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Study on the effect of plant growth regulators on rooting performance of dragon fruit stem cuttings under net house conditions in Bastar district of Chhattisgarh

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Abstract
The present investigation was conducted under net house conditions at Bastar district, Chhattisgarh, to study the influence of plant growth regulators on the rooting behavior of dragon fruit (*Hylocereus polyrhizus*) stem cuttings. The experiment consisted of ten treatments including control, Indole-3-butyric acid (IBA) at concentrations of 2000, 3000, 4000, 5000, 6000, and 7000 ppm, humic acid (2000 ppm), humic + fulvic acid (2000 ppm), and seaweed extract (2000 ppm), arranged in a completely randomized design (CRD) with three replications. Results revealed that IBA significantly enhanced root initiation, root number, and root length over control and biostimulant treatments. Among all treatments, IBA 7000 ppm (T$_6$) recorded the earliest root initiation (15.85 days), the highest average number of roots (10.79 per cutting), maximum root length (25.91 cm), and average root length (13.56 cm) at 90 DAS. The same treatment also produced the highest fresh (2.32 g) and dry (1.40 g) root weights, with a lower shoot-to-root ratio (5.39) and the maximum survival percentage (93.33%). Treatments with humic acid and seaweed extract showed moderate improvement compared to control. The study confirms that IBA application, particularly at 6000-7000 ppm, is most effective in promoting rooting performance, biomass accumulation, and survival of dragon fruit stem cuttings. The findings highlight the potential of auxin-based propagation as a reliable and cost-effective method for large-scale multiplication of dragon fruit planting material under protected cultivation in Bastar and similar agro-climatic regions.

Keywords: Dragon fruit, *Hylocereus polyrhizus*, IBA, root initiation, biostimulants, humic acid, seaweed extract, net house propagation

1. Introduction

Dragon fruit (*Hylocereus* spp.), commonly known as pitaya, is a climbing cactus of economic and nutraceutical importance, increasingly cultivated in tropical and subtropical regions of the world including parts of India (Mizrahi, Nerd, & Nobel, 1997). Its attractive fruit, vibrant pulp color, and health-benefiting properties (antioxidants, dietary fiber, etc.) have stimulated interest in scaling up production (Raut, Rathod, Bharad, & More, 2022) [12]. To expand its cultivation, the development of efficient, large-scale propagation techniques is necessary.

Vegetative propagation via stem cuttings is the preferred method to multiply planting material of dragon fruit because it is simple, cost-effective, and ensures clonal uniformity (Raut *et al.* 2022) [12]. However, rooting of dragon fruit cuttings is often slow and inconsistent under field or net-house conditions unless rooting stimuli are provided (Dharani, Rajangam, Beaulah, Venkatesan, & Vijayasamundeeswari, 2023) [2]. Exogenous application of plant growth regulators (PGRs), particularly auxins such as indole-3-butyric acid (IBA), is widely deployed to enhance rooting in difficult-to-root species (Frick, Strader, & Bartel, 2017) [3].

Auxins like IBA promote root initiation and subsequent root development by inducing cell division and differentiation in stem tissues, mobilizing carbohydrates, and regulating expression of auxin-responsive genes (Frick, Strader, & Bartel, 2017) [3]. Numerous studies have demonstrated that IBA improves root number, root length, biomass, and survival of cuttings in many horticultural species (Sevik, Turan, & Yildiz, 2013; Oğuztürk *et al.* 2025) [13, 8]. For instance, in species under water stress conditions, IBA has been shown to maintain better rooting performance, likely by accelerating root formation (Oğuztürk *et al.* 2025) [8].

In dragon fruit specifically, research has explored the effect of IBA and other auxins on rooting efficacy. Kakade *et al.* (2024) [4] found that IBA at 6000 ppm improved root growth traits (root length, number, biomass) and reduced the time to sprouting, compared to untreated controls. Similarly, Pandey (2024) [10] studied IBA and NAA treatments for dragon fruit and found improved shoot development in IBA-treated cuttings. Other authors have reported optimal IBA concentrations in the range of 2000 to 4000 ppm for root induction in dragon fruit (Singh & Kaur, 2024; Dharani *et al.* 2023) [14, 2].

Nevertheless, the response of dragon fruit cuttings to IBA is known to be influenced by local environmental conditions (temperature, humidity, light), substrate medium, cutting size, and interaction with biostimulants (humic acid, seaweed extracts) (Dharani *et al.* 2023; Raut *et al.* 2022) [2, 12]. Also, excessively high auxin concentrations may suppress shoot growth or induce callus rather than functional roots (Sun, 1991) [16].

In the Bastar district of Chhattisgarh, dragon fruit cultivation under net houses is emerging but the propagation protocols are not yet optimized regionally. Therefore, this study aims to evaluate a range of IBA and biostimulant treatments for their effect on rooting parameters (root initiation, root number, root length, biomass) and survival, under net-house conditions. The objective is to identify the optimal treatment for enhancing rooting performance of *Hylocereus polyrhizus* stem cuttings in this agro-ecological zone.

2. Materials and Methods

The present investigation entitled *"Study on the Effect of Plant Growth Regulators on Rooting Performance of Dragon Fruit (Hylocereus polyrhizus) Stem Cuttings under Net House Conditions in Bastar District of Chhattisgarh"* was conducted during 2024-25 at net house at Krantikari Debridhur College of Horticulture and Research Station Jagdalpur (C.G.). The experiment was carried out under controlled net house conditions to ensure uniform microclimatic parameters. Healthy, mature, and disease-free stem cuttings (20-25 cm in length) of dragon fruit were selected from 8-month-old mother plants. The cuttings were shade-dried for 24 hours before treatment. The study comprised ten treatments, including control (distilled water), Indole-3-butyric acid (IBA) at 2000, 3000, 4000, 5000, 6000, and 7000 ppm, humic acid (2000 ppm), humic + fulvic acid (2000 ppm), and seaweed extract (2000 ppm). The cuttings were dipped in their respective solutions for 5 minutes before planting. The experiment was laid out in a Completely Randomized Design (CRD) with three replications, and each replication consisted of ten cuttings.

Treated cuttings were planted in polythene bags (12 x 30 cm) containing a growth medium mixture of soil : sand : FYM (1 : 1 : 1 v/v) and maintained under 50% shade net conditions. Regular irrigation and cultural operations were carried out to ensure proper growth. Observations were recorded at 30, 60, and 90 days after planting (DAS) on parameters such as days taken for root initiation, average number of roots per cutting, length of the longest root, average root length, fresh and dry weight of roots, shoot/root ratio, and survival percentage of cuttings. The collected data were statistically analyzed following standard ANOVA procedures as outlined by Panse and Sukhatme (1985), and treatment means were compared at the 5% level of significance to determine the effect of plant growth regulators on rooting behavior.

3. Results and Discussion

3.1. Days Taken for Root Initiation

The number of days required for root initiation varied significantly among treatments. The earliest root initiation (15.85 days) was recorded in T_6 (IBA 7000 ppm), followed by T_5 (16.72 days), while the maximum (25.36 days) was observed in control (T_0). This shows that IBA significantly accelerated root formation compared to humic, fulvic, or seaweed extracts. These findings are in close agreement with Lesmes-Vesga *et al.* (2021) [7], who reported that increasing IBA concentration reduced root initiation time in peach cuttings due to enhanced cell differentiation at the basal portion of cuttings. Similarly, Singh (2014) [15] and Kumar *et al.* (2021) [6] found that IBA enhanced early root formation in grapevine cuttings by stimulating adventitious root primordia.

3.2. Average Number of Roots per Cutting

A gradual and consistent increase in the average number of roots per cutting was observed with increasing IBA concentration. At 90 DAS, T_6 (IBA 7000 ppm) produced the maximum number of roots (10.79), while the lowest (5.34) was observed in control (T_0). Treatments with humic acid (T_7) and seaweed extract (T_9) showed moderate improvement compared to control but were inferior to IBA treatments. This result supports the findings of Prager (1983), Kumar *et al.* (2021) [6] and Ali *et al.* (2021) [1], who stated that IBA promotes more root initials and increases the number of lateral roots due to the accumulation of carbohydrates and the stimulation of auxin-responsive genes.

3.3. Length of the Longest Root (cm)

Root length was significantly influenced by plant growth regulator treatments. The longest root (25.91 cm) was recorded in T_6 (IBA 7000 ppm), followed by T_5 (24.71 cm), while the shortest (16.19 cm) occurred in the control treatment. The humic and seaweed-based treatments (T_7-T_9) produced moderately longer roots than control but were inferior to IBA treatments. The enhancement in root elongation by IBA may be attributed to its ability to promote cell division and elongation in root meristematic tissues (Singh, 2014) [15]. Similar results were reported by Lesmes-Vesga *et al.* (2021) [7] and Kumar *et al.* (2021) [6] in peach and Sun *et al.* (1991) [16] in ornamental species, where IBA significantly increased root length.

3.4. Average Root Length per Cutting (cm)

Average root length per cutting also followed a similar trend. The highest average root length (13.56 cm at 90 DAS) was recorded under IBA 7000 ppm (T_6), followed by IBA 6000 ppm (T_5 = 13.27 cm), while the control showed the lowest (7.61 cm). These results confirm that auxin treatments improve both the number and elongation of roots, resulting in a denser and longer root system. The effect may be due to enhanced protein synthesis and enzymatic activity related to root growth (Lesmes-Vesga *et al.* 2021; Singh, 2014; Kumar *et al.* 2021) [15, 7, 6].

3.5. Fresh Weight of Root (g)
A significant increase in root fresh weight was recorded with the increase in IBA concentration. The maximum fresh weight (2.32 g) was observed in T_6 (IBA 7000 ppm), followed by T_5 = 2.22 g, while the control recorded the lowest (1.15 g). Similar results were obtained by Ali *et al.* (2021) [1], who reported that IBA enhances biomass accumulation by promoting root initiation and growth. Treatments with seaweed and humic acid also increased root weight compared to control, due to bioactive compounds with auxin-like activity (Kisvarga *et al.* 2024 and Kumar *et al.* 2021) [6].

3.6. Dry Weight of Root (g)
Dry weight of root showed a similar trend as fresh weight. The highest dry weight (1.40 g) was recorded in IBA 7000 ppm (T_6), followed by IBA 6000 ppm (T_5 = 1.34 g), and the lowest in control (0.32 g). The increase in root dry weight with IBA concentration can be attributed to the formation of more and thicker roots with higher dry matter accumulation (Singh, 2014; Lesmes-Vesga *et al.* 2021) [15, 7].

3.7. Shoot/Root Ratio
The shoot/root ratio decreased gradually with increasing IBA concentration. The lowest ratio (5.39) was recorded in T_6, compared to the highest (10.75) in control. A lower shoot/root ratio indicates better root growth relative to shoot development, which is favorable for the successful establishment of cuttings. Sun *et al.* (1991) [17] and Kumar *et al.* (2021) [6] also observed that high IBA concentrations enhance root development at the expense of shoot elongation, leading to a more balanced plant system.

3.8. Survival Percentage of Cuttings (%)
Survival percentage increased notably with IBA treatments. The maximum survival (93.33%) was obtained in IBA 7000 ppm (T_6), followed by IBA 6000 ppm (T_5 = 86.67%), whereas the minimum (66.67%) was recorded in the control. Humic acid and seaweed extract treatments showed intermediate survival rates. This improvement in cutting survival under IBA treatments may be attributed to the development of a strong and extensive root system capable of sustaining higher water and nutrient uptake (Kisvarga *et al.* 2024; Ali *et al.* 2021) [1]. Similar survival enhancement effects of auxins have been reported in dragon fruit and other cactus species under semi-controlled environments (Lesmes-Vesga *et al.* 2021 and Kumar *et al.* 2021) [7, 6].

5. Conclusion
The present study clearly demonstrated that the application of plant growth regulators, particularly Indole-3-butyric acid (IBA), significantly enhanced the rooting performance and survival of dragon fruit (*Hylocereus polyrhizus*) stem cuttings under net house conditions in Bastar district of Chhattisgarh. Among all treatments, IBA at 7000 ppm (T_6) proved to be the most effective in promoting early root initiation (15.85 days), producing the highest number of roots (10.79 per cutting), maximum root length (25.91 cm), and the greatest root biomass (fresh weight = 2.32 g; dry weight = 1.40 g). The treatment also recorded the highest survival percentage (93.33%) and a favorable shoot-to-root ratio, indicating a well-balanced vegetative growth.

Humic acid, fulvic acid, and seaweed extract treatments also improved rooting over the control but were less effective than IBA. The overall findings suggest that IBA application at 6000-7000 ppm concentration range is optimal for enhancing root induction, elongation, and establishment success of dragon fruit stem cuttings under protected cultivation. The study highlights the potential of auxin-based propagation as a low-cost, efficient technique for mass multiplication of dragon fruit planting material, which could support large-scale orchard establishment and livelihood opportunities for farmers in Bastar and similar agro-climatic zones of Chhattisgarh.

Table 1: Effect of Plant Growth Regulators on Root Growth Parameters of Dragon Fruit (*Hylocereus polyrhizus*) Stem Cuttings under Net House Conditions at Different Growth Intervals.

Tr. No.	Treatment Details	Days taken for root initiation (days)	Average number roots per cutting			Length of the longest root (cm)			Average length of root per cutting		
			30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_0	Control (Dipped in distilled water)	25.36	4.56	7.70	16.19	2.47	5.34	9.74	2.21	4.55	7.61
T_1	Indole 3 butyric acid 2000 ppm	20.77	7.08	11.09	22.20	3.59	7.98	15.97	3.03	6.22	11.02
T_2	Indole 3 butyric acid 3000 ppm	19.64	7.73	12.31	22.49	3.74	8.21	16.91	3.18	6.63	11.26
T_3	Indole 3 butyric acid 4000 ppm	18.66	8.73	13.07	22.88	3.78	8.95	18.68	3.36	6.96	11.69
T_4	Indole 3 butyric acid 5000 ppm	17.84	8.89	13.41	23.43	3.89	9.82	20.02	3.58	7.37	12.58
T_5	Indole 3 butyric acid 6000 ppm	16.72	9.31	15.04	24.71	4.20	10.28	20.99	3.85	7.80	13.27
T_6	Indole 3 butyric acid 7000 ppm	15.85	9.93	15.53	25.91	4.53	10.79	22.12	3.90	8.61	13.56
T_7	Humic acid 2000ppm	24.93	5.68	8.57	17.11	2.83	5.99	10.46	2.28	5.48	9.30
T_8	Humic acid + Fulvic acid 2000ppm	22.54	6.33	8.92	19.42	3.32	6.29	11.80	2.69	5.82	10.31
T_9	Sea weed extract 2000ppm	21.26	6.52	9.88	20.00	3.50	7.17	14.30	2.76	6.11	10.56
	Sem (±)	0.56	0.20	0.32	0.54	0.08	0.19	0.29	0.05	0.09	0.24
	CD (5%) =	1.65	0.60	0.94	1.58	0.24	0.57	0.86	0.16	0.27	0.72
	CV (%) =	4.76	4.71	4.78	4.32	3.91	4.15	3.13	3.08	2.45	3.80

Table 2: Effect of Plant Growth Regulators on Root Biomass, Shoot-Root Ratio, and Survival Percentage of Dragon Fruit (*Hylocereus polyrhizus*) Stem Cuttings under Net House Conditions

Tr. No.	Treatment Details	Fresh weight of root (g)	Dry weight of root (g)	Shoot/ Root ratio	Survival percentage of cuttings
T_0	Control (Dipped in distilled water)	1.15	0.32	10.75	66.67
T_1	Indole 3 butyric acid 2000 ppm	1.75	0.68	7.93	76.67
T_2	Indole 3 butyric acid 3000 ppm	1.87	0.78	7.12	76.67
T_3	Indole 3 butyric acid 4000 ppm	2.04	0.93	6.73	80.00
T_4	Indole 3 butyric acid 5000 ppm	2.15	1.08	6.16	80.00
T_5	Indole 3 butyric acid 6000 ppm	2.22	1.34	4.96	86.67
T_6	Indole 3 butyric acid 7000 ppm	2.32	1.40	5.39	93.33
T_7	Humic acid 2000ppm	1.36	0.40	9.81	70.00
T_8	Humic acid + Fulvic acid 2000ppm	1.44	0.46	10.31	70.00
T_9	Sea weed extract 2000ppm	1.58	0.60	8.39	73.33
	Sem (±)	0.03	0.01	0.23	2.58
	CD (5%) =	0.09	0.03	0.68	7.62
	CV (%) =	2.80	2.50	5.11	5.78

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7. Future Scope

This study provides a foundational understanding of the ecological and socio-economic importance of traditional agroforestry and wild edible plant systems. Future research can expand by integrating advanced geospatial mapping, carbon stock modeling, and biodiversity indexing across multiple agro-climatic zones of Chhattisgarh. The inclusion of molecular and biochemical analyses may further elucidate the nutraceutical and adaptive potential of indigenous plant species. Long-term monitoring of carbon sequestration trends, coupled with community-based participatory approaches, can guide sustainable agroforestry planning and policy formulation to strengthen climate resilience, food security, and rural livelihoods.

8. Conflict of Study

The authors declare no conflict of interest related to the conduct, analysis, or publication of this study. All data were collected and interpreted objectively for academic and scientific purposes only.

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