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EFFECT OF PLANT GROWTH REGULATORS AND LIQUID NANO-UREA ON VEGETATIVE GROWTH, FRUIT SET AND PHYSICAL QUALITY PARAMETER OF DRAGON FRUIT (*HYLOCEREUS COSTARICENSIS*)

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ABSTRACT

Dragon fruit (Hylocereus costaricensis) is an emerging fruit crop in subtropical regions, where optimization of vegetative growth and fruit development is essential for improving productivity. A two-year field experiment was conducted during 2024-25 and 2025-26 under subtropical conditions of Western Uttar Pradesh, India, to evaluate the effect of plant growth regulators and liquid nano-urea on growth and fruit attributes of dragon fruit. Ten treatments comprising brassinosteroid, jasmonic acid and liquid nano-urea in combination with the recommended dose of fertilizers (RDF) were evaluated in a randomized block design with three replications. The pooled results showed that T_2 (brassinosteroid 5 ppm + RDF) performed consistently better for most of the growth and fruit attributes. It recorded the highest plant length at 90 DAI (187.86 cm), number of segments (13.67 plant^{-1}) and number of areoles (300.67 plant^{-1}), while the maximum number of primary branches was recorded with T_1 (35.00 plant^{-1}). T_2 also produced the highest fruit length (12.25 cm), fruit volume (318.06 cc), fruit diameter (8.698 cm) and pulp weight (219.17 g). Fruit set was highest under T_2 and T_9 (98.17% each), compared with 94.67% in the control (T_0). Among the nano-urea treatments, T_8 (15 ml/4.5 L + RDF) showed comparatively better performance for growth and fruit attributes. Overall, the application of brassinosteroid at 5 ppm along with RDF was the most effective treatment for improving vegetative growth and physical fruit attributes of dragon fruit under the subtropical conditions of Western Uttar Pradesh.

KEYWORDS: dragon fruit, brassinosteroid, nano-urea, plant growth, fruit attributes

INTRODUCTION

The dragon fruit (Hylocereus costaricensis) is a climber cactus plant to the family of Cactaceae and the genera Hylocereus (2n=22), It is emerging as an important fruit crop due to its high nutritional, medicinal and economic value, it is popularly known as pitaya, king of the night, strawberry pear, belle of the night and queen of the night because of its attractive nocturnal flowers [1]. It is native to Central and South America and is now widely cultivated in tropical and subtropical regions, including Mexico, Costa Rica, Guatemala, Malaysia, Taiwan, Indonesia, Sri Lanka, Bangladesh, Vietnam and India [2, 3]. In India, commercial cultivation is rapidly expanding in Gujarat, Karnataka, Maharashtra, Andhra Pradesh, Tamil Nadu, West Bengal, Uttar Pradesh. The fruit is available in different types based on peel and flesh colour, such as pink skin with white flesh, pink skin with red flesh and yellow skin with white flesh. Dragon fruit is rich in vitamins, carbohydrates, minerals, calcium, magnesium, phosphorus, antioxidants, crude fibre and ascorbic acid [4, 5]. It also contains bioactive compounds such as betanin, phylocactin, hylocerenin and betacyanin. Regular consumption of dragon fruit greatly controls asthma, cough, cholesterol, help in prevent cancer, blood sugar regulation and immunity improvement. Dragon fruit grows well under tropical and subtropical climates with an optimum temperature of 21-29 °C and annual rainfall of 600-1300 mm [6].

As per the, Dragon fruit cultivation in India expanded from 5.30 thousand hectares in 2022–23 to 14.51 thousand hectares in 2024-25 [7], while production increased from 21.22 to 53.72 thousand metric tonnes. The productivity during 2024-25 was recorded at 3.70 MT/ha [8].

Dragon fruit is a low-maintenance fruit crop with relatively low production costs owing to its limited incidence of major pests and diseases [9]. However, its shallow root system requires balanced nutrient management to achieve optimum growth, yield, and fruit quality [10]. Under the agro-climatic conditions of Western Uttar Pradesh, poor vegetative growth, reduced flowering, smaller fruit size [11, 12]. Plant growth regulators enhance cell division, delay senescence, improve assimilate translocation, and regulate fruit development, while liquid nano-urea enhances nitrogen-use efficiency and nutrient availability [13,14,10]. Therefore, the present investigation was undertaken to evaluate the effects of different plant growth regulators and liquid nano-urea, along with the recommended dose of fertilizers (RDF), on the vegetative growth, flowering, yield attributes of dragon fruit under the agro-climatic conditions of Western Uttar Pradesh.

MATERIALS AND METHODS

The experiment was carried out at Horticulture Research Centre and College of Horticulture at Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (Uttar Pradesh), it lies in the North-Western Plain of India (29o05'38.2" N latitude and 77o41'44.5" E longitude, 220 meters above mean sea level) in the subtropical climate of Uttar Pradesh During 2023-24 and 2025-26. Soil was sandy loam with uniform fertility having pH of 7.8-8.2. The experiment was laid out in Randomized Block Design (RBD) with 10 treatments and three replications - Control (T0), Brassinosteroid 1 ppm + RDF (T1), Brassinosteroid 5 ppm + RDF (T2), Brassinosteroid 10 ppm + RDF (T3), Jasmonic Acid 10 ppm + RDF (T4), Jasmonic Acid 20 ppm + RDF (T5), Jasmonic Acid 40 ppm + RDF (T6), Nano urea 10 ml/4.5 l + RDF (T7), Nano urea 15 ml/ 4.5 l + RDF (T8), Nano urea 20 ml/ 4.5 l + RDF (T9). There are 30 poles each having four plants planted at 4m x 4m spacing. The whole field area is well cleaned and drip irrigation conducted 1 m radius of pole. Plants along with new growth are tied up with cemented pole regularly for better support.

Brassinosteroid, jasmonic acid and nano Urea was collected from online platform of India Mart and iffco bazar which had a desirable particle size about 20-25 nm and more surface area (10000 times over 1 mm urea prill). Well-rotted FYM@ 14 Kg/pole, Vermicompost @ 9 kg/pole and recommended dose of fertilizer applied in 3 to 4 equal splits February/March, May/June during fruit set of 2023-24 and 2025-26) 350-400 N gram/pole, 200-250 P gram/pole and 150- 200 K gram/pole [23]. Inorganic (Chemical fertilizer), Farm Yard Manure and vermicompost were applied as soil application by irrigation whereas PGR and Nano urea was applied as foliar spray as per treatment. Observations were recorded for its vegetative growth and Flowering Character like plant Length (cm), stem girth, number of primary branches/plant, number of segment/plant, number of areoles and Percentage of fruit set, fruit length (cm), fruit diameter, pulp weight. T0 test the significance of variance in data obtained from the various vegetative growth characters, the technique of analysis was adopted as suggested by [15] for Randomized Block Design (RBD). Significance of difference in the treatment effect was tested through 'F' test at 5% level of significance and critical difference (CD) was calculated, wherever the result found significant or not according to OPSTAT.

RESULTS AND DISCUSSION

Vegetative Parameters

Effect of plant growth regulators and liquid nano-urea on vegetative growth parameters of dragon fruit (Pooled mean of two years)

The pooled data showed that plant growth regulators and liquid nano-urea significantly improved vegetative growth of dragon fruit (Table 1). Plant length increased progressively from the initial stage to 90 DAI under all treatments showed in (Figure 1). Treatment T_2 (Brassinosteroid 5 ppm + RDF) produced the maximum plant length (187.86 cm) with the highest net increase (53.58 cm), followed by T_1 (172.07 cm), T_8 (171.87 cm), T_9 (169.91 cm) and T_3 (169.87 cm), whereas the untreated control (T_0) recorded the lowest value (142.20 cm). These findings indicate the superior response of brassinosteroid at 5 ppm in promoting vegetative growth [16].

Stem girth also increased steadily throughout the experimental period. The highest stem girth at 90 DAI was observed under T_3 (9.79 cm), followed by T_8 (9.52 cm), T_2 (9.38 cm) and T_6 (9.28 cm), while the lowest value was recorded under T_5 and T_7 (8.97 cm). Overall, pooled analysis indicated that T_2 was the most effective treatment for enhancing plant vigour, whereas T_3 was superior in improving stem girth showed in (Figure 2) [13,17].

Table 1. Effect of plant growth regulators and liquid nano-urea on vegetative growth parameters of dragon fruit (Pooled mean of two years)

Treatment	Plant length (cm)				Stem girth (cm)			
	Initial	30 DAI	60 DAI	90 DAI	Initial	30 DAI	60 DAI	90 DAI
T0	119.57	126.18	136.83	142.20	8.97	9.04	9.13	9.18
T1	136.93	148.39	164.39	172.07	8.76	8.87	8.99	9.08
T2	134.28	149.46	176.27	187.86	8.98	9.11	9.26	9.38
T3	135.77	146.09	161.40	169.87	9.48	9.57	9.70	9.79
T4	134.99	143.44	156.32	164.17	9.02	9.09	9.17	9.23
T5	130.14	137.81	151.35	158.43	8.76	8.85	8.92	8.97
T6	133.90	141.55	153.60	159.76	9.07	9.14	9.22	9.28
T7	131.89	141.21	155.12	163.69	8.65	8.76	8.88	8.97
T8	134.67	145.95	164.08	171.87	9.24	9.35	9.45	9.52

T9	133.62	143.03	160.97	169.91	8.80	8.89	8.98	9.05
C.D.	9.0651	9.197	NS	9.692	NS	NS	9.13	NS
SE(m)	3.0401	3.072	7.548	3.237	0.298	0.299	8.99	0.299
SE(d)	4.2994	4.344	10.675	4.578	0.421	0.423	9.26	0.422
C.V.	3.97	3.738	6.787	3.378	5.75	5.714	9.70	5.592

Note: T0: Control + (RDF), T1: Brassinosteroid 1 ppm + (RDF), T2: Brassinosteroid 5 ppm + (RDF), T3: Brassinosteroid 10 ppm + (RDF), T4: Jasmonic Acid 10 ppm + (RDF), T5: Jasmonic Acid 20 ppm + (RDF), T6: Jasmonic Acid 40 ppm + (RDF), T7: Nano urea 10 ml/4.5 l + (RDF), T8: Nano urea 15 ml/ 4.5 l + (RDF), T9: Nano urea 20 ml/ 4.5 l + (RDF)

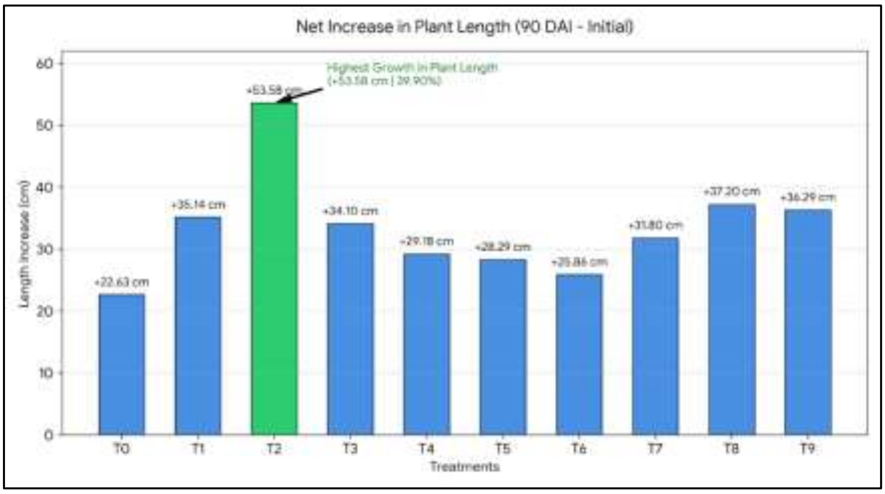
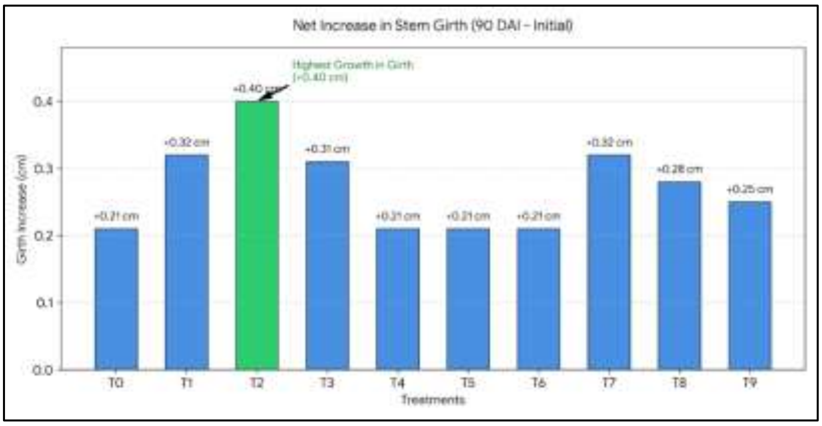


Figure 1. Effect of plant growth regulators and liquid nano-urea on plant length parameters of dragon fruit (Pooled mean of two years)



Figer 2. Effect of plant growth regulators and liquid nano-urea on Stem girth parameters of dragon fruit (Pooled mean of two years)

Effect of plant growth regulators and liquid nano-urea on branching and structural growth parameters of dragon fruit (Pooled mean of two years)

The pooled mean data indicated that plant growth regulators and liquid nano-urea significantly influenced branching and structural growth of dragon fruit (Table 2) and visually showed in (Figure 3). The number of primary branches increased progressively under all treatments, with T_1 (Brassinosteroid 1 ppm + RDF) recording the highest number of branches (35.00 plant^{-1}) at 90 DAI, followed by T_9 (32.00 plant^{-1}), T_2 and T_8 (29.00 plant^{-1} each), whereas the untreated control (T_0) recorded the lowest value (17.00 plant^{-1}). The improved branching under T_1 may be attributed to enhanced bud differentiation and meristematic activity induced by brassinosteroids [18,19].

Segment and areole production also increased significantly during the experimental period. Treatment T_2 (Brassinosteroid 5 ppm + RDF) produced the highest number of segments (13.67 plant^{-1}) and areoles (300.67 plant^{-1}) at 90 DAI, followed by T_1, T_5 and T_8, while the lowest values were recorded under T_0. The superior response of T_2 suggests that brassinosteroid, together with adequate nutrient availability, promoted cladode development and the formation of additional potential sites for flowering and fruiting, in agreement with earlier reports [20,21].

Table 2. Effect of plant growth regulators and liquid nano-urea on branching and structural growth parameters of dragon fruit (Pooled mean of two years)

Tret	No. Primary Branches / Plant	No. Of Segments /Plant	No. of areoles

ment	Initial	30 DAI	60 DAI	90 DAI	Initial	30 DAI	60 DAI	90 DAI	Initial	30 DAI	60 DAI	90 DAI
T0	7	8	13	17	6.83	7.17	8.00	8.17	130.67	139.17	153	156.5
T1	8	13	26	35	9.50	10.17	11.67	12.00	199.5	213.5	256.67	264
T2	7	11	22	29	10.33	11.00	13.00	13.67	220.67	234.33	289.67	300.67
T3	7	10	19	26	7.00	7.50	8.67	9.17	133	139.33	158.33	161.5
T4	7	9	16	23	7.83	8.33	9.67	10.00	156.67	166.67	193.33	200
T5	7	9	16	22	9.00	9.67	11.33	11.83	189	203	249.33	259
T6	8	10	17	24	7.33	7.67	8.67	8.67	139.33	145.67	165	166.17
T7	8	11	21	28	8.50	9.17	10.50	10.83	175.5	189	220.5	227.5
T8	8	12	22	29	9.17	10.00	11.33	11.83	198.33	220	249.33	260.33
T9	8	12	25	32	7.50	8.00	9.17	9.33	144.33	153.67	183.33	183.33
C.D.	NS	1.751	2.242	1.849	1.118	1.092	1.34	0.988	18.31	19.17	23.07	22.40
SE(m)	0.435	0.585	0.749	0.618	0.374	0.365	0.448	0.33	6.16	6.45	7.76	7.54
SE(d)	0.615	0.827	1.059	0.873	0.528	0.516	0.633	0.467	8.71	9.12	10.98	10.66
C.V.	10.037	9.496	6.505	4.002	7.794	7.125	7.6	5.419	6.41	6.25	6.36	5.96

Note: T0: Control + (RDF), T1: Brassinosteroid 1 ppm + (RDF), T2: Brassinosteroid 5 ppm + (RDF), T3: Brassinosteroid 10 ppm + (RDF), T4: Jasmonic Acid 10 ppm + (RDF), T5: Jasmonic Acid 20 ppm + (RDF), T6: Jasmonic Acid 40 ppm + (RDF), T7: Nano urea 10 ml/4.5 l + (RDF), T8: Nano urea 15 ml/ 4.5 l + (RDF), T9: Nano urea 20 ml/ 4.5 l + (RDF)

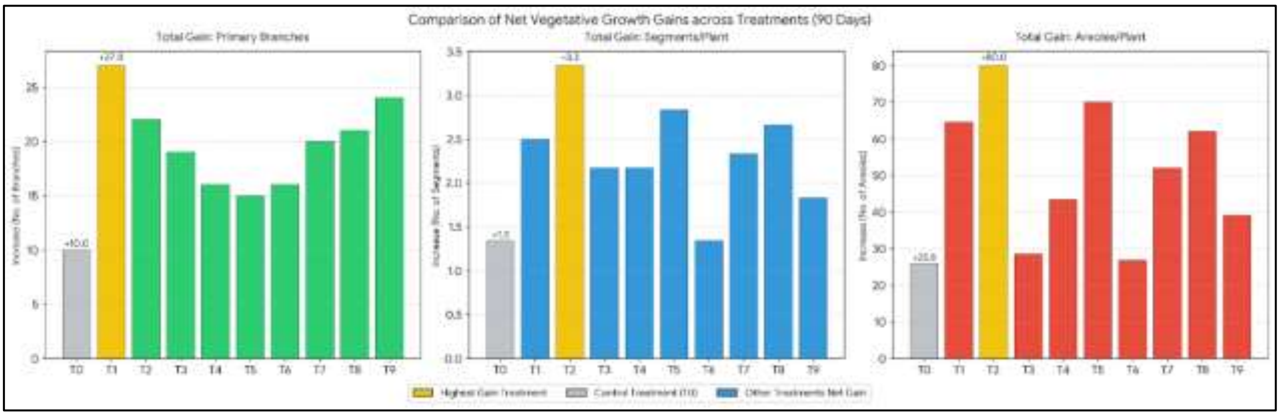


Figure 3. Effect of plant growth regulators and liquid nano-urea on branching and structural growth parameters of dragon fruit (Pooled mean of two years)

Effect of plant growth regulators and liquid nano-urea on fruit set and physical quality parameter of dragon fruit (Pooled mean of two years)

The pooled analysis revealed that the application of plant growth regulators and liquid nano-urea influenced fruit set and significantly improved the physical attributes of dragon fruit (Table 3 & Figure 4). Fruit set showed numerical variation among treatments, with the highest values recorded in T_2 (Brassinosteroid 5 ppm + RDF) followed by T_3 (98.00%), T_4 (97.91%) and T_7 and T_8 (97.67% each), whereas the lowest fruit set was recorded in T_0 (Control + RDF) (94.67%).

Fruit physical attributes varied significantly among treatments. T_2 recorded the maximum fruit length (12.25 cm), fruit volume (318.06 cc) and fruit diameter (8.698 cm), followed by T_8 (10.95 cm, 309.77 cc and 8.352 cm) and T_7 (10.63 cm, 296.59 cc and 8.222 cm), respectively. The minimum fruit length, volume and diameter were recorded under T_0 (8.61 cm, 238.69 cc and 6.838 cm). Similarly, pulp weight was highest under T_2 (219.17 g), followed by T_8 (207.67 g), T_7 (199.33 g) and T_3 (187.67 g), while the lowest pulp weight was observed in T_0 (144.67 g). The superior performance of T_2 may be attributed to enhanced cell division and enlargement, photosynthetic activity and assimilate translocation, while the response of nano-urea treatments may reflect improved nitrogen-use efficiency and nutrient availability during fruit development. Overall, T_2 emerged as the most effective treatment for improving fruit size and pulp development, with T_8 showing the next-best performance [20, 22, 23].

Table 3. Effect of plant growth regulators and liquid nano-urea on fruit set and physical attributes of dragon fruit (Pooled mean of two years)

Treatment	Fruit Set (%)	Fruit Length (cm)	Fruit volume (cc)	Fruit Diameter	Pulp Weight (gm)
T0	94.667	8.61	238.69	6.838	144.67

T1	97.333	9.18	252.52	7.370	164.67
T2	98.167	12.25	318.06	8.698	219.17
T3	98.000	10.16	292.50	7.987	187.67
T4	97.908	8.85	251.56	7.377	157.17
T5	96.833	9.44	258.55	7.608	175.00
T6	95.167	9.15	266.87	7.443	167.50
T7	97.667	10.63	296.59	8.222	199.33
T8	97.667	10.95	309.77	8.352	207.67
T9	97.500	9.76	275.93	7.767	179.17
C.D.	NS	0.407	4.65	0.235	0.92
SE(m)	1.099	0.136	1.55	0.078	0.31
SE(d)	1.555	0.192	2.19	0.111	0.44
C.V.	1.961	8.61	0.97	1.75	0.30

Note: T0: Control + (RDF), T1: Brassinosteroid 1 ppm + (RDF), T2: Brassinosteroid 5 ppm + (RDF), T3: Brassinosteroid 10 ppm + (RDF), T4: Jasmonic Acid 10 ppm + (RDF), T5: Jasmonic Acid 20 ppm + (RDF), T6: Jasmonic Acid 40 ppm + (RDF), T7: Nano urea 10 ml/4.5 l + (RDF), T8: Nano urea 15 ml/ 4.5 l + (RDF), T9: Nano urea 20 ml/ 4.5 l + (RDF)

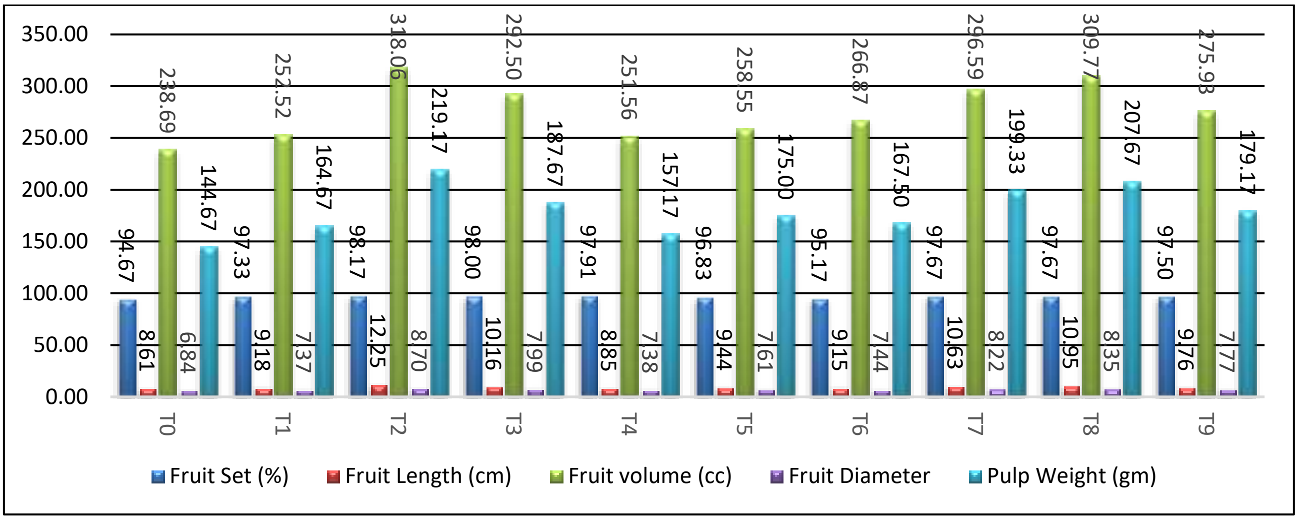


Figure 4: Effect of plant growth regulators and liquid nano-urea on fruit set and physical attributes of dragon fruit (Pooled mean of two years)

CONCLUSION

This two-year field investigation demonstrates that strategic integration of bio-active phytohormones and nano-urea sprays with soil-applied recommended dose of fertilizers significantly enhances canopy, floral node proliferation and fruit structural capacity in red pitaya (Hylocereus costaricensis) under subtropical agro-climatic conditions. Foliar application of 5 ppm Brassinosteroid + RDF (T_2) consistently triggered superior physiological responses—significantly improving primary stem extension, cladode branching, areole recruitment, fruit set percentage, and fruit pulp accumulation over the unsupplemented control. Additionally, foliar application of liquid nano-urea at 15 mL/4.5 L + RDF (T_8) demonstrated strong efficacy as a secondary high-performance nutrient delivery mechanism, showing substantial improvement in fruit weight and dimensions. In conclusion, exogenous application of 5 ppm brassinosteroid combined with standard RDF represents a highly potent, physiologically sound, and commercially viable management practice to optimize canopy vigor and reproductive efficiency in Hylocereus costaricensis. Multi-location trial validation and biochemical dynamics studies are recommended to facilitate scaled field adoption.

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