



Optimisation of indole butyric acid concentrations in dragon fruit (*Selenicereus polyrhizus*) stem cuttings under nursery condition of semi-arid region of Rajasthan, India

KEERTHIKA A¹, A K SHUKLA^{2*}, M B NOOR MOHAMED², KAMLA K CHOUDHARY²,
R S MEHTA² and S R MEENA²

ICAR-Central Arid Zone Research Institute, Regional Research Station, Pali-Marwar, Rajasthan 306 401, India

Received: 15 September 2025; Accepted: 05 March 2026

Keywords: Dragon cladode, IBA concentration, Root dry weight, Sprouting

Dragon fruit [*Selenicereus polyrhizus* (A. Berger) Riccob], commonly known as Pitaya or Pitahaya or strawberry pear, is an emerging and promising climbing vine type perennial fruit crop belonging to the family Cactaceae. It is originated from central or South America and Mexico (Mizrahi and Nerd 1999). India produces approximately 12,000 tonnes of fruit per year, holding high economic potential and huge demand in market (Wakchure *et al.* 2021). Since the area under cultivation continues to expand, the effective technique for production of quality planting material is highly essential. Although dragon fruit is propagated both sexually and asexually, seed propagation is constrained by low seed viability, poor seedling vigour and takes long time i.e. even after a year, the seedlings are not ready to transplant in field (Tripathi *et al.* 2014). Vegetative propagation (stem cuttings) is rapid, easiest, cost effective, true to type and reliable method for multiplication of dragon fruit as it ensures genetic fidelity as well as clonal uniformity. Therefore, stem cutting is the most widely adopted and extensively recommended propagation method for dragon fruit.

Plant hormone (auxin) plays a significant role in regulating adventitious root formation and development of stem cuttings. Based on intrinsic rooting capacity, cuttings can be categorised into easy to root and difficult to root type, the former possess adequate endogenous hormonal balance to initiate roots with simple techniques, while the later exhibit physiological or biochemical constraints, requiring exogenous hormonal application of growth regulators and special techniques to stimulate root primordia formation (Liu *et al.* 2025). Thus, the success of dragon fruit stem cuttings

is significantly affected by the exogenous application of growth regulators under varying environmental conditions. Furthermore, ensuring supply of quality planting material is the foremost criteria in establishing a dragon orchard. Despite stem cuttings being the easiest method of propagation, supply of inferior quality seedlings by private nurseries poses a significant challenge. Additionally, several factors including the timing of collection of cuttings, age of mother plant, size of the cuttings, season in which cuttings are planted, portion of stem used, fresh weight of the cuttings, environmental conditions, growing media and application of PGR (plant growth regulators), collectively influence survival and overall establishment of dragon fruit stem cuttings. Numerous experiments have been conducted to standardise ideal concentration of rooting hormone and length of cuttings for growth of dragon fruit stem cuttings, viz. Ahmed (2006) reported 10 mM IBA (Indole 3-Butyric acid) for obtaining high quality seedlings, Siddhiqua *et al.* (2018) recommend IBA @6,000 and 7,000 ppm, Malsawmkimi and Alila (2019) registered IBA @1,000 ppm, and Singh and Kaur (2024) in IBA @3,500 ppm. These observations clearly indicated that the effectiveness of root hormone concentration can vary widely based on location, season and other environmental factors. However, there is a lack of studies focusing specifically on the semi-arid regions regarding the growth of dragon fruit stem cuttings in nursery conditions. Therefore, this study aimed to standardise IBA concentrations in the semi-arid region of Rajasthan.

The study was carried out in shade house during November to February 2024–2025 at ICAR-Central Arid Zone Research Institute, Regional Research Station, Pali-Marwar (25.79° N, 73.30° E), Rajasthan. The experiment was conducted in completely randomised design (CRD) with five replications.

Healthy dragon cladodes collected from two-year-old mother plant were used for study. Slant cutting was given at the base of cuttings and kept in shade for 4–5

¹ICAR-Central Research Institute for Dryland Agriculture, Hyderabad, Telangana; ²ICAR-Central Arid Zone Research Institute, Regional Research Station, Pali-Marwar, Rajasthan.
*Corresponding author email: anilciah@gmail.com

days for callusing. The cuttings were treated with Bavistin @0.2% solution to prevent fungal attack. Different concentrations of IBA @250, 500, 750, and 1000 ppm were prepared with control (no treatment) and cuttings were dipped in it for 2–3 min. The IBA treated cuttings were planted in polybag (Soil: Sand: FYM ratio 2:1:1). In each concentration, 50 cuttings were planted in polybag (12 cm × 26 cm). A total of 250 cuttings were planted in polybag. As a precautionary measure, chlorpyrifos @2 mL/L water was drenched to prevent termite damage. After 2.5 months, five plants were retrieved from each IBA concentrations and recorded the following growth parameters. Sprouting percentage was calculated by counting new sprout from the treated cuttings out of total cuttings planted and expressed as percentage. Number of cladodes was recorded by counting the emergence of new cladodes. Length of cladode was measured from base to the tip of newly merged shoots while longest root length was measured from base to tip of root initiation point with measuring scale. Other parameters like adventitious root [three adventitious roots/plant (base to tip) and averaged] and number of roots/stem cuttings were also recorded.

Root dry weight: After separation of roots, they were washed and dried to obtain constant weight, they were weighed in electronic balance and its average was recorded in grams. The data were fed into Excel sheet and analysed in SPSS software version 16. The treatment means were compared at 5% significance level to determine the effect of IBA levels on growth and rooting behaviour.

Seasonal variation modulates the success of vegetative propagation techniques including cuttings, layering and grafting in perennial fruits by altering micro climatic patterns and other physiological process such as carbohydrate mobilisation, hormonal regulation, and cambial activity. In the present study, irrespective of size of the cuttings, the emergence of first new cladode was observed after 45–50 days after planting during winter. This duration was effected by environmental and soil factors including temperature, humidity, moisture availability, soil type or growth media, season (winter, summer and rainy), and physiological maturity of the cuttings. The present findings

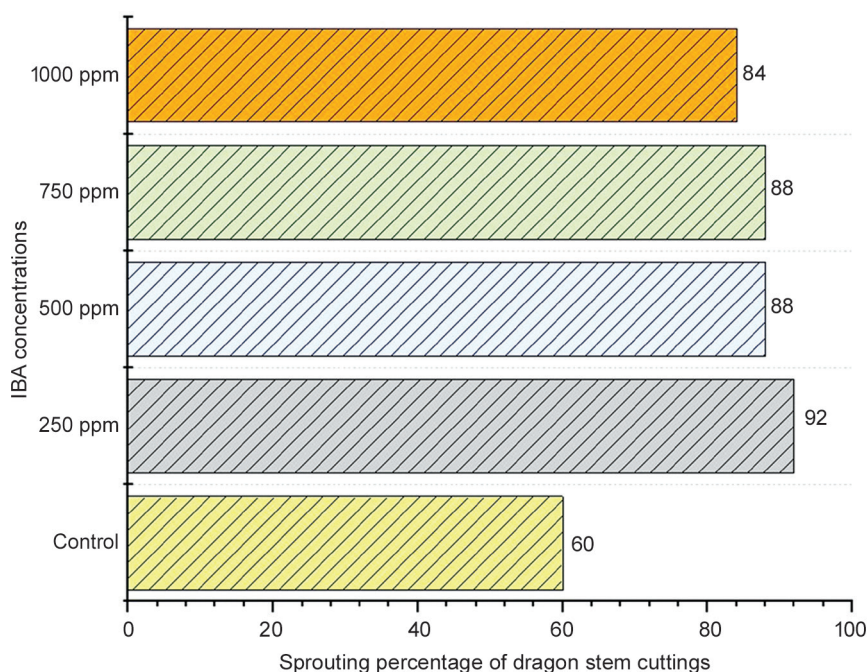


Fig. 1 Sprouting percentage of dragon fruit stem cuttings in nursery condition of semi-arid Rajasthan.



Fig. 2 Growth of dragon fruit cladodes in different concentration of rooting hormone (IBA).

are in consonance with the results of Nandi *et al.* (2019) who reported better rooting percentage in winter. In contrast, Chettri *et al.* (2026) reported 96.7% survival percentage (7,000 ppm IBA) in June, with no survival in control. This indicated that season and excessive hormonal application affects survival ability of dragon fruit stem cuttings. Among the different IBA concentrations, 250 ppm recorded the highest sprouting of 92% closely followed by 88% in 500 and 750 ppm, respectively (Fig. 1 and 2). The decreased sprouting in higher IBA concentrations supports findings of Singh and Kaur (2024), suggesting excessive auxin application might inhibit bud break. The control recorded a low sprouting percentage (60%) which indicates rooting

Table 1 Effect of IBA (root hormone) concentration on growth characteristics of dragon stem cuttings

IBA concentration	Mean new cladode length (cm)			No. of new cladodes	Length of longest root (cm)	Adventitious root (cm)			No. of roots	Dry weight of root (g)
	Mean	Max	Min			Mean	Max	Min		
Control	6.93 ± 0.91	8.55	5.37	2.33 ± 0.33	17.93 ± 1.27	10.46 ± 0.94	11.50	8.80	12.33 ± 0.88	3.82 ± 0.19
250 ppm	13.92 ± 0.47	15.25	12.83	2.66 ± 0.33	21.83 ± 2.24	10.78 ± 0.56	11.70	9.60	14.00 ± 0.57	4.51 ± 0.82
500 ppm	11.12 ± 0.17	11.33	10.80	3.00 ± 0.57	25.00 ± 3.61	12.75 ± 0.78	13.70	9.20	14.00 ± 0.57	4.61 ± 0.97
750 ppm	15.46 ± 1.02	23.5	-	2.33 ± 0.88	25.33 ± 4.37	14.60 ± 2.16	17.20	10.30	14.33 ± 0.88	4.74 ± 0.88
1,000 ppm	9.80 ± 0.86	11.50	8.67	2.67 ± 0.33	21.30 ± 1.90	10.11 ± 0.78	11.70	9.20	13.33 ± 0.33	4.21 ± 1.00
CD	2.42			N/S	N/S	N/S			N/S	N/S
SEM±	0.75			0.53	2.91	1.19			0.83	0.71
SE(d)	1.07			0.76	4.11	1.68			1.78	1.01

Data presented as Mean ± SE.

hormone has effect on growth of the dragon cladode. The findings are in concurrence with the results reported by Tripathi *et al.* (2014) which suggested that IBA @250 ppm promotes the highest percentage of proteins and nitrogen in the shoots compared to other concentrations. These observations suggested that successful vegetative propagation is governed by integration of seasonal, hormonal and physiological cues for expressing traits. Few more studies have reported better sprouting percentage under different levels of IBA concentration. However, in contrary to our findings, Meena *et al.* (2023), Singh and Kaur (2024) and Chettri *et al.* (2026) reported sprouting under higher concentration of IBA @3,500, 4,000 and 7,000 ppm, indicating possible genotype and environment specific responses.

Significant differences were found in new cladode length among different IBA concentrations. The mean cladode length (15.46 ± 1.02) was higher in 750 ppm followed by 250 ppm (13.92 ± 0.47) (Table 1). The maximum new cladode length recorded was 23.5 cm in 750 ppm and minimum in control (5.37 cm). Similar results were obtained by Ali *et al.* (2022) and Maji *et al.* (2021). The increased cladode length might be attributed to acceleration of cellular activity mobilised by reserved food material and auxin mediated shoot induction well known for stimulation of shoots and roots (Hartman *et al.* 1990). Additionally, genetic factors, type of cut, planting time and IBA application might have influenced new shoot emergence (Singh 2014). The number of new cladodes ranged from 2.33 ± 0.33 (control) to 3.00 ± 0.57 (500 ppm). The maximum sprout length was also observed with the application of IBA corroborating the findings of Meena *et al.* (2023) in dragon fruit.

In the present study, it was also found that improvement in performance of root parameters namely length of longest root, mean adventitious root and dry weight of the roots were noted with the use of IBA. Although root parameters exhibited non-significant differences, there were visible differences in maximum and minimum values (Table 1). Application of IBA concentration @750 ppm showed

maximum length of longest root (25.33 ± 4.37) followed by 500 ppm (25.00 ± 3.61). Similar trend was observed for mean adventitious root length, with maximum recorded in 750ppm (17.20 cm) and minimum in control (8.80 cm). Comparable results of longest root length were obtained by Yadav *et al.* (2025) under high concentrations of IBA 7,000 ppm in net-house conditions. These findings corroborate Singh and Singh (2005) who reported that IBA enhances root elongation by promoting cell division in root meristematic tissues. Adventitious rooting in plants is influenced by total carbohydrate and nitrogen levels and their C/N ratio (Rapaka *et al.* 2005). Kumar (2016) reported better root growth in narrow leaved evergreen cuttings collected during early winter, which was attributable to reduced shoot growth, progressive stem hardening and greater carbohydrate accumulation. Moreover, relatively lower nitrogen level might reduce tissue succulence, thereby making stem cuttings less susceptible to rot and enhancing rooting efficiency. The highest number of roots was registered in 750 ppm (14.33 ± 0.88; Table 1) possible due to acceleration of microbial activity in root initiation induced by growth regulators. It was also noticed that the decreased root parameters in IBA @1,000 ppm might be attributed to the release of toxicity associated with higher dosage as reported by Hartmann *et al.* (1990). Pandey *et al.* (2022) demonstrated positive relationship between increase in degree of root formation with increase in IBA concentration in dragon fruit cuttings. The dry weight of root was almost at par with each other (>4.0 g) across IBA concentrations; however, IBA @750 ppm registered 19.40% higher root dry weight than the control. Root dry weight also exhibited positive linear relationship with longest root length and number of roots ($R^2=0.91$ and 0.98 , respectively) while moderate relationship was observed with adventitious roots ($R^2=0.58$; Fig. 3). This indicates root elongation and proliferation contributes to biomass accumulation because longer roots possess greater surface area for water and nutrient absorption, thereby promoting structural development, resulting in increased root dry

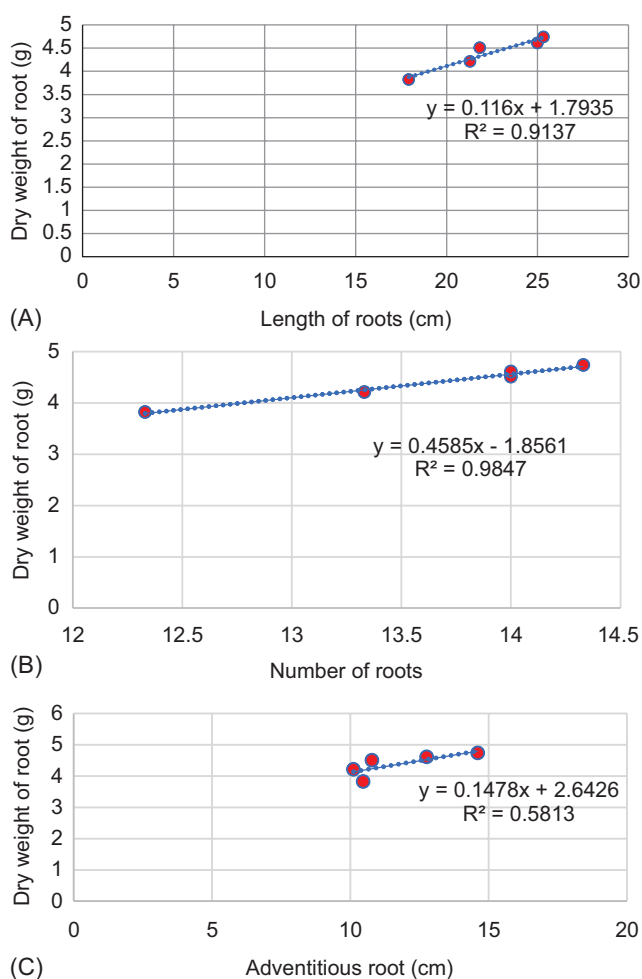


Fig. 4 Relationship between root parameters and dry weight of root.

weight. Similar correlations were reported by Kakade *et al.* (2019) and Chettri *et al.* (2026). Anagha *et al.* (2025) also indicated that early root induction and higher root biomass were the indicative parameters for survival of cuttings in dragon fruit. Moreover, the higher cambial activity during the season would have attributed to the better rooting percentage, as endogenous auxin levels will be higher during the months of November to March (Cabahug *et al.* 2018, Nandi *et al.* 2019) which supports the results of the present study.

SUMMARY

The study was carried out during November to February 2024–25 in shade house established at ICAR-Central Arid Zone Research Institute, Regional Research Station, Pali Marwar, Rajasthan to assess the effect of different concentrations of rooting hormone on dragon fruit stem cuttings. Dragon fruit stem cuttings collected from two-year-old mother plant treated with different Indole-3 Butyric Acid (IBA) concentrations revealed that irrespective of the length of cuttings, maximum sprouting (92%) was obtained in 250 ppm closely followed by 88% in 500 and 750 ppm. The mean cladode length and rooting parameters were better

in IBA @750 ppm. Rooting length and number of roots exhibited a strong linear relationship with root dry weight. These results provide valuable insights into optimising rooting hormone concentrations for mass multiplication of dragon fruit plants under semi-arid region of Rajasthan.

ACKNOWLEDGEMENT

The research was supported by the Indian Council of Agricultural Research (ICAR), Department of Agricultural Research and Education (DARE), Government of India. The authors also gratefully acknowledge the support and facilities provided by ICAR-Central Arid Zone Research Institute (CAZRI), Regional Research Station (RRS), Pali Marwar, Rajasthan.

REFERENCES

- Ahmed A E. 2006. Mass propagation of pitaya (dragon fruit). *Fruits* **61**(5): 313–19.
- Ali S I, Kumar T S, Kumar A K, Joshi V and Kumar B N. 2022. Studies on effect of different concentrations of IBA and length of cuttings on rooting and shoot growth performance in dragon fruit *Hylocereus* spp.-red flesh with pink skin under Telangana conditions. *Journal of Pharma Innovation* **11**(3): 738–43.
- Anagha P K, Prakasha D P, Anand N, Vijay M, Ryavalad S and Sree M R. 2025. Enhancing dragon fruit (*Hylocereus undatus*) propagation efficiency through growing media. *International Journal of Economic Plants* **12**(1): 1–5.
- Cabahug R A M, Nam S Y, Lim K B, Jeon J K and Hwang Y J. 2018. Propagation techniques for ornamental succulents. *Flower Research Journal* **26**(3): 90–101. <https://doi.org/10.11623/fij.2018.26.3.02>
- Chettri P, Wangchu L, Nimbolkar P K, Singh S, Rozerto K and Dhanalakshmi S. 2026. Optimization of type of cuts, timing and IBA concentration for dragon fruit (*Hylocereus costaricensis*) propagation in the foothills of Arunachal Pradesh. *Vegetos*. <http://doi.org/10.1007/s42535-025-01607-1>
- Hartmann H T, Kester D E and Davies F J. 1990. *Plant Propagation: Principles and Practices*, 6th edn.
- Kakade V, Dinesh D, Singh D, Bhatnagar P R and Kadam D. 2019. Influence of length of cutting on root and shoot growth in dragon fruit (*Hylocereus undatus*). *The Indian Journal of Agricultural Sciences* **89**(11): 1895–99.
- Kumar M G N. 2016. *Propagating Shrubs, Vines, and Trees from Stem Cuttings*, pp. 1–8. PNW Publication, Washington State University.
- Liu S, Li X, Xu L and Zhang F. 2025. Hormone functions in adventitious root formation during cutting propagation of woody plants. *Journal of Plant Research* **138**(6): 907–14. <https://doi.org/10.1007/s10265-024-01602-8>
- Maji S, Meena K and Kumar S. 2021. Influence of various length of stem cutting for successful propagation of dragon fruit [*Hylocereus costaricensis* (Web.) Briton and Rose]. *Crop Research* **56**(6): 313–36.
- Malsawmkimi R W and Alila P. 2019. Effect of various levels of IBA and stem cutting sizes on propagation of dragon fruit (*Hylocereus polyrhizus*). *Current Horticulture* **7**(1): 64–68.
- Meena P K, Maji S and Ali M. 2023. Augmentation of rooting and shooting in stem cuttings of dragon fruit. *Indian Journal of Ecology* **50**(2): 404–07.
- Mizrahi Y and Nerd A. 1999. Climbing and columnar cacti: New arid land fruit crops. *Perspectives on New Crops and New*

Uses 1: 358–66.

- Nandi P N, Tarai R K and Ghosh S N. 2019. Study on rooting behaviour of different types of cutting of dragon fruit at different period of year. *International Journal of Minor Fruits, Medicinal and Aromatic Plants* 5(2):45–49.
- Pandey L, Verma R S, Shukla K K, Shukla J K and Pathak S. 2022. Effect of IBA and NAA on rooting of stem cutting in dragon fruit [*Hylocereus undatus* (Haworth) Britton & Rose]. *Journal of Experimental Agriculture International* 44: 1–6.
- Rapaka V K, Bessler B, Schreiner M and Druege U. 2005. Interplay between initial carbohydrate availability, current photosynthesis, and adventitious root formation in Pelargonium cuttings. *Plant Science* 168: 1547–60.
- Singh A K and Singh R. 2005. Influence of growth regulating substances on rooting of cuttings of poinsettia cv. Flaming Sphere. *Progressive Horticulture* 37(1): 85–88.
- Singh D and Kaur A. 2024. Response of dragon fruit (*Hylocereus* spp.) cuttings to different plant growth regulators. *Current Agriculture Research Journal* 12(1): 339–47.
- Singh G. 2014. Study of IBA containing rooting powder on root induction behaviour in grape (*Vitis vinifera* L.) cuttings. *Indian Journal of Agricultural Research* 48(4): 324–29.
- Siddiqua A, Thippesha D, Shivakumar B S, Adivappan N and Ganapathi M. 2018. Effect of growth regulators on rooting and shooting of stem cuttings in dragon fruit [*Hylocereus undatus* (Haworth) Britton & Rose]. *Journal of Pharmacognosy and Phytochemistry* 7(5): 1595–98.
- Tripathi P C, Karunakaran G, Sankar V and Kumar R S. 2014. Dragon fruit: Nutritive and ruminative fruit. *Technical Bulletin 11*. Central Horticultural Experiment Station, Indian Institute of Horticultural Research, Chettalli. 10p.
- Wakchaure G C, Kumar S, Meena K K, Rane J and Pathak H. 2021. Dragon fruit cultivation in India: Scope, constraints and policy issues. *Technical Bulletin 27*. Central Horticultural Experiment Station, Indian Institute of Horticultural Research, Chettalli. 47p.
- Yadav A, Garg S, Kumar S, Alam B and Arunachalam A. 2025. A review on genetic resources, breeding status and strategies of dragon fruit. *Genetic Resources and Crop Evolution* 72(3): 2511–31.