 g l⁻¹. Similar observations were also reported by Ibrahim *et al.* (2019) [4] and Fadala *et al.* (2021) [3] in chilli. Moreover, growth regulators such as gibberellic acid (GA₃) and naphthalene acetic acid (NAA) have been reported to improve vegetative growth, flowering behaviour, fruit development, and yield in several vegetable crops by enhancing physiological activities and source-sink relationships within the plant.

Despite the increasing commercial importance of bird's eye chilli, information on the influence of plant growth stimulants on its growth, yield, and quality attributes under hill-zone conditions remains limited. As bird's eye chilli possesses tremendous potential for domestic consumption, value addition, and export markets, there is a need to develop appropriate production technologies that enhance both productivity and fruit quality. Important quality parameters such as capsaicin, oleoresin, ascorbic acid, chlorophyll, and capsanthin content largely determine its market acceptability and industrial utility. Therefore, the present investigation was undertaken to evaluate the effect of different plant growth stimulants on vegetative growth, yield, and quality parameters of bird's eye chilli (*Capsicum frutescens* L.) with the objective of identifying suitable growth stimulant treatments for improving productivity and fruit quality under hill-zone conditions.

Materials and Methods

The experiment was conducted at College of Horticulture, Mudigere during *rabi* season 2023-24 at College of Horticulture, Mudigere. The statistical design adopted was Randomized Complete Block Design (RCBD) with thirteen treatments and two replications. The aim of study was to find out the suitable growth stimulants for improved quality attributes of bird's eye chilli. The treatments included in the study were T₁ (NAA @ 50ppm), T₂ (NAA @ 75ppm), T₃ (GA₃ @ 50ppm), T₄ (GA₃ @ 75ppm), T₅ (CCC @ 500ppm), T₆ (CCC @ 750ppm), T₇ (Seaweed extract @ 0.25 per cent), T₈ (Seaweed extract @ 0.50 per cent), T₉ (Triacantanol @ 0.25 per cent), T₁₀ (Triacantanol @ 0.50 per cent), T₁₁ (Humic acid @ 0.25 per cent), T₁₂ (Humic acid @ 0.50 per cent) and T₁₃ (Control). Foliar spray was taken at 60,90 and 120 DAT (Days After Transplanting) and Observations on quality attributing parameters of bird's eye chilli were recorded at 45, 75, 105 and 135 DAT (Days After Transplanting).

Results and Discussion

The findings were considerably interpreted and listed in Table 1 based on the observations recorded in the present research.

The growth and yield parameters of bird's eye chilli were significantly influenced by the application of different growth stimulants (Table 1). Significant variations were observed among the treatments with respect to plant height, number of primary branches, number of leaves per plant, leaf area index (LAI), and fresh fruit yield.

Among the treatments, foliar application of GA₃ @ 75 ppm (T₄) recorded the maximum plant height (83.59 cm), which was statistically on par with triacantanol @ 0.25 per cent (T₉; 82.90 cm) and significantly superior to the control (47.85 cm). The increased plant height under GA₃ treatment may be attributed to enhanced cell division, cell elongation, and internodal elongation induced by gibberellins.

The highest number of primary branches per plant (12.00) was recorded in seaweed extract @ 0.25 per cent (T₇) and humic acid @ 0.50 per cent (T₁₂), which were on par with triacantanol @ 0.50 per cent (11.90), triacantanol @ 0.25 per cent (11.70), GA₃ @ 75 ppm (11.50), and humic acid @ 0.25 per cent (11.50). The lowest number of branches was observed in the control (8.50). Increased branching might be due to improved nutrient uptake and enhanced metabolic activity resulting from growth stimulant application.

Significantly higher number of leaves per plant was observed with humic acid @ 0.50 per cent (T₁₂), recording 477.55 leaves per plant, followed by triacantanol @ 0.50 per cent (439.45) and GA₃ @ 75 ppm (432.90). The control treatment recorded the lowest number of leaves (299.40). The increase in leaf production may be attributed to enhanced photosynthetic activity and better nutrient assimilation promoted by humic acid. These findings are also supported by Mathur *et al.* (2006) [10] in mung bean.

Leaf area index (LAI) was also significantly influenced by growth stimulants. The highest LAI (3.21) was recorded with humic acid @ 0.50 per cent (T₁₂), followed by humic acid @ 0.25 per cent (2.77) and GA₃ @ 75 ppm (2.73). The lowest LAI was observed in the control (1.59). Increased LAI under humic acid treatments could be due to improved vegetative growth and greater leaf expansion.

Fresh fruit yield differed significantly among the treatments. The maximum fresh fruit yield (90.71 q ha⁻¹) was recorded with foliar application of humic acid @ 0.50 per cent (T₁₂), which was significantly superior to all other treatments. This was followed by seaweed extract @ 0.25 per cent (83.50 q ha⁻¹), humic acid @ 0.25 per cent (78.15 q ha⁻¹), triacantanol @ 0.50 per cent (76.14 q ha⁻¹), and seaweed extract @ 0.50 per cent (71.48 q ha⁻¹). The lowest yield was recorded in the control (46.63 q ha⁻¹).

The superior yield observed with humic acid @ 0.50 per cent may be attributed to increased leaf production, higher leaf area index, enhanced photosynthetic efficiency, improved nutrient uptake, and efficient translocation of photosynthates towards developing fruits. The overall results indicate that foliar application of humic acid @ 0.50 per cent was the most effective treatment for improving vegetative growth and fresh fruit yield of bird's eye chilli under the conditions of the study (Zhang *et al.*, 2003) [17].

When evaluating fruit performance in relation to its functional utilization, fruit quality (Table 2) is just as important as yield. Quality of the produce is influenced by various factors like environmental, nutritional and most crucially, genetic make-up. There is a much need of research for the development of

superior quality characteristics in bird's eye chilli. In this context, influence of growth stimulants was evaluated on quality traits.

In the present investigation, the treatment T₁₂ (Humic acid @ 0.50%), recorded significantly maximum chlorophyll-a (1.54 mg/g fr. wt.), chlorophyll-b (0.69 mg/g fr. wt.) and total chlorophyll (2.23 mg/g fr. wt.) in the leaves at 75 DAT. While treatment T₁₃ (Control) recorded minimum chlorophyll-a (0.66 mg/g fr. wt.), chlorophyll-b (0.30 mg/g fr. wt.) and total chlorophyll (1.11 mg/g fr. wt.) at 75 DAT. The increased total leaf chlorophyll contents might be due to the acceleration of nitrogen and NO₃ uptake, enhancing N metabolism by humic acid that ultimately increased chlorophyll content (Haghighi *et al.*, 2012) [5]. Similar findings were also reported by Dawa *et al.* (2012) [1], Manas *et al.* (2014) [9], Kakakurt *et al.* (2009), El-Sayed *et al.* (2019) [2] and Pavani *et al.* (2022) [12] in chilli.

Among various treatments, T₁₂ (Humic acid @ 0.50%), recorded significantly highest ascorbic acid content (119.60 mg/100 g) and capsaicin content (1.89%). While, T₁₃ (Control) recorded lowest ascorbic acid content (90.56 mg/100 g) and capsaicin content (1.08%). Humic acid can stimulate the enzymes responsible for the synthesis of ascorbic acid and capsaicin such as Phenylalanine ammonia lyase (Zamljen *et al.*, 2022) [16], also it can enhance the availability and uptake of essential nutrients

by plants, including nitrogen and potassium. These nutrients play a role in the synthesis of secondary metabolites. Improved nutrient availability might have indirectly supported capsaicin production (Ibrahim *et al.*, 2019) [4]. Similar result was also reported by Karakurt *et al.* (2009) [7], Wang *et al.* (2010) [15] and El-Sayed *et al.* (2019) [2] in chilli.

The treatment T₁₂ (Humic acid @ 0.50%) recorded significantly maximum oleoresin content (8.83%), while T₁₃ (Control) recorded minimum oleoresin content (6.18%). It might be due to the influence of humic acid which, has been reported to stimulate various enzymatic reactions responsible for oleoresin synthesis and accumulation in plants. Similar result was also reported by El-Sayed *et al.* (2019) [2] in chilli and Saxena *et al.* (2015) [14] in Coriander.

In the present study, significantly higher capsanthin content (17.29 g/kg) was recorded in T₁ (NAA @ 50 ppm), while, T₁₃ (Control) recorded the lowest capsanthin content (11.22 g/kg). This might be due to the influence of auxins like NAA on the synthesis of enzymes such as geranylgeranyl diphosphate synthase, an enzyme responsible for the production of geranylgeranyl pyrophosphate (GGPP) which is the precursor for the carotenoids such as capsanthin (Kumar *et al.*, 2020) [8]. Similar result was also reported by Rongsennungla *et al.* (2012) [13] and Nisar *et al.* (2015) [11] in chilli.

Table 1: Growth and yield of bird's eye chilli as influenced by growth stimulants

Treatments	Plant height (cm)	No. of primary branches per plant	Number of leaves per plant	LAI	Fresh yield (q/ha)
T ₁ : NAA @ 50 ppm	63.45	9.30	328.80	1.78	56.17
T ₂ : NAA @ 75 ppm	62.46	9.10	316.10	1.68	48.96
T ₃ : GA ₃ @ 50 ppm	73.91	9.60	374.85	2.35	53.65
T ₄ : GA ₃ @ 75 ppm	83.59	11.50	432.90	2.73	59.08
T ₅ : CCC @ 500 ppm	67.95	10.00	348.10	1.91	65.14
T ₆ : CCC @ 750 ppm	61.30	10.10	361.90	1.94	52.94
T ₇ : Seaweed extract @ 0.25%	62.35	12.00	424.50	2.41	83.50
T ₈ : Seaweed extract @ 0.50%	69.70	10.80	412.55	2.18	71.48
T ₉ : Triacantanol @ 0.25%	82.90	11.70	395.15	2.08	66.52
T ₁₀ : Triacantanol @ 0.50%	73.00	11.90	439.45	2.43	76.14
T ₁₁ : Humic acid @ 0.25%	78.41	11.50	415.70	2.77	78.15
T ₁₂ : Humic acid @ 0.50%	69.32	12.00	477.55	3.21	90.71
T ₁₃ : Control	47.85	8.50	299.40	1.59	46.63
S. Em±	2.60	0.44	6.43	0.02	2.71
CD @ 5%	7.66	1.30	18.93	0.07	8.00

NS – Non-Significant DAT: Days after transplanting

Table 2: Quality parameters of bird's eye chilli as influenced by growth stimulants

Treatments	Total chlorophyll	Ascorbic acid (mg/100 g)	Oleoresin content (%)	Capsaicin content (%)	Capsanthin content (g/kg)
T ₁ : NAA @ 50 ppm	1.81	115.55	8.70	1.71	17.29
T ₂ : NAA @ 75 ppm	1.20	108.68	6.77	1.51	13.92
T ₃ : GA ₃ @ 50 ppm	1.33	103.69	6.67	1.59	15.81
T ₄ : GA ₃ @ 75 ppm	1.20	112.45	8.16	1.25	16.48
T ₅ : CCC @ 500 ppm	1.73	93.84	6.35	1.35	14.67
T ₆ : CCC @ 750 ppm	1.73	91.17	6.31	1.54	13.29
T ₇ : Seaweed extract @ 0.25%	1.69	106.47	8.59	1.50	15.58
T ₈ : Seaweed extract @ 0.50%	1.73	101.46	7.36	1.22	13.62
T ₉ : Triacantanol @ 0.25%	1.38	97.95	7.84	1.64	14.66
T ₁₀ : Triacantanol @ 0.50%	1.72	94.73	6.94	1.29	12.46
T ₁₁ : Humic acid @ 0.25%	2.20	99.89	6.98	1.27	12.66
T ₁₂ : Humic acid @ 0.50%	2.23	119.60	8.83	1.89	17.12
T ₁₃ : Control	1.11	90.56	6.18	1.08	11.22
S.Em ±	0.13	1.86	0.28	0.11	0.48
CD @ 5%	0.40	5.47	0.84	0.34	1.43

Conclusion

The present investigation demonstrated that growth stimulants exerted a significant influence on the growth, yield, and quality parameters of bird's eye chilli (*Capsicum frutescens* L.). Foliar application of humic acid @ 0.50 per cent was found to be the most effective treatment, resulting in superior leaf production, leaf area index, fresh fruit yield, chlorophyll content, ascorbic acid, oleoresin, and capsaicin content. GA₃ @ 75 ppm significantly enhanced vegetative growth attributes, particularly plant height, while NAA @ 50 ppm recorded the highest capsanthin content. Therefore, foliar application of humic acid @ 0.50 per cent at 60, 90, and 120 days after transplanting can be recommended for improving productivity and fruit quality of bird's eye chilli under hill-zone conditions.

Acknowledgement

The author is highly thankful to the Guide and Head, Department of PSMAC, College of Horticulture, Mudigere, KSNUAHS, Shivamogga (Karnataka) for providing essential facilities and support during the research experiment.

Conflict of Interest

The authors have declared that no conflict of interest exists.

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