Plant Archives Vol. 26, No. 2, 2026 pp. 3104-3108 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.no.2.429

INFLUENCE OF COMBINED FOLIAR APPLICATION OF KNO_3 AND GA_3 ON VEGETATIVE GROWTH OF DRAGON FRUIT (*Hylocereus costaricensis* WEB. BRITTON AND ROSE) UNDER SUBTROPICAL CONDITIONS

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(Date of Receiving-01-08-2026; Date of Revision-03-10-2026; Date of Acceptance-09-10-2026)

ABSTRACT

An investigation was conducted under subtropical conditions of Lucknow during 2022–2023 to study the Influence of Combined Foliar Application of KNO_3 and GA_3 on Vegetative Growth of Dragon Fruit [*Hylocereus costaricensis* (Web.) Britton and Rose] under Subtropical Conditions. The experiment comprised nine treatments laid out in Randomized Block Design with three replications. Treatments included two levels each of GA_3 (50 and 100 ppm) and KNO_3 (3 and 4%), applied singly and in combination, along with a control. Different doses of GA_3 and KNO_3 significantly influenced the vegetative growth characters of dragon fruit. Treatment T_7 (KNO_3 @ 3% + GA_3 @ 100 ppm) recorded the maximum plant length (215.3 cm) and the highest overall increase in plant length, stem circumference, number of segments per plant, distance between areoles, number of spines per areole and arch height from 30 to 90 days after treatment, while the greatest number of primary branches (12.7) was recorded under treatment T_5 (GA_3 @ 100 ppm). The study suggests foliar application of KNO_3 @ 3% combined with GA_3 @ 100 ppm for improved vegetative growth of Dragon fruit under the subtropical conditions of Lucknow.

Keywords: Dragon fruit; GA_3; Growth, KNO_3; Vegetative growth; Foliar application

Introduction

Dragon fruit (*Hylocereus* spp., syn. *Selenicereus* spp.), commonly called pitaya or strawberry pear, is a high-value Cactaceae crop native to Central and South America, now commercially important across Asia. In India, its adaptability, low water requirement, perennial habit, and market demand have driven interest, though productivity remains inconsistent due to a lack of region-specific production technologies (Kakade *et al*., 2025). Because of its minimal water requirement and its ability to thrive under high temperatures, dragon fruit has considerable potential as a emerging crop for regions with hot, dry climates (Trivellini *et al*., 2020).

Most investigations on the floral biology of dragon fruit indicate that pitayas produce large, hermaphroditic, nocturnal blooms that flower and fruit naturally during the warmer months. Being a long-day plant with attractive night-blooming flowers, it is popularly called the “Queen of Night.” Dragon fruit contains four dominant species, *viz.*, *Hylocereus undatus* (white flesh), *H. polyrhizus* (red flesh), *H. costaricensis* (violet red flesh with pink skin) and *H. megalanthus* (yellow flesh). White-fleshed dragon fruit has comparatively lower sweetness (10-13 °Brix) and can weigh up to 650 g, while red dragon fruit is smaller (up to 500 g) but sweeter (up to 15 °Brix). Yellow dragon fruit is more compact, has an almost scale-free skin and can reach up to 18 °Brix in sweetness (Umayah, 2007).

Dragon fruit also has therapeutic significance particularly red-fleshed cultivars are rich in antioxidants. Regular consumption is reported to lower the risk of asthma, cough, cholesterol, high blood pressure, cardiovascular disease and cancer, besides boosting immunity, easing arthritic pain, supporting bone health and improving ocular and nervous function. The fruit is a good source of vitamin C, B_2 and B_3, protein, dietary fibre and minerals such as Fe, P and Ca (Morton 1987). Owing to these nutritional and medicinal qualities, dragon fruit is rapidly expanding as a highly remunerative crop in India and elsewhere.

As a perennial climbing cactus, dragon fruit relies on triangular, succulent cladodes as its main photosynthetic organs; their development directly influences plant vigour, canopy establishment and later flowering and fruiting (Raut *et al.*, 2022; Das *et al*., 2024). Since the crop has a shallow root system and continuous succulent growth, nutrient management particularly nitrogen and potassium requirement is critical. Nitrogen is responsible for cell division, chlorophyll synthesis and shoot development, while potassium regulates enzyme activity, water relations and assimilate transportion (Karunakaran *et al.*, 2024). Field studies confirm that balanced NPK nutrition significantly improves vegetative parameters, with 200:50:50 g N:P:K/plant giving optimal results in one trial (Raut *et al*., 2022; Perween and Hasan, 2019).

Potassium nitrate (KNO_3), supplying soluble nitrate-N and K together, is of particular interest for supporting chlorophyll synthesis, water regulation and biomass development (Kumar *et al*., 2026). Split, stage-specific fertilizer application further improves nutrient-use efficiency. Gibberellic acid (GA_3), a growth regulator promoting cell elongation and division, has also been shown to influence dragon fruit growth.

Since KNO_3 supports nutritional/structural development while GA_3 drives hormonal elongation, their combined application may offer complementary benefits, though optimal doses likely vary by location and cultivar (Maurya *et al*., 2023). As dragon fruit expands into new Indian regions with differing agro-climatic conditions, region-specific evaluation remains essential (Kakade *et al.*, 2025). This study was therefore undertaken to assess the effect of KNO_3 and GA_3, alone and in combination, on the vegetative growth of dragon fruit under local conditions.

Materials and Methods

The experiment was carried out at the Dragon fruit orchard, Department of Horticulture, Babasaheb Bhimrao Ambedkar University, Lucknow, Uttar Pradesh, India (26°55' N and 80°54' E, 123 m above MSL), under the subtropical climate of central Uttar Pradesh, during 2022-2023. The soil of the experimental site was sandy loam with uniform fertility and a pH of 8.1.

The experiment comprised nine treatments, *viz.* T_1 - Control (water spray), T_2 - KNO_3 @ 3%, T_3 - KNO_3 @ 4%, T_4 - GA_3 @ 50 ppm, T_5 - GA_3 @ 100 ppm, T_6 - KNO_3 @ 3% + GA_3 @ 50 ppm, T_7 - KNO_3 @ 3% + GA_3 @ 100 ppm, T_8 - KNO_3 @ 4% + GA_3 @ 50 ppm and T_9 - KNO_3 @ 4% + GA_3 @ 100 ppm, laid out in Randomized Block Design with three replications. Foliar sprays were applied in the late afternoon to minimize the risk of stem/leaf burn and heat stress. Four split doses were applied at 14 days interval, commencing from the end of January.

Observations on vegetative growth, *viz.*, plant length, number of primary branches per plant, number of segments per plant, number of areoles per segment, stem thickness, stem circumference, number of spines per areole, distance between areoles, arch height and chlorophyll content, were recorded at 30, 45, 60, 75 and 90 days after treatment (DAT) following standard methods. The data recorded were analyzed statistically using OPSTAT software following the technique of analysis of variance suggested for Randomized Block Design, and treatment means were compared through the 'F' test at 5% level of significance; critical difference (CD) was calculated wherever the result was found significant.

Results and Discussion

Plant length (cm)

Data presented in Table 1 revealed that vegetative growth of dragon fruit was significantly influenced by the application of KNO_3 and GA_3, both singly and in combination. The maximum increase in plant length (6.0 cm) at 45 DAT (30–45 days) was recorded under T_7 (KNO_3 @ 3% + GA_3 @ 100 ppm) which was statistically

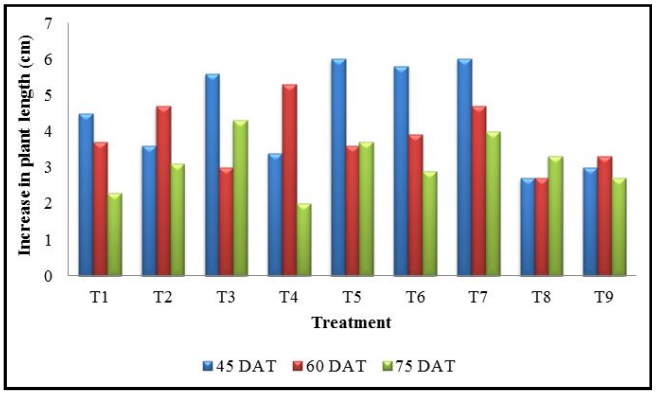


Fig. 1: Increase in plant length of dragon fruit with foliar application of KNO_3 and GA_3.

Table 1: Effect of GA_3 and KNO_3 on increase of plant length and number of primary branches per plant of Dragon fruit.

Treatment	Plant length at 30 DAT (cm)	Percent increase in plant length at				Plant length at 90 DAT (cm)	Total increase in plant length (30-90 days)	Percent increase in primary branches at					Total increase (30-90 days)
		45 DAT	60 DAT	75 DAT	90 DAT			30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	
T_1	193.20	4.50	3.70	2.30	1.00	204.70	12.80	6.70	0.70	2.00	1.40	11.30	10.70
T_2	183.30	3.60	4.70	3.10	1.40	196.20	13.50	7.00	2.30	2.70	1.70	15.70	13.70
T_3	201.70	5.60	3.00	4.30	5.90	210.60	15.00	10.50	0.50	1.30	2.30	17.00	14.70
T_4	193.90	3.40	5.30	2.00	4.20	208.90	18.90	8.70	1.00	1.30	1.30	14.30	12.30
T_5	186.10	6.00	3.60	3.70	4.00	203.30	17.20	4.00	2.30	1.30	2.70	12.70	10.30
T_6	187.50	5.80	3.90	2.90	2.40	202.50	15.00	9.00	1.70	2.00	1.20	15.30	13.90
T_7	195.70	6.00	4.70	4.00	5.00	215.30	19.60	5.00	2.30	2.30	0.30	11.00	10.00
T_8	187.70	2.70	2.70	3.30	4.80	201.20	11.50	10.70	0.60	1.30	2.30	18.30	15.00
T_9	183.30	3.00	3.30	2.70	4.00	196.30	13.00	8.70	0.30	1.70	0.70	14.70	11.30
SEm (±)		**0.03**	**0.05**	**0.03**	**0.05**		**0.12**		**0.01**	**0.02**	**0.03**		**0.15**
CD (P=0.05)		**0.11**	**0.14**	**0.09**	**0.14**		**0.38**		**0.04**	**0.06**	**0.08**		**0.44**

T_1 - Control (water spray), T_2 - KNO_3 @ 3%, T_3 - KNO_3 @ 4%, T_4 - GA_3 @ 50 ppm, T_5 - GA_3 @ 100 ppm, T_6 - KNO_3 @ 3% + GA_3 @ 50 ppm, T_7 - KNO_3 @ 3% + GA_3 @ 100 ppm, T_8 - KNO_3 @ 4% + GA_3 @ 50 ppm, T_9 - KNO_3 @ 4% + GA_3 @ 100 ppm.

at par with T_5 (GA_3 @ 100 ppm), while the minimum increase (2.7 cm) was observed under T_8. At 60 DAT, the highest increase (5.3 cm) was recorded under T_4 (GA_3 @ 50 ppm), followed by T_7 (4.7 cm), whereas the lowest (2.7 cm) was again recorded under T_8. At 75 DAT, the maximum increase (4.3 cm) was observed under T_3 (KNO_3 @ 4%), closely followed by T_7 (4.0 cm), the two being statistically at par, while the minimum increase (2.0 cm) occurred under T_4.

At 90 DAT, T_3 recorded the maximum increase (5.9 cm), followed by T_7 (5.0 cm), while the control (T_1) recorded the lowest increase (1.0 cm). The overall increase in plant length from 30 to 90 DAT was highest under T_7 (19.6 cm), followed by T_3 (18.9 cm), whereas the minimum (11.5 cm) was recorded under T_8; the control performed poorly throughout the study period. These results confirm that combined application of KNO_3 and GA_3 exerts a synergistic effect on shoot elongation, wherein KNO_3 supplies readily available nitrate-nitrogen and potassium for structural development while GA_3 promotes cell elongation and division, together enhancing overall plant length (Kumar *et al.*, 2026; Anagha *et al.*, 2024; Phin *et al.*, 2023).

Number of primary branches per plant

The maximum number of primary branches at 45 DAT (2.3) was recorded under T_5 (GA_3 @ 100 ppm) and T_2 (KNO_3 @ 3%), while the minimum (0.3) occurred under T_9. At 60 DAT, T_2 recorded the highest increase (2.7), followed by T_7 (2.3), whereas T_3 recorded the lowest (1.3). At 75 DAT, T_5 registered the maximum increase (2.7), followed by T_8 (2.3), with the lowest increase (0.3) recorded under T_7.

The overall increase in number of primary branches from 30 to 90 DAT was maximum under T_5 (12..7), statistically at par with T_2, followed by T_8 (7.6), while the control (T_1) recorded the minimum increase (4.7). The pronounced branching response to GA_3 alone supports its established role in promoting lateral bud break and cell division, consistent with earlier reports of enhanced shoot proliferation following GA_3 application in *Hylocereus* spp. (Anagha *et al.*, 2024; da Silva *et al.*, 2026).

Number of segments per plant

No significant variation in the number of segments per plant was recorded at 45 DAT. At 60 DAT, the maximum increase (0.67) was observed under T_2 and T_6 (statistically at par), followed by T_3 (0.34), while the control recorded the minimum increase. At 75 DAT, T_5 registered the highest increase (1.33), at par with T_3, followed by T_8 (1.00), with the control again showing the lowest response.

At 90 DAT, T_7 and T_6 recorded the maximum increase (0.67), followed by T_3 (0.33), while the control recorded the minimum. The overall increase in segment number from 30 to 90 DAT was highest under T_7 (2.33), followed by T_5 (2.00), while the control (T_1) recorded the lowest increase indicating that combined nutrient and hormone application favours continuous cladode segmentation more effectively than either input applied alone. Anagha *et al.*, (2024) and da Silva *et al.*, (2026) reported improved shoot length and biomass with application of GA_3.

Stem thickness (cm)

Table 2 shows that the maximum increase in stem

Table 2: Effect of GA_3 and KNO_3 on increase of number of segments per plant and stem thickness of Dragon fruit.

Treatment	No. of segments at 30 DAT	Percent increase in number of segments					Total increase in number of segments (30-90 days)	Stem thickness (cm) at 30 DAT	Percent increase in stem thickness at				Total increase in stem thickness (30-90 days)
		45 DAT	60 DAT	75 DAT	90 DAT	90 DAT			45 DAT	60 DAT	75 DAT	90 DAT	
T_1	5.00	0.00	0.33	0.34	5.67	0.00	0.67	3.80	0.00	0.10	0.10	4.20	0.30
T_2	5.00	0.00	0.67	1.00	7.00	0.33	2.00	3.90	0.10	0.10	0.20	4.30	0.40
T_3	5.00	0.33	0.34	0.33	6.33	0.33	1.33	4.00	0.10	0.20	0.20	4.60	0.60
T_4	4.33	0.34	0.33	0.67	6.00	0.33	1.67	4.60	0.10	0.10	0.10	4.90	0.30
T_5	4.00	0.00	0.33	1.34	6.00	0.33	2.00	3.90	0.10	0.20	0.20	4.40	0.50
T_6	4.67	0.00	0.67	1.00	7.00	0.67	2.33	4.30	0.20	0.10	0.10	4.70	0.50
T_7	4.67	0.00	0.33	1.33	7.00	0.67	2.33	3.40	0.00	0.10	0.20	3.90	0.40
T_8	3.00	0.00	0.33	0.34	4.00	0.33	1.00	4.20	0.20	0.10	0.20	4.70	0.50
T_9	3.33	0.00	0.00	0.67	4.33	0.33	-	3.70	0.10	0.10	0.20	4.10	0.50
SEm (±)		0.002	0.007	0.003		0.005			0.002	0.001	0.001		0.002
CD (P=0.05)		0.006	0.020	NS		0.014			0.005	0.003	0.003		0.006

T_1 - Control (water spray), T_2 - KNO_3 @ 3%, T_3 - KNO_3 @ 4%, T_4 - GA_3 @ 50 ppm, T_5 - GA_3 @ 100 ppm, T_6 - KNO_3 @ 3% + GA_3 @ 50 ppm, T_7 - KNO_3 @ 3% + GA_3 @ 100 ppm, T_8 - KNO_3 @ 4% + GA_3 @ 50 ppm, T_9 - KNO_3 @ 4% + GA_3 @ 100 ppm.

thickness at 45 DAT (0.2 cm) was recorded under T_6 (KNO_3 @ 3% + GA_3 @ 50 ppm), followed by T_1, T_4 and T_8 (0.1 cm each), with no change recorded under the control. At 60 DAT, T_3 and T_5 (GA_3 @ 100 ppm) recorded the maximum increase (0.20 cm), followed by 0.1 cm under the remaining treatments. At 75 DAT, T_2, T_3, T_5 and T_7 recorded the highest increase (0.2 cm), whereas T_1, T_4 and T_6 recorded the lowest (0.1 cm).

The overall increase in stem thickness from 30 to 90 DAT was maximum under T_3 (0.6 cm), followed by T_7 (0.5 cm), while the control (T_1) recorded the minimum (0.3 cm). The maximum absolute stem thickness at 90 DAT was recorded under T_4 (4.9 cm). The greater stem girth observed under potassium-rich treatments (T_3, T_7) reflects potassium's established role in osmotic regulation, cell turgidity and assimilate translocation, which together support radial stem expansion (Karunakaran *et al.*, 2024; Raut *et al.*, 2022).

Other vegetative growth parameters

Growth parameters such as number of areoles per segment, stem circumference, number of spines per areole, distance between areoles and arch height also varied significantly among treatments. Treatment T_6 (KNO_3 @ 3% + GA_3 @ 50 ppm) recorded the highest increase in number of areoles per segment and distance between areoles, whereas T_7 (KNO_3 @ 3% + GA_3 @ 100 ppm) recorded the highest increase in stem girth, stem circumference, number of spines per areole, arch height from 30 to 90 DAT. The minimum overall increase in stem circumference (0.7 cm), number of spines per areole and arch height was consistently recorded under the control (T_1).

The rate of increase in vegetative growth gained momentum after 75 DAT, coinciding with a steady rise in ambient temperature, which likely enhanced metabolic activity and nutrient/hormone uptake efficiency. (Garbanzo León *et al.*, 2024; Kakde *et al.*, 2025; Murillo Paz *et al.*, 2023). This increase may also be attributed to the cumulative effect of nutrient application combined with regular irrigation up to that stage. A significant variation in total chlorophyll content was also observed, with the maximum and minimum increase recorded under T_7 and the control (T_1), respectively, corroborating the combined role of potassium in chlorophyll stability and GA_3 in promoting chloroplast development and photosynthetic tissue expansion (Kumar *et al.*, 2026).

Overall, the results clearly demonstrate that the combined application of KNO_3 and GA_3 particularly T_7 (KNO_3 @ 3% + GA_3 @ 100 ppm) produced the most consistent and substantial improvement across the majority of vegetative growth parameters, supporting the hypothesis that complementary nutritional and hormonal mechanisms act synergistically to enhance vegetative development in dragon fruit (Raut *et al.*, 2022; Maurya *et al.*, 2023). These findings are in close agreement with Dhanshri *et al.*, (2020) in tuberose and Dogra *et al.*, (2019) in Kinnow mandarin, both of whom also reported significantly enhanced vegetative growth following combined application of KNO_3 and GA_3, further reinforcing the broader applicability of this nutrient–hormone synergy across diverse horticultural crops.

Conclusion

On the basis of the results obtained in the present investigation, it is clear that the combined application of

KNO_3 and GA_3 resulted in better vegetative growth in terms of plant length, branch production, number and length of segments, distance between areoles and stem chlorophyll content, although a few growth parameters showed non-significant differences among treatments. It may be concluded that foliar application of KNO_3 @ 3% + GA_3 @ 100 ppm may be recommended for improved vegetative growth of Dragon fruit under the subtropical conditions of Lucknow.

Acknowledgement

The authors are grateful to the Department of Horticulture for providing the research farm and laboratory facilities required for this investigation. Sincere thanks are extended to the field assistants and supporting staff for their help during crop raising, treatment application and data recording. The guidance and cooperation received from the advisory committee and fellow scholars are also gratefully acknowledged.

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