



Response of Dragon Fruit (*Hylocereus* Sp.) Cuttings to Different Plant Growth Regulators.

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Abstract

Dragon fruit (*Hylocereus* sp.) is an exotic crop with a great potential for its cultivation in semi arid tracts throughout India. Its planting is mainly confined to harsh climates and degraded lands facing challenges in its establishment. Hence, availability of quality planting material is essential for attaining success. Due to long juvenile phase of the sexually propagated seedlings it can be propagated asexually by stem cuttings but proper rooting is not possible without exogenous auxin application. Hence, during 2022-2023 a research was carried out at the Horticultural Experimental area of Khalsa College, Amritsar to standardize the concentration of plant growth regulators viz. IBA, NAA and PHB for rooting and success rate in stem cuttings comprising of sixteen treatments with three replications arranged in randomized block design. The results revealed that the stem cuttings treated with IBA 4000 ppm proved to be superior for the sprouting and survival of the cuttings resulting in the improved vegetative growth with profuse, longer, thicker and the heaviest roots. Hence, the cutting treatment of IBA 4000 ppm can be proposed for dragon fruit plant propagation to meet the market demand in India.



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Introduction

Dragon fruit (*Hylocereus* sp.) has received worldwide recognition¹ as a promising fruit crop. It belongs to family Cacteaceae which comprises of 120-200 genera and 1500-2000 species with their existence in America.² Due to the formation of large flowers blooming at night dragon has an ornamental value. The fruit comes in the market in three forms with leathery, slightly leafy skin. Due to the presence of bracts or scales on fruit skin the

fruit has been given the name of pitaya. It is also known as pitahaya, pitajua, pitalla or pithaya.³ The fruit is mainly confined to tropical and subtropical regions of Mexico and Central south America.⁴ Besides industrial as well as medicinal significance it also excels economic potential due to which this fruit crop has been taken up for commercial cultivation by the grower's world-wide.⁵ Dragon fruit is packed with potential health benefits. Recent studies investigate the antioxidants activity

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of dragon fruit which suggested the pigments in providing protection against certain oxidative-stress related disorders.⁶ A broad spectrum of vitamins, lycopene, minerals and carbohydrates in the form of reducing sugars including glucose and fructose has been advocated.^{7,8} The pulp and peel extract showed anti-inflammatory, anti-spasmodic, radioprotective⁹ antimicrobial, anti-cancer and anti-diabetic activities.¹⁰ Both the flesh and seeds have a good control on fatty acids. Dragon fruit is eaten as a fresh fruit. Fresh and dried dragon skin is used as natural food thickener and natural coloring agent. Albedo of the fruit is used to color rice, milk, yoghurt, juice and pastry.¹¹ Propagation of dragon fruit through vegetative method is a pre-requisite to produce true to type plants. Among vegetative propagation cuttings of majority of plants are normally dipped in growth regulators before planting to boost root formation. Among propagation techniques the easiest and cheapest method of propagation is by cutting.^{12,4} Propagation through cutting ensures faster fruiting. In some dragon fruit cultivars cuttings do not root easily without the use of auxin treatments and have extended root initiation and root growth as compared to treated cuttings. Cuttings of majority plants are normally dipped in growth regulators before planting to boost root formation. Researchers demonstrated the rooting stimulated by IBA treatment.^{13,14}

Materials used and Methodology

Procurement of Cuttings and Treatment

The dragon fruit cuttings were sourced out of a one year old healthy mother plant of cv. American Beauty. The solution of growth regulators were prepared by dissolving it in 50 % ethanol (with a purity of 96%) with different concentrations. Sixteen treatment combinations (100-500) ppm NAA, (1000-5000) ppm IBA and (500-1500) ppm PHB along with untreated cuttings were replicated three times in randomized block design. The cuttings of the size of 20 cm were planted in the polybags of size of 16×10 inches filled with soil in the middle of March.

Rooting Media

Before planting, the polybags of size of 16×10 inches were filled with the respective rooting media. On the bottom and sides of polythene bags, holes for water drainage were made.

Cutting Plantation

While planting, about 2/3rd length of the cuttings were buried in the media, leaving 1/3rd part exposed in the environment.

Experimental Procedures

Days of Sprout Initiation

Daily observations were recorded of the treated cuttings regarding sprout initiation and the time elapsed in it was noted.

Number of Sprouts

The number of sprouts per cutting was calculated out of the total cuttings planted.

Percentage of Shoot Emergence

Shoot emergence percentage was calculated by dividing the total sprouted cuttings by total planted cuttings and expressed as its percentage.

Sprout length

Shoot length was measured by a measuring scale taking into account the base up to the growing tip.

Fresh Shoot Weight

It was taken on average basis of the randomly selected five plants per treatment on an electronic balance expressed in grams.

Dry shoot weight

Using destructive method the selected shoots were packed in paper bags and then air dried at 60° C in hot air oven. On drying, their weight was calculated as grams.

Survival

The survived cuttings under each treatment in each replication was recorded and its percentage was calculated by the division of total survived cuttings by total planted ones expressing it in per cent.

Roots Per Cutting

The roots arising from the base of the cuttings were counted after gentle washing them with water.

Average Root Length

Starting from the base to growing tip of root length was measured with scale of the selected plants and later on averaged.

Longest Root Length

Length of longest root was taken as centimetres after its measurement with the scale.

Fresh Root Weight

After separation of the roots they were washed and weighed on an electronic balance and its average was calculated in grams.

Root Dry weight

To calculate the dry weight of roots, roots were air dried at 55°C in hot air oven. After drying the weight was calculated again on the electronic balance and weight was calculated in grams.

Data Collection and Statistical Analysis

The observations pertaining to germination, vegetative growth and survival were calculated at 90 DAP and processed in MS-Excel. The statistical analysis of data which comprised of 7 treatments and 3 replications were analyzed by randomized block design with factorial arrangement ($p \leq 0.05$) with IBM-SPSS Statistics (Version 29.0) software. The significant difference between means were compared by using DMRT'S.

Experimental Results And Discussion**Number of Sprouts**

It is apparent from the results that slight variations were found among the treatments on sprout production in the cuttings. Increased sprout production was achieved up to certain concentrations but decreased at the highest concentration (Table-1). Maximum sprouts (2.94) were formed in IBA 4000 ppm. PHB succeeded IBA within the range of 0.99 -1.86 with the maximum (1.86) in PHB 750 ppm which also showed decreased sprout production with increased concentrations. The untreated cuttings produced the least (0.83) sprout production. The accelerated sprout formation can be ascribed to the enhanced division of cells and their elongation with application of increased dose of IBA leading to an increased shoot growth activation that led to sprout development¹³ The research study of 16 stated that sprouting can be due to the availability of the reserved food material as recorded in *Citrus limon*,²⁰ in pomegranate²¹ and in dragon fruit cuttings.^{22,23}

Percentage of Shoot Emergence

Based on the data analysis presented in Table-1 the treatments administering NAA, IBA and PHB

significantly affected the percentage of shoot emergence. More prominence in shoot emergence was observed in IBA treatments than NAA and PHB treatments. The application of IBA has a significant effect on the percentage of shoot emergence namely (4000 ppm) as the maximum percentage of shoot emergence. In PHB treatments emergence percentage was in the range of 39.78 to 42.09 per cent with an increase in emergence with increasing concentration depicting maximum 51.41 per cent in 1000 ppm treated cuttings. Out of all NAA registered the lowest emergence within the range 53.31-67.33 per cent with an increase up to 400 ppm NAA as maximum (67.33 %) shoots. For promotion of adventitious rooting IBA treatment proved to be the most effective.²⁴ The increased concentration of IBA increased the root formation²⁵ due to the presence of stable chemical content for root stimulation²³ in dragon fruit cuttings and ensured improved uniformity in plants. The acceleration of cell activity resulted from the energy obtained from the proper utilization of the reserved food material might have resulted in the increased sprout emergence percentage.^{26,27} The research findings concluding IBA as the best for the establishment of the dragon fruit cuttings are akin to the present research results.^{22,19}

Sprout length

Significant variations ($p \leq 0.05$) were found regarding sprout length as affected by various concentrations of growth regulators (Table-1). The treatments of IBA escalated with the maximum sprout length as compared to PHB and NAA registering the highest (107.20 cm) sprout length. Sprout length decreased at the highest IBA concentration of 5000 ppm with (102.53 cm). PHB produced sprouts with lesser length than IBA and NAA which showed a decline at the higher concentrations beyond 750 ppm which showed the maximum (65.66 cm) sprout length. Augmentation of nutrient availability might have resulted in the plant metabolism as reported in *ficus* spp.²⁹ Increased linear growth of stem due to cell elongation by the action of auxins and maximum sprout length was recorded with the application of IBA and NAA as reported in scented geranium cuttings³⁰ Decline in the shoot length by PHB treatments has also been reported which are in sustenance with the present findings.^{31,32}

Table 1: Sprouting and vegetative growth in dragon fruit cuttings as affected by plant growth regulators

Treatments	Number of Sprouts	Shoot emergence	Survival percentage	Length of shoot (cm)	Fresh shoot weight(g)	Dry shoot weight(g)
T ₁ -NAA 100ppm	1.48±0.08 ^j	53.31±2.06 ^j	72.80±0.30 ^j	56.07±1.36 ^l	37.93±0.20 ^l	6.71±0.15 ^k
T ₂ -NAA 200ppm	1.72±0.05 ^{gh}	57.96±4.12 ^j	78.10±0.30 ^f	71.60±2.43 ^e	39.03±0.41 ^k	7.15±0.20 ^j
T ₃ -NAA 300ppm	1.98±0.03 ^e	63.02±3.29 ^g	82.00±0.30 ^d	79.40±2.33 ^d	45.50±0.20 ^f	9.18±0.20 ^e
T ₄ -NAA 400ppm	1.63±0.12 ^{hi}	67.33±4.96 ^e	83.50±0.30 ^c	69.53±1.32 ^f	41.63±0.41 ⁱ	8.87±0.20 ^f
T ₅ -NAA 500ppm	1.11±0.08 ^l	65.15±4.23 ^f	71.20±0.30 ^j	62.60±3.75 ⁱ	40.33±0.41 ^j	8.19 ±0.20 ^h
T ₆ -IBA 1000ppm	1.78±0.07 ^g	60.82±4.49 ^h	74.40±0.30 ^h	59.10±1.21 ^{jk}	48.74±0.20 ^d	8.43±0.20 ^g
T ₇ -IBA 2000ppm	2.12±0.07 ^d	70.44±3.63 ^d	80.50±0.30 ^e	67.66±2.88 ^g	49.66±0.35 ^d	9.96±0.20 ^c
T ₈ -IBA 3000ppm	2.54±0.10 ^c	74.54±5.09 ^c	84.60±0.30 ^c	93.26±1.85 ^c	50.73±0.41 ^c	9.40±0.20 ^d
T ₉ -IBA 4000ppm	2.94±0.05 ^a	79.27±4.80 ^a	90.70±1.47 ^a	107.20±1.44 ^a	56.30±0.80 ^a	12.19±0.20 ^a
T ₁₀ -IBA 5000ppm	2.74±0.06 ^b	77.02±4.46 ^b	70.36±0.85 ^k	102.53±2.40 ^b	52.80±0.80 ^b	10.53±0.20 ^b
T ₁₁ -PHB 500ppm	1.53±0.05 ^{ij}	39.78±3.56 ^m	87.50±0.30 ^b	57.93±0.95 ^k	36.70±0.26 ^m	6.20±0.20 ^m
T ₁₂ -PHB 750ppm	1.86±0.11 ^{ef}	47.79±4.96 ^k	75.60±0.30 ^g	65.66±0.76 ^h	47.00±0.20 ^e	8.20±0.20 ^h
T ₁₃ -PHB 1000ppm	1.35±0.09 ^k	51.41±2.91 ^j	55.70±0.30 ^l	60.60±0.72 ^j	44.30±0.20 ^g	7.59±0.20 ⁱ
T ₁₄ -PHB 1250ppm	1.11±0.09 ^{lm}	43.57±6.51 ^l	45.60±0.30 ^m	53.66±0.76 ^m	43.10±0.20 ^h	6.44±0.20 ^l
T ₁₅ -PHB 1500ppm	0.99±0.07 ^m	42.09±5.52 ^l	32.70±1.99 ⁿ	40.33±0.57 ^o	30.00±2.00 ^o	4.71±0.48 ^o
T ₁₆ -Control (Distilled water)	0.83±0.08 ⁿ	32.90±4.98 ⁿ	65.16±0.30 ^k	49.33±0.76 ⁿ	35.63±0.91 ⁿ	5.70±0.20 ⁿ
Mean ± S.D	1.73±0.61	57.90±14.34	71.90±15.31	68.53±18.35	43.71±6.89	8.09±1.90
CD (p≤ 0.05)	0.13	1.98	1.19	1.79	1.06	0.19

Numbers in rows and columns followed by the same letters show no difference.

Shoot Weight (Fresh and Dry)

Maximum (56.30 g) fresh weight was depicted by (IBA 4000 ppm). It was followed by PHB which also showed an increase up to 750 ppm with 47.00 g showing decline at higher concentrations but a great decline was noticed with PHB 1500 ppm accounting to 30.00 g of shoot fresh weight (Table-1). There was an increase in the shoot weight to a certain extent in NAA treated cuttings respectively. The untreated cuttings surpassed the PHB concentration of 1500 ppm weighing 35.63g as shoot fresh weight. The shoot dry weight followed the same trend with the maximum (12.19 g) observed in (2000 ppm IBA). The treatments of NAA was followed by IBA with the highest (9.18 g) at NAA 300 ppm. Among PHB treatments the shoot dry weight decreased below 750 ppm from 8.50 g to 4.71 g at 1500 ppm which was the least of all the treatments but the untreated cuttings was greater than this treatment. The increased weight with IBA can be attributed to the role of auxins in increasing the cell permeability for moisture and essential nutrients resulting in the

cell division and its enlargement leading to the plant growth in terms of shoot number and their higher fresh shoot weight. Similar results are confirmed in fig.³³ dragon fruit cuttings.^{19, 22, 17} The decline in the shoot weight at higher concentrations of growth regulators might be due to the toxicity of K⁺ ions.³⁴ The low response of PHB than IBA can be attributed to its inhibition action as reported in peach.³⁵ The superiority of IBA over NAA has also been reported in dragon fruit cuttings.¹

Survival Percentage

According to the results incurred 72% of cuttings treated with the growth regulators survived (Table-1). Out of applied growth regulators the treatments which were treated with IBA prompted to the best in plant survival with maximum (90.7%) in the cuttings treated with IBA 4000ppm significantly. Minimum survival (32.70) was achieved in the cuttings treated with PHB 1500ppm. Distinct differences in survival rate of plants raised from cuttings with the application of growth regulators was noticed. PGRs such as

IBA and NAA accelerates the rooting rate resulting in the increase of survivability of cuttings.^{36,37} IBA proved to be the best auxin for general use due to its non-toxicity to plants than NAA.³⁸ Its effective role in rooting and survival promotion has been advocated.³⁹ The research findings in Kiwi fruit,⁴⁰ pomegranate⁴¹ and dragon fruit advocated the highest survival with IBA^{13,42,17}

Number of Roots Per Cutting

Significantly ($p \leq 0.05$) increase in the root number was observed with (21.56) roots produced with the 4000 ppm IBA application. The treatments of NAA followed IBA with 18.54 roots being the maximum with NAA 300 ppm. PHB lagged behind in the root production than IBA and PHB with the root production range of 16.15 -12.16 being the highest with 750 ppm and the lowest at the highest concentration of 1500

ppm. Untreated cuttings performed better than PHB 1500 ppm with the root production of 12.99 roots per cutting respectively. More root production with IBA pertains to the promotion of cell division and their elongation with the auxins resulting in distinctness of cambium formation into root initials due to the availableness of the energy reserves thus producing more roots.⁴³ A correlation between primordial division in root initiation and endogenous or exogenous auxin results in the increase of roots.⁴⁴ The increase in the degree of root formation in cuttings with increasing IBA concentration has been reported in dragon fruit cuttings.^{45,1} There was a reverse tendency in root production pertaining to IBA dosage. These results are in conformity with in fig.³⁰ Lesser root production with PHB than IBA has also been reported in pomegranate,³² fig,³¹ peach,³⁵ and in olive.⁴⁶

Table 2: Rooting in dragon fruit cuttings as affected by plant growth regulators

Treatments	Root number	Root length (cm)	Longest root (cm)	Fresh root weight (g)	Dry root weight (g)
T ₁ -NAA 100ppm	15.44±0.40 ^h	3.70±0.20 ^h	5.30±0.20 ^j	1.20±0.20 ^k	0.84±0.20 ^k
T ₂ -NAA 200ppm	17.91±0.13 ^e	4.03±0.20 ^g	7.43±0.25 ^h	2.00±0.20 ⁱ	1.25±0.20 ^j
T ₃ - NAA 300ppm	18.54±0.40 ^d	6.10±0.20 ^c	10.10±0.20 ^d	3.50±0.20 ^d	2.13±0.20 ^d
T ₄ -NAA 400ppm	16.01±0.37 ^g	5.30±0.20 ^d	9.60±0.20 ^e	2.90±0.20 ^e	2.00±0.20 ^e
T ₅ -NAA 500ppm	15.03±0.17 ⁱ	4.50±0.20 ^f	8.70±0.20 ^f	2.30±0.20 ^{gh}	1.60±0.20 ^h
T ₆ -IBA 1000ppm	17.21±0.16 ^f	3.10±0.20 ^j	5.40±0.20 ^j	0.80±0.20 ^m	0.65±0.20 ^{lm}
T ₇ -IBA 2000ppm	18.29±0.20 ^d	3.40±0.20 ⁱ	6.40±0.20 ⁱ	1.00±0.20 ^l	0.70±0.20 ^l
T ₈ -IBA 3000ppm	19.39±0.15 ^c	5.51±0.15 ^d	10.63±0.42 ^c	4.20±0.20 ^c	2.48±0.20 ^c
T ₉ -IBA 4000ppm	21.56±0.20 ^a	7.63±0.25 ^a	14.50±0.20 ^a	6.13±0.11 ^a	3.01±0.11 ^a
T ₁₀ -IBA 5000ppm	20.46±0.12 ^b	6.63±0.25 ^b	13.20±0.20 ^b	5.10±0.20 ^b	2.70±0.20 ^b
T ₁₁ -PHB 500ppm	14.91±0.13 ^j	2.70±0.20 ^k	4.20±0.20 ^k	1.50±0.20 ^j	0.97±0.20 ^j
T ₁₂ -PHB 750ppm	16.15±0.15 ^g	4.90±0.20 ^e	8.96±0.11 ^f	2.60±0.20 ^f	1.86±0.15 ^f
T ₁₃ -PHB 1000ppm	15.02±0.16 ⁱ	4.23±0.25 ^g	8.20±0.20 ^g	2.40±0.20 ^g	1.72±0.20 ^g
T ₁₄ -PHB 1250ppm	14.10±0.10 ^j	3.20±0.20 ^j	6.10±0.20 ⁱ	2.20±0.20 ^h	1.08±0.12 ^j
T ₁₅ -PHB 1500ppm	12.16±0.08 ^l	0.59±0.45 ^m	1.00±0.50 ^m	0.50±0.20 ⁿ	0.25±0.13 ⁿ
T ₁₆ -Control (Distilled water)	12.99±0.10 ^k	1.55±0.47 ^l	3.36±0.75 ⁱ	0.70±0.20 ^m	0.55±0.20 ^m
Mean ± S.D	16.53±2.62	4.18±1.81	7.70 ±3.50	2.43±1.59	1.48±0.82
CD ($p \leq 0.05$)	0.36	0.25	0.437	0.17	0.12

Numbers in rows and columns followed by the same letters show no difference

Average Length of Root

Significantly (7.63cm) as maximum length of root was recorded in IBA 4000ppm. Out of NAA and PHB highest (6.10 cm) was recorded in NAA

300ppm (Table-2). Reduction in the root length at the highest concentration was reported in all the growth regulators tried. The research findings described that the increment in root length can be attributed to high

C/N ratio, sucrose and reducing sugars produced as a result of enhanced carbohydrates disintegration depleting starch, their accumulation at the action site which in turn synthesise new proteins causing cell division and elongation.^{17,22} These factors shows their correlation with enhanced rooting and its further growth in dragon fruit.⁴ Decreased parameters at the highest growth regulator dosage might have produced toxicity in the cuttings.³⁴

Longest Root length

According to the results depicted in (Table-2) significantly longest of all the roots (14.50 cm) length was recorded in (IBA 4000 ppm). On the other hand, out of NAA the longest root was of the length (10.10 cm) recorded in (NAA 500 ppm). PHB generated the longest root with length showing a great reduction at the highest concentration of 1500 ppm with only 1.00 cm which was lesser than the untreated cuttings with 3.36 cm respectively. The longest root production with IBA might be due to an increased metabolic activity of hormones in young tissues, availability of essential nutrients, balanced C:N ratio and better utilization of higher carbohydrates⁴⁷ The present findings are akin to the results in dragon fruit.^{17, 22}

Root Weight

The highest (6.13 and 3.01g) fresh and dry weight was in (4000 ppm) IBA treated cuttings and the lowest in PHB-1500ppm (Table-2). The treatment of PHB on cuttings produced lower fresh weight of roots compared to IBA. The treatment of PHB 1500 ppm proved to be the poor in generating weight accounting to 0.50 g which was even lesser than the untreated cuttings with 0.70 g and 0.55 g of fresh and dry weight respectively. The role of the auxins naturally occurring or exogenously applied might be the reason for root initiation and its invigoration. Increased root dry weight with improved root traits with IBA due to the higher dry matter accumulation has been ascribed in dragon fruit.¹⁷ Heaviest roots with enough dry weight with IBA than PHB has also

been reported in fig.³¹ Decreased shoot weight has been attributable to the toxic effect of K⁺ ions produced in the cuttings.³⁴

Conclusion

The present study divulged the substantial potential of plant growth regulators leading to alterations in the shoot induction and root system with improved agronomic parameters. The hitherto conducted investigation revealed the effect of 4000 ppm IBA in dragon fruit cuttings for raising good quality plants. The conclusion of the research is in the context of the future application of stem cutting with IBA 4000 ppm as a means of the multiplication of the superior plants on commercial basis.

Author,s Contribution

Conceptualization of research work and Designing of work (AK), Execution of field/Lab experiments and execution of data (DS), Analysis of data and interpretation (AK and DS), Preparation of manuscript (AK), Both authors read and approved the final manuscript.

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Conflict of Interest

The authors declare no conflict of interest.

Data Availability Statement

Not applicable

Ethics Approval Statement

The study did not involve an experiment on humans and animals.

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