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Vegetative propagation of *Selenicereus costaricensis*

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Abstract
In the current study, investigated the role of three phytohormones; IAA, IBA, and NAA each at three different concentrations for inducing rooting in Dragon fruit stem ex-plants. The experiment was conducted by dipping the shoots in a solution containing a specific concentration of a phytohormone for 24 hrs. The shoots grown after 30 and 50 days were subjected to phytohormone treatment for root induction. Shoots dipped in distilled water in the absence of any phytohormone were considered as control and the root length obtained in response to a particular phytohormone at a given concentration was compared with root lengths obtained in the absence of any phytohormone. This analysis provided appropriate information on the role of a particular phytohormone in root induction in *Selenicereus costaricensis*. Our study identified that IAA positively regulates root induction in Dragon fruit with roots reaching a maximum length of 18 cm after the application of 1500 mg/L of IAA, indicating that IAA is a suitable for root induction phytohormone in *Selenicereus costaricensis*.

Keywords: IAA, IBA, NAA, *Selenicereus costaricensis*, rooting

Introduction
Dragon fruit, also known as pitaya or *Selenicereus*, a climbing cactus, is a tropical fruit that is native to Central America but is now cultivated in various regions of the world. The Salanicereus costaricensis plant has long, vining, and succulent-like stems that can grow up to several meters in length (Balendres, Bengoa, 2019) [6]. These stems have aerial roots and require support, such as a trellis or a sturdy structure, to climb and grow (Pushpakumara *et al*. 2005) [7]. Dragon fruit can be propagated through seeds, but it is more commonly done through stem cuttings. The cuttings are rooted in a well-draining potting mix and kept in a warm, humid environment until roots develop. Dragon fruit plants can be propagated through stem cuttings. The cuttings are usually around 20-30 cm long and must be allowed to dry and callous before planting. Once rooted, the cuttings can be planted in well-draining soil or a potting mix (ElO beidy, 2006) [8].

In this method of plant reproduction where new plants are produced from vegetative parts of a parent plant, such as stems, roots, or leaves. This process does not involve the formation of seeds or the fusion of gametes, as in sexual reproduction. Vegetative propagation is commonly used in horticulture and agriculture to propagate desirable plant varieties with specific traits, such as disease resistance or fruit quality. It allows for the rapid and reliable production of new plants that are genetically identical to the parent plant. Root induction can be achieved using different methods, depending on the type of plant material and the desired outcome. Stem or leaf cuttings involves taking a section of stem orleaf from a parent plant and treating it with a rooting hormone before planting it in a suitable rooting medium (Dahanayake & Ranawake, 2011) [4]. The hormone stimulates the formation of adventitious roots, leading to the development of a new plant. Similarly, in tissue culture, small pieces of plant tissues, such as shoot tips or leaf explants, are cultured in a sterile nutrient medium containing a combination of plant growth regulators, including rooting hormones.

Materials and Methods
The study aimed to investigate the effect of three phytohormones namely IAA (Indole-3-acetic acid), IBA (Indole-3-butyric acid), and NAA (1-Naphthaleneacetic acid), on the Dragon fruit stem cuttings. The treatments involved three different concentrations (500 mg/L, 1000 mg/L, and 1500 mg/L) of these phytohormones.

Initially, the stem cuttings of approximately 10 cm in length were carefully collected during the early morning. The basal part of each cutting, around 1 inch, was immersed in the respective concentrations of IAA, IBA, and NAA for a duration of 24 hours. This immersion allowed the phytohormones to be absorbed by the cuttings and potentially influence their growth and development. A control was also included, where the cuttings were exposed with distilled water. This control group served as a baseline for comparison, enabling the evaluation of the specific effects of the phytohormone treatments on the cuttings. The planting medium was carefully prepared by blending topsoil, sand, and cow dung in a ratio of 1:2:1. This composition was thoroughly mixed to ensure proper integration. Subsequently, the soil mixture was filled into individual pots up to three-fourths of their depth. After the stem cuttings were soaked in their respective phytohormone treatments, they were gently placed into the prepared soil mixture.

Proper care was ensured so that the cuttings were inserted to an appropriate depth for optimal root development. Once planted, the pots were transferred to a controlled environment within a net house. To provide the necessary moisture, water was evenly sprayed over the cuttings and the surrounding soil. This helped to create a suitable growing environment and support the initial growth of the cuttings. Throughout the experiment, the pots were diligently maintained within the net house, where factors such as temperature, light, and ventilation were carefully regulated to promote healthy plant growth and development.

Subsequently, the growth of the stem cuttings was evaluated by measuring the increase in height, which serves as a reliable indicator of the growth rate. However, it is important to note that the growth rate may vary based on the age of the cuttings. To thoroughly assess the growth pattern, the length of the dried roots was measured at two specific time intervals; 30 and 50 days after the cuttings were initially planted. These time points were chosen to capture the progression of root development and evaluate any variations in growth rates over time. By measuring the root length, insights can be gained into the overall growth and establishment of the cuttings in response to the different phytohormone treatments.

Table 1: Root induction of Dragon fruit by using different types of phytohormones

S. No	Root length (cm)											
	IAA (mg/L)				NAA (mg/L)				IBA (mg/L)			
	0	500	1000	1500	0	500	1000	1500	0	500	1000	1500
	after 30 days of shoot growth											
1	1.1	2.5	5.3	6.2	1.2	4.0	3.0	2.5	0.2	0.8	1.0	1.5
2	1.3	4.0	3.0	5.0	1.3	6.0	2.8	2.0	0.6	1.3	1.4	3.0
3	0.8	2.0	5.5	4.7	0.9	3.8	4.0	1.0	0.4	1.5	1.8	4.0
	after 50 days of shoot growth											
4	1.4	3.0	10.0	14.0	1.1	6.0	6.3	7.6	1.2	6.0	10.0	13.0
5	0.7	2.0	12.0	18.0	1.4	8.0	5.0	7.5	0.8	2.3	8.0	9.0
6	1.2	6.0	10.3	15.0	1.2	5.0	7.1	8.0	0.7	3.0	6.0	7.0

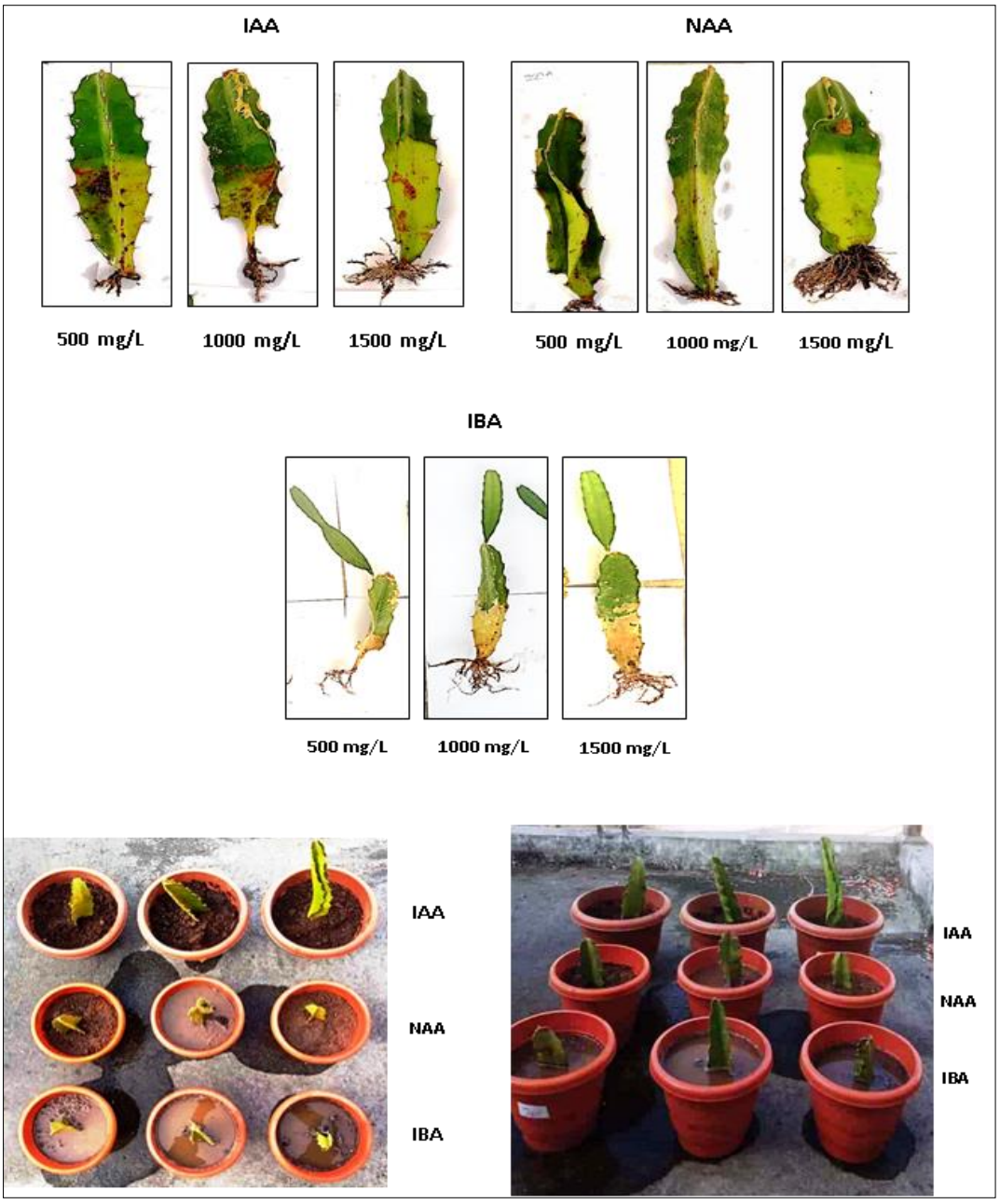
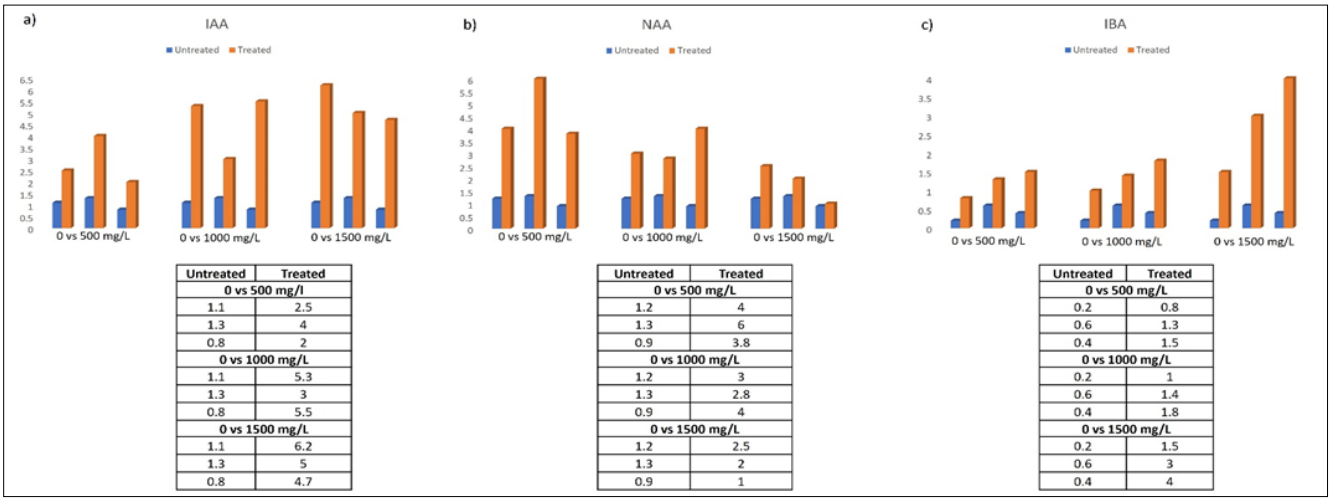


Fig 1: Root length measurements in response to three phytohormone

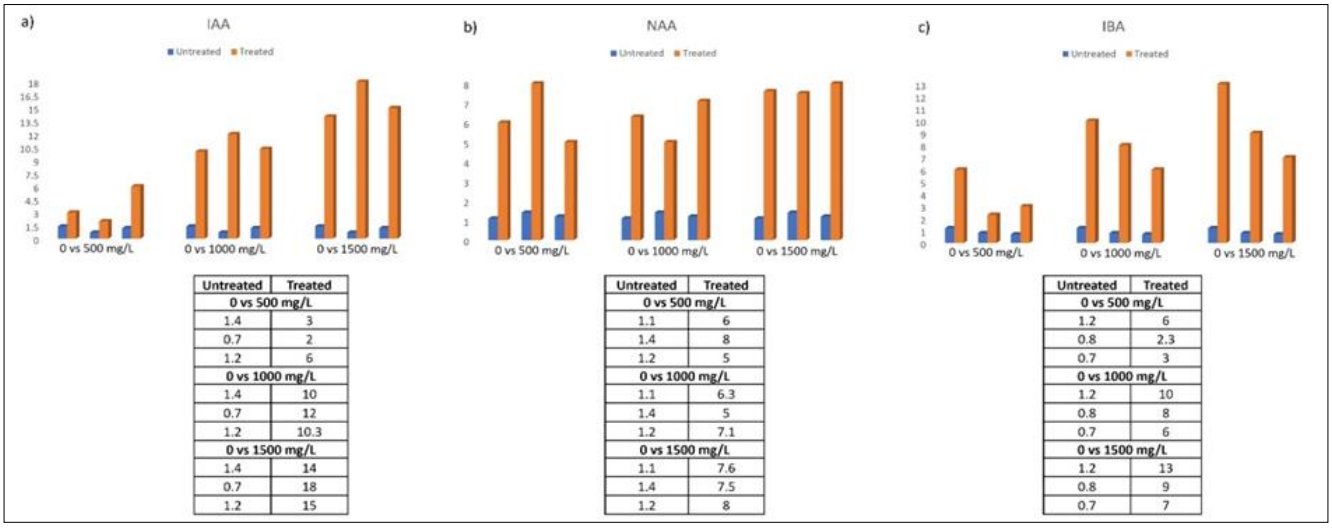


Untreated	Treated
0 vs 500 mg/l	
1.1	2.5
1.3	4
0.8	2
0 vs 1000 mg/L	
1.1	5.3
1.3	3
0.8	5.5
0 vs 1500 mg/L	
1.1	6.2
1.3	5
0.8	4.7

Untreated	Treated
0 vs 500 mg/L	
1.2	4
1.3	6
0.9	3.8
0 vs 1000 mg/L	
1.2	3
1.3	2.8
0.9	4
0 vs 1500 mg/L	
1.2	2.5
1.3	2
0.9	1

Untreated	Treated
0 vs 500 mg/L	
0.2	0.8
0.6	1.3
0.4	1.5
0 vs 1000 mg/L	
0.2	1
0.6	1.4
0.4	1.8
0 vs 1500 mg/L	
0.2	1.5
0.6	3
0.4	4

Fig 2: Graphical representation of root length measurements in response to three phytohormones applied 30 days after initial shoot growth



Untreated	Treated
0 vs 500 mg/L	
1.4	3
0.7	2
1.2	6
0 vs 1000 mg/L	
1.4	10
0.7	12
1.2	10.3
0 vs 1500 mg/L	
1.4	14
0.7	18
1.2	15

Untreated	Treated
0 vs 500 mg/L	
1.1	6
1.4	8
1.2	5
0 vs 1000 mg/L	
1.1	6.3
1.4	5
1.2	7.1
0 vs 1500 mg/L	
1.1	7.6
1.4	7.5
1.2	8

Untreated	Treated
0 vs 500 mg/L	
1.2	6
0.8	2.3
0.7	3
0 vs 1000 mg/L	
1.2	10
0.8	8
0.7	6
0 vs 1500 mg/L	
1.2	13
0.8	9
0.7	7

Fig 3: Graphical representation of root length measurements in response to three phytohormones applied 50 days after initial shoot growth

Results

The present investigation was carried out to determine the effect of three phytohormones IAA, NAA, and IBA on the rooting system of Dragon fruit stem cutting. The root length was measured at three different concentrations i.e., 0 mg/L (control), 500 mg/L, 1000 mg/L, and 1500 mg/L. The root length was measured after the application of three different concentrations. The data was measured in two different time sets *viz.*, 30 days and 50 days.

Analysis of root length

The data on the length of the longest root per cutting of dragon fruit as influenced by different concentrations of growth regulators with different combinations are provided in the table (Table 1). The average length of the longest roots per cutting was significantly varied among the treatments (Fig. 1a-1d). The maximum average length of the longest root was attained in 1500 mg/L concentration with IAA and the shortest was observed in the control which was grown in distilled water in the absence of any phytohormones. The average value of root length across three phytohormones ranged from 0.2 to 18 cm.

In comparison with the control group, the application of IAA in all treatments led to a gradual increase in root length. After 30 days of application, three plants exhibited maximum root lengths of 6.2 cm, 5.0 cm, and 4.7 cm, while minimum lengths were recorded as 1.1 cm, 1.3 cm, and 0.8 cm, respectively. The control group, which did not contain any phytohormones, less root length, while the 1500 mg/L treatment displayed the longest root length (Fig. 2a-2c). After 50 days of phytohormone application, the second set of plants showed significantly higher root lengths reaching 14 cm, 18 cm, and 15 cm in the presence of 1500 mg/L of IAA whereas the root length in control was around 1.4 cm, 0.7 cm, and 1.2 cm, respectively (Fig. 3a-3c). Similarly, in the case of NAA, root length was measured 30 days after application. The measured lengths varied from 0.9 cm to 6.0 cm. Furthermore, in the second set of plants (50 days after application), the root length ranged from 1.1 cm to 8.0 cm. Notably, all the treatments, including 500 mg/L, 1000 mg/L, and 1500 mg/L, exhibited significant improvements in root length when compared to the control.

The phytohormone, IBA was applied in three different concentrations (500 mg/L, 1000 mg/L, and 1500 mg/L) and the root lengths were measured at two different time points (30 and 50 days after application) with respect to the control grown in the absence of IBA. After 30 days of application, the maximum root length recorded was 4.0 cm in the 1500 mg/L treatment, while the control group had a root length of 0.2 cm. However, after 50 days of application, there was a significant increase in root length, with the 1500 mg/L treatment inducing a maximum of 13.0 cm, while the

control group exhibited a length of 0.7 cm. It is important to note that the root length in response to specific phytohormone treatment was compared to the root length obtained in the control group that was grown in the absence of any phytohormone.

Discussion and conclusion

Rooting in plants refers to the process by which new roots are developed from a plant cutting or a plant's own stem root system (Benfey *et al*. 2010) [9]. Its is essential step in plant propagation and is commonly used in gardening, horticulture, and agriculture to produce new plants. Rooting typically occurs when a portion of plant, such as a stem or leaf, is placed in a suitable environment supplied with specific nutrients that promotes root growth. Several factors influence successful rooting in plants amongwhich hormones play a crucial role. The most commonly used hormone for root induction is Auxin, specially Indole-3 butyric acid (IBA) andIndole -3-acetic acid (IAA). These hormones help stimulate cell division and elongation, promoting the formation of new roots. They work in combination with auxins to stimulate cell division and differentiation. They help in the elongation and growth of roots (Schmulling, 2002) [11].

1-Napthaleneacetic acid (NAA) is another synthetic plant hormone that is commonly used as rooting hormone. NAA stimulates the formation of Adventitious roots, promoting successful rooting. Its work by promoting cell division and elongation in the tissues of the cuttings, leading to the formation of root primordial and subsequent root growth (Sourati *et al*. 2022) [14].

IAA isinvolved in promoting root growth and development, as well as root branching. In the roots, IAA helps in the formation of lateral roots and root hair.

Indole-3-butyric acid (IBA) is a synthetic plant hormone and auxin that is commonly used as rooting hormone in plant propagation. It is structurally similar to indole -3-acetic acid, IAA, naturally occurring auxin in plants. IBA is highly effective in promoting root growth and development in plant cutting (Ludwig –Muller, 2000). IBA is available in various formulation, including powders, gels and liquids.

The length of roots after root induction can vary depending onseveral factors, including the type of plant, environmental conditions, and the duration of root induction. In general the length of roots can increase significantly after root induction due to increased cell division and elongation. It is important to note that the length of roots can also be influenced by other factors such as nutrient availability, water availability, and the presence of any inhibitory substances.

Therefore, it is recommended to provide optimal growing conditions and monitor the progress of root induction to ensure successful root development. In this study, IAA was found to have a significant impact on root development in *Selenicereus costaricensis*. In the presence of IAA, maximum root length was achieved, suggesting that this phytohormone may be applied even in the field conditions to induce appropriate rooting in *Selenicereus costaricensis*.

Out of the three Phytohormones the best responded one is the IAA. In the concentration of 1500mg/ L, root length is obtained 18 cm. (Table 1, serial no.5). Similarly results are reported by other Author Vitisvinifera Singh, KK (2018).

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