International Journal of Minor Fruits, Medicinal and Aromatic Plants. Vol. 10 (1) : 125-133, June 2024

Influence of indole butyric acid on root and shoot growth in dragon fruit (*Selenicereus undatus*) stem cuttings

VD Kakade[1]*, DD Nangare[1], SB Chavan[1], RR Babar[1], Amrut Morade[1], Sonal Jadhav[2], VN Salunkhe[1] and Dinesh Jinger[3]

[1]*ICAR-National Institute of Abiotic Stress Management, Baramati, Maharashtra, India*

[2]*Vasantrao Naik Marathwada Krishi Vidyapeeth, College of Agriculture, Parbhani, Maharashtra, India*

[3]*ICAR-Indian Institute of Soil and Water Conservation, Research Centre, Anand, Gujarat, India*

**Email: vijaykakade.7@gmail.com*

Receipt : 17.05.2024 ; Revised : 24.05.2024 ; Acceptance: 25.05.24

DOI : 10.53552/ijmfmap.10.1.2024.125-133

ABSTRACT

To study influence of indole butyric acid (IBA) for enhancing root and shoot growth of dragon fruit stem cuttings and optimise the concentration of IBA, 0, 1000, 2000, 4000, 6000 and 8000 ppm were used to treat the stem cuttings planted in polybags as well as field experiment (raised bed planting). Polybags filled with sandy loam soil from ravine bed mixed with farm yard manure (FYM) and without FYM and raised beds were prepared in native murrum soil filled with FYM. Results revealed that the application of IBA @6000 ppm enhanced root and shoot growth of dragon fruit at 20 and 60 days after planting (DAP) in both the growing medium as well as in the field. Root length (34.50 ± 1.25 cm), numbers of roots (25.20 ± 1.52), fresh (10.81 ± 0.70 g) and dry weight of roots (5.16 ± 0.49 g)as well as shot growth represented by number of new shoots, shoot weigh on fresh and dry basis etc. were found greater with application of IBA @6000 ppm at 60 DAP; in soil with FYM medium. Similar trend was also observed in cuttings planted in polybags filled with soil without FYM and in the field experiment where application of IBA @6000 ppm found at par with 8000 ppm. IBA @ 6000ppm treatment also resulted in to sprouting of cuttings in 16-17 days compared to control where it took 19-20 days under the experiments. Therefore, IBA@6000 ppm is optimum for enhancement of adventitious root and shoots growth of dragon fruit stem cuttings.

***Keywords*:** Dragon fruit, Indole butyric acid, propagation, stems cutting

INTRODUCTION

Dragon fruit plant (*Selenicereus undatus* [Berger] Britton & Rose) is fast growing; perennial epiphyte, produces beautiful flowers and fruits (Britton and Rose, 1963). It has enormous economic and medicinal importance due to richness in vitamins and minerals, and essential fatty acids. Therefore, it is considered as wholesome and remunerative fruit crop. Wider climatic and edaphic adaptability, hardy nature, less water and fertilizer requirement offers abundant opportunities for extending its cultivation particularly under degraded lands (Kakade *et al*., 2020). Government of India is also planned to expand its area to almost 50000 hectare in the country in coming five years. In this connection, availability of good quality planting material with well-developed root and shoot growth will be crucial.

Dragon fruit is largely propagated through stem cutting of 10-60 cm length. Stem cuttings can be planted in polybags as well as in raised beds to develop nursery. In dragon fruit, root and shoot growth increases with size of cutting (Gehlot *et al*., 2014; Kakade *et al*., 2019). However, growers prefer medium sized owing to ease of handling and transportation. Therefore, in order to enhance root and shoot growth in medium sized cuttings, application of rooting hormones under nursery is found to be easiest way. Auxins derivatives have relatively greater impact than others and among auxins, higher efficiency and stability of IBA is very well proven (Zimmerman and Wilcoxon, 1935; Nordstrom *et al*., 1991), therefore, it is widely used for developing adventitious rooting in plants (Chander and Kumar, 2023). Wide range of concentrations of IBA *i.e*., from 50-10,000 ppm has been reported in different plants (Rahbin *et al*., 2012; Khajehpour *et al*., 2014). However, 300 ppm and 10 mM concentration reported by Rahad *et al*. (2016) and Elobeidy (2006) respectively in dragon fruit plant. These contradictory findings could be due to species variation, media composition, types of propagation material and growth regulators etc. used while multiplication. Since IBA concentration can influence the rooting of dragon fruit cutting, its low or high levels may inhibit the rooting as observed in other crops (Sulusoglu and Cavusoglu, 2010). Therefore, in view of above facts, an experiment has been undertaken to determine the optimum concentration of IBA for dragon fruit propagated through stem cutting in polybag as well as raised bed in field conditions with respect to root and shoot growth.

MATERIALS AND METHODS

Pot and field experiment was conducted during the year 2018-19 and 2019-20 at ICAR-Indian Institute of Soil and Water Conservation, Research Centre, Vasad, Anand (Gujarat) and ICAR-National Institute of Abiotic Stress Management, Baramati, Pune (Maharashtra) which falls under semi-arid ago-ecological regions of western India. One year old medium sized stem cuttings of 20-25 cm and 15-20 cm length selected from healthy white fleshed dragon fruit (*S. undatus*) plants in the month of June and kept for callusing in shade for a week. Before planting, basal part (3-4 cm) of cuttings was dipped for 10 seconds in 0, 1000, 2000, 4000, 6000, and 8000 ppm IBA. Post application of IBA, cuttings were planted in polybags of size (30 × 12 cm) filled with only soil and soil + FYM @ 3:1 ratio, and also in the raised beds at uniform planting depth. Polybags were transferred under shade net having 50% shade efficiency. Soil used while filling the bags was sandy loam, well drained having organic carbon, pH and electrical conductivity of 0.3%, 7.6 and 0.22 dS/m respectively. Whereas, in case of field experiment on raised beds, cuttings were planted in soil developed from basaltic rocks and it was porous, gravelly, and low in organic matter. Plants were uprooted at 20 and 60 DAP, and 100 DAP (days after planting) in case of polybag and raised bed field experiment respectively to measure root and shoot growth. Fresh weight of shoots and roots and length of new shoots and roots was measured with help of digital weighing balance and vernier calliper. Uprooted plants were then transferred to hot air oven (70°C) for 36-48 hours to assess the biomass on dry weight basis. This experiment was conducted in completely randomised design using 5 replications and analysis was performed using analysis of variance using SPSS (16.0) software and CD was compared at 5% level of probability.

RESULTS AND DISCUSSION

Average number of roots : The higher number of roots was obtained in cutting treated with IBA at 6000 ppm on par with 8000 and 2000 ppm at 20 DAP, whereas IBA @6000ppm has resulted in to increased roots at 60 DAP over control and other treatments in case of soil + FYM medium. IBA @6000 ppm also resulted in to highest number of roots (18.00 ± 0.95) as compared to other treatments except IBA @4000 ppm at 20 DAP, whereas IBA @6000ppm on par with IBA @8000ppm shower greater root numbers over control and other treatments at 60 DAP in soil medium (Table 1 &2). In case of field experiment, the degree of root formation in cuttings increased with higher IBA concentration and IBA @6000 ppm produced higher number of roots followed by IBA @8000 and 4000 ppm and lowest was recorded in Control (Table 5). IBA growth hormone has been extensively used as rooting hormone in agriculture to promote adventitious rooting in cutting (Braun and Wyse, 2019). Induction of adventitious rooting can be classified as three distinct stages: the root induction period, root initiation, and protrusion (Arya and Husen, 2022). Auxins primarily play a critical role at the induction stage; thus benefits adventitious rooting (Pincelli-Souza *et al*., 2024). In dragon fruit Seran and Thiresh (2015) also proposed 6000 ppm IBA for enhancing rooting with smaller cuttings. Findings of present experiment though agree with Seran and Thiresh (2015) but vary from Gehlot *et al*. (2014) and Rahad *et al*. (2016) who reported 10 mM and 300 ppm concentration in dragon fruit. This may be because

Table 1: Effect of IBA concentrations on root parameters of Dragon fruit at 20 DAP in Soil + FYM and soil medium

Treatments	Number of roots		Root length (cm)		Fresh weight of roots (g)		Dry weight of roots (g)	
	SFM	SM	SFM	SM	SFM	SM	SFM	SM
IBA@ 0ppm	8.40 ± 0.60^{c}	9.00 ± 0.40^{c}	2.42 ± 0.14^{c}	2.89 ± 0.18^{e}	0.82 ± 0.04^{d}	1.96 ± 0.11^{b}	0.35 ± 0.24^{d}	0.79 ± 0.06^{b}
IBA@1000ppm	13.80 ± 0.73^{b}	10.20 ± 0.73^{c}	2.92 ± 0.05^{c}	4.12 ± 0.07^{d}	1.39 ± 0.07^{c}	1.47 ± 0.02^{c}	0.98 ± 0.08^{b}	1.06 ± 0.43^{a}
IBA@2000ppm	14.40 ± 0.60^{ab}	10.80 ± 1.20^{c}	3.78 ± 0.12^{b}	5.32 ± 0.31^{c}	2.24 ± 0.04^{b}	1.20 ± 0.04^{d}	1.24 ± 0.02^{a}	0.63 ± 0.08^{c}
IBA@4000ppm	9.00 ± 0.95^{c}	16.20 ± 0.74^{a}	1.80 ± 0.07^{d}	5.60 ± 0.09^{c}	1.45 ± 0.03^{c}	1.69 ± 0.04^{c}	0.75 ± 0.03^{c}	0.82 ± 0.02^{b}
IBA@6000ppm	16.80 ± 0.74^{a}	18.00 ± 0.95^{a}	4.82 ± 0.09^{a}	7.02 ± 0.26^{a}	2.34 ± 0.68^{b}	2.10 ± 0.08^{b}	1.18 ± 0.05^{a}	1.14 ± 0.91^{a}
IBA@8000ppm	16.20 ± 1.53^{ab}	13.80 ± 0.74^{b}	5.16 ± 0.21^{a}	6.42 ± 0.09^{b}	3.06 ± 0.08^{a}	2.63 ± 0.12^{a}	1.32 ± 0.07^{a}	0.87 ± 0.04^{b}

Values are means ± standard error of five replicates. Means followed by same letter are not significantly different from each other at 5% significant level. Values in parenthesis are transformed values.
SFM: Soil + FYM medium; SM: Soil medium

Table 2: Effect of IBA concentrations on root parameters of Dragon fruit at 60 DAP in Soil + FYM and Soil medium

Treatments	Number of roots		Root length (cm)		Fresh weight of roots (g)		Dry weight of roots (g)	
	SFM	SM	SFM	SM	SFM	SM	SFM	SM
IBA@ 0ppm	13.20 ± 0.74^{c}	12.60 ± 0.60^{cd}	7.80 ± 0.58^{d}	10.34 ± 0.45^{c}	2.54 ± 0.32^{d}	7.27 ± 0.52^{d}	0.81 ± 0.10^{c}	1.90 ± 0.20^{d}
IBA@ 1000ppm	12.60 ± 1.47^{c}	15.60 ± 1.47^{bc}	16.60 ± 0.25^{c}	18.80 ± 1.24^{ab}	6.70 ± 0.77^{c}	9.30 ± 0.22^{c}	3.00 ± 0.35^{b}	3.11 ± 0.47^{c}
IBA@ 2000ppm	17.40 ± 0.60^{b}	10.20 ± 0.73^{d}	19.70 ± 1.04^{bc}	18.70 ± 1.16^{ab}	7.59 ± 0.71^{bc}	6.45 ± 0.06^{d}	3.38 ± 0.52^{b}	3.71 ± 0.31^{bc}
IBA@ 4000ppm	11.40 ± 1.12^{c}	12.00 ± 0.95^{d}	16.30 ± 1.50^{c}	15.54 ± 0.74^{b}	8.91 ± 0.32^{b}	6.36 ± 0.22^{d}	4.40 ± 0.59^{ab}	3.02 ± 0.34^{c}
IBA@ 6000ppm	25.20 ± 1.52^{a}	21.00 ± 1.64^{a}	34.50 ± 1.25^{a}	20.62 ± 1.63^{a}	10.81 ± 0.70^{a}	13.72 ± 0.35^{a}	5.16 ± 0.49^{a}	4.31 ± 0.40^{ab}
IBA@ 8000ppm	15.00 ± 1.34^{bc}	18.00 ± 0.94^{ab}	21.90 ± 1.57^{b}	20.00 ± 0.82^{a}	7.82 ± 0.29^{bc}	11.06 ± 0.21^{b}	3.96 ± 0.42^{ab}	4.98 ± 0.20^{a}

Values are means ± standard error of five replicates. Means followed by same letter are not significantly different from each other at 5% significant level.
SFM: Soil + FYM medium; SM: Soil medium

Table 3: Effect of IBA concentrations on shoot parameters of Dragon fruit at 20 DAP in Soil+FYM and Soil medium

Treatments	No. of new shoots		Shoot length (cm)		Fresh weight of shoots (g)		Dry weight of shoots (g)		Days to sprout (number)	
	SFM	SM	SFM	SM	SFM	SM	SFM	SM	SFM	SM
IBA@ 0ppm	(0.71) ± 0.00^{a}	(0.71) ± 0.00^{a}	0.71 ± 0.00^{a}	0.71 ± 0.00^{a}	91.80 ± 1.30^{d}	101.36 ± 7.50^{c}	8.73 ± 0.25^{b}	11.40 ± 0.34^{bc}	19.20 ± 0.37^{a}	18.20 ± 0.37^{a}
IBA@ 1000ppm	(0.71) ± 0.00^{a}	(0.81) ± 0.10^{a}	0.71 ± 0.00^{a}	0.94 ± 0.23^{a}	91.33 ± 4.10^{d}	99.38 ± 4.72^{c}	8.64 ± 0.19^{b}	10.06 ± 0.44^{c}	18.40 ± 0.25^{ab}	17.80 ± 0.38^{ab}
IBA@ 2000ppm	(0.71) ± 0.00^{a}	(0.71) ± 0.00^{a}	0.71 ± 0.00^{a}	0.71 ± 0.00^{a}	115.15 ± 4.25^{bc}	115.38 ± 4.82^{bc}	8.04 ± 0.31^{b}	13.05 ± 0.44^{b}	18.00 ± 0.32^{bc}	17.00 ± 0.31^{bc}
IBA@ 4000ppm	(0.81) ± 0.10^{a}	(0.71) ± 0.00^{a}	0.94 ± 0.23^{a}	0.71 ± 0.00^{a}	105.16 ± 3.91^{cd}	127.80 ± 6.51^{ab}	10.05 ± 0.30^{a}	15.79 ± 0.23^{a}	18.20 ± 0.37^{bc}	16.80 ± 0.37^{bcd}
IBA@ 6000ppm	(0.71) ± 0.00^{a}	(0.81) ± 0.10^{a}	0.71 ± 0.00^{a}	0.99 ± 0.40^{a}	135.83 ± 2.94^{a}	146.74 ± 7.08^{a}	10.12 ± 0.31^{a}	16.34 ± 0.67^{a}	17.00 ± 0.32^{d}	15.80 ± 0.37^{d}
IBA@ 8000ppm	(0.71) ± 0.00^{a}	(0.71) ± 0.00^{a}	0.71 ± 0.00^{a}	0.71 ± 0.00^{a}	124.04 ± 2.03^{ab}	128.52 ± 7.16^{ab}	10.01 ± 0.26^{a}	15.78 ± 0.53^{a}	17.40 ± 0.25^{cd}	16.20 ± 0.40^{cd}

Values are means ± standard error of five replicates. Means followed by same letter are not significantly different from each other at 5% significant level. Values in parenthesis are transformed values.
SFM: Soil + FYM medium; SM: Soil medium

Table 4: Effect of IBA concentrations on shoot parameters of Dragon fruit at 60 DAP in Soil+FYM and Soil medium

Treatments	No. of new shoots		Shoot length (cm)		Fresh weight of shoots(g)		Dry weightof shoots(g)	
	SFM	SM	SFM	SM	SFM	SM	SFM	SM
IBA@ 0ppm	1.40 ± 0.25^{bc}	1.20 ± 0.20b	7.76 ± 0.27^{b}	6.12 ± 0.17^{c}	137.22 ± 1.08^{c}	122.22 ± 1.42^{c}	10.90 ± 0.60^{c}	11.92 ± 0.50^{b}
IBA@ 1000ppm	1.40 ± 0.25^{bc}	1.20 ± 0.20b	10.48 ± 0.37^{a}	5.50 ± 0.45^{c}	136.39 ± 4.85^{c}	127.40 ± 1.18^{c}	13.50 ± 0.35^{b}	14.49 ± 1.26^{ab}
IBA@ 2000ppm	1.80 ± 0.20^{ab}	0.80 ± 0.20b	10.68 ± 0.65^{a}	2.76 ± 0.34^{d}	186.72 ± 2.35^{abc}	168.30 ± 2.14^{ab}	14.75 ± 0.66^{b}	12.98 ± 0.96^{b}
IBA@ 4000ppm	1.00 ± 0.00^{c}	1.00 ± 0.00b	11.88 ± 0.61^{a}	5.66 ± 0.50^{c}	160.11 ± 2.22^{bc}	162.80 ± 1.79^{ab}	13.46 ± 0.91^{b}	14.84 ± 0.61^{ab}
IBA@ 6000ppm	2.40 ± 0.55^{a}	1.80 ± 0.20a	11.56 ± 0.49^{a}	12.46 ± 0.92^{a}	204.48 ± 2.04^{ab}	197.72 ± 2.49^{a}	19.52 ± 0.27^{a}	16.91 ± 1.17^{a}
IBA@ 8000ppm	1.80 ± 0.45^{ab}	0.80 ± 0.20b	10.86 ± 0.64^{a}	9.78 ± 0.45^{b}	228.00 ± 1.95^{a}	160.90 ± 8.45^{ab}	21.19 ± 0.72^{a}	16.49 ± 1.21^{a}

Values are means ± standard error of five replicates. Means followed by same letter are not significantly different from each other at 5% significant level.
SFM: Soil + FYM medium; SM: Soil medium

correlation between primordial division in root initiation and endogenous or exogenous auxins may result in to increase of rooting at different concentrations.

Average root length : Higher root length was obtained with IBA 8000 ppm on par with 6000 ppm at 20 DAP. However, at 60 DAP highest root length (34.50 ± 1.25 cm) was observed with IBA @6000 ppm followed by IBA @8000 ppm and lower values were reported in control and lower concentrations of IBA in case of soil + FYM medium. IBA @6000 ppm on par with IBA @8000 ppm, showed greater root length at 20 DAP and 60 DAP over control where lowest root growth was observed in soil medium (Table 1 &2). Root length after 100 DAP was also varied significantly with different treatments in field experiment too. Longest root length was obtained in IBA @8000 ppm on par with IBA @6000 ppm, whereas shortest was observed from control with no IBA treatment under field experiment (Table 5). IBA plays significant role in enhancing rooting process (root hair elongation, later root development and formation of adventitious roots) by involving in physiological process of cell division, cell enlargement and interaction with other hormones through different mechanisms (Zimmerman and Wilcoxon, 1935; Gehlot *et al*., 2014). Madhavan *et al.* (2021), Sabatino *et al*. (2014), Rahbin *et al.* (2012) and Shiri *et al.* (2019) reported enhancement of root length with the use of IBA in grapes, night jessamine (*Cestrum nocturnum*), silver germander (*Teucrium fruticans*) and *Duranta errecta* respectively. In Dragon fruit, Seran and Thiresh (2015) observed longest root length in cutting treated with 8000 ppm and 6000 ppm IBA.

Fresh and dry weight of roots : Higher fresh and dry weight of roots was also recorded with IBA @8000 ppm followed by 6000 ppm whereas; it was least in control at 20 DAP. However at 60 DAP, IBA @6000 ppm followed by IBA @8000 ppm produced roots with greater root biomass on fresh and dry weight basis in soil + FYM medium. Similarly, in soil medium also IBA at higher concentrations 6000 and 8000 ppm performed better in producing greater root biomass while

Table 5: Effect of IBA concentrations on root and shoot parameters of Dragon fruit at 100 DAP under raised bed field experiment

Treatments	Number of roots	Root length (cm)	Fresh weight of roots (g)	Dry weight of roots(g)	No. of new shoots	Shoot length (cm)	Fresh weight of shoots (g)	Dry weight of shoots (g)	Days to sprout (Number)
IBA@ 0ppm	20.88 ± 1.07^{d}	14.30 ± 1.10^{b}	13.50 ± 0.77^{c}	1.35 ± 0.24^{d}	2.40 ± 0.60^{a}	17.50 ± 0.76^{b}	56.61 ± 1.40^{d}	4.63 ± 0.15^{c}	19.60 ± 0.50^{b}
IBA@ 1000ppm	32.80 ± 0.66^{c}	27.54 ± 0.46^{a}	21.70 ± 1.29^{b}	2.13 ± 0.15^{c}	2.40 ± 0.40^{a}	19.50 ± 0.57^{ab}	71.86 ± 1.61^{bc}	6.14 ± 0.14^{b}	17.80 ± 0.86^{a}
IBA@ 2000ppm	34.00 ± 0.70^{c}	27.50 ± 0.47^{a}	23.18 ± 0.95^{ab}	2.43 ± 0.17^{c}	2.20 ± 0.37^{a}	19.70 ± 0.56^{a}	72.50 ± 2.50^{bc}	6.21 ± 0.17^{b}	17.60 ± 0.50^{a}
IBA@ 4000ppm	36.80 ± 0.66^{b}	29.10 ± 1.00^{a}	23.99 ± 1.40^{ab}	3.16 ± 0.18^{ab}	2.60 ± 0.50^{a}	20.38 ± 0.89^{a}	76.02 ± 1.40^{ab}	6.64 ± 0.11^{a}	19.20 ± 1.52^{b}
IBA@ 6000ppm	39.40 ± 0.50^{a}	31.32 ± 0.71^{a}	26.12 ± 1.05^{a}	3.36 ± 0.22^{a}	2.80 ± 0.37^{a}	21.70 ± 0.87^{a}	78.52 ± 1.24^{a}	6.92 ± 0.07^{a}	17.20 ± 0.37^{a}
IBA@ 8000ppm	37.00 ± 0.70^{b}	34.68 ± 6.21^{a}	21.16 ± 0.79^{b}	2.63 ± 0.17^{bc}	2.20 ± 0.20^{a}	20.70 ± 0.49^{a}	70.47 ± 1.45^{c}	6.15 ± 0.12^{b}	17.20 ± 0.49^{a}

Values are means ± standard error of five replicates. Means followed by same letter are not significantly different from each other at 5% significant level.
SFM: Soil + FYM medium; SM: Soil medium

lower root biomass was recorded in lower concentrations of IBA and in control at 20 and 60 DAP under pot experiment (Table 1 & 2). Similarly, in field experiment too, higher concentration produced maximum root biomass on fresh and dry weight basis *i.e.*, IBA @6000 ppm, followed by IBA 8000 ppm and lowest were recorded in control treatment i.e. no IBA (Table 5). IBA is effective in enhancing rooting percentage; root length thus ultimately causes enhanced root biomass in plants (Sabatino *et al*., 2014; Madhavan *et al*., 2021). Further, higher rooting and dipper roots may results in higher absorption of nutrients from the soil which results in better root growth. In the present experiment also IBA enhanced root percentage and root length which resulted in to higher root biomass. Enhancement of root biomass with the help of IBA has been reported by Kaur and Kaur (2016) in pomegranate, Rahbin *et al*. (2012) in night jessamine (*Cestrum nocturnum*). Whereas, in dragon fruit enhanced root biomass with use of IBA has been observed by Seran and Thiresh (2015).

Days to sprout : IBA treatments significantly helped to reduce number of days required for sprouting of cuttings in pot experiment under both the mediums and also in the field experiment. IBA @6000ppm on par with 8000ppm helped cuttings to sprout in 16-17 days compared to control where it took 19-20 days (Table 3 & 4). Similar trend was observed in the raised bed field experiment, where IBA @6000 and 8000 ppm produced sprouts in 17 days whereas it took 19-20 days in control with no IBA application (Table 5). The application of IBA assists in reducing the number of days required for sprouting by promoting deeper and more extensive root development. Enhanced rooting enables more efficient uptake of water and essential nutrients from the soil, providing the necessary resources for faster plant growth and development. This accelerated resource acquisition leads to a quicker initiation of sprouting. The beneficial effect of treating cuttings with IBA for reducing the number of days to sprouting has been corroborated by Patil *et al.* (2017), demonstrating that IBA treatment effectively speeds up the sprouting process by enhancing root formation and nutrient uptake efficiency.

Average number of shoots : IBA did not influence the formations of new shoots at 20 DAP under both soil mediums in the present experiment. However, at 60 DAP, IBA significantly influenced formation of new shoots. Numbers of new shoots were also observed highest in IBA @6000 ppm on par with 8000 ppm, which varied significantly from other treatments under both the mediums (Table 3& 4). Whereas, IBA treatments had non-significant effect of number of shoots produced in cuttings in field experiment. IBA is known to play a significant role in enhancing adventitious rooting in plants. This enhancement in rooting is crucial as it allows plants to better acquire water and essential nutrients from the soil, leading to increased sprouting and shoot formation. Research has demonstrated the effectiveness of IBA in promoting higher shoot formation in various plant species. For instance, Seran and Thiresh (2015) reported improved shoot formation in dragon fruit, while Madhavan *et al.* (2021) observed similar results in grapes. The application of IBA not only boosts root development but also supports the overall growth and productivity of the plants, highlighting its importance in horticultural practices.

Average shoot length : IBA @6000 ppm significantly improved shoot length which varied from other treatments. However, all IBA treatments showed significantly higher shoot length over control in soil + FYM medium and IBA @6000 ppm also improved shoot length in soil medium also. Lowest shoot length was reported in the control with no IBA treatment (Table 3& 4). In field experiment, highest shoot length was recorded in cuttings treated with IBA @6000 ppm followed by 8000ppm while minimum length of shoots was recorded in control with no IBA treatment (Table 5). Shoot growth, including sprouting and subsequent development, is directly proportional to the rooting rate and the hormonal levels in the plant. The exogenous application of IBA in this experiment not only elevated the hormonal levels but also enhanced rooting, consequently leading to increased shoot growth. Khajehpour *et al.* (2014) and Rahman *et al.* (2002) reported that branch length in olive increased at a hormone level of 3000 ppm, while the shortest branch length was observed in the control treatment. Further, Khadr *et al.* (2020) also observed enhancement of shoot length in carrot with IBA application. Similarly, Seran and Thiresh (2015) observed the greatest shoot length with the application of IBA at 6000 ppm. IBA facilitates cell elongation, resulting in enhanced shoot length, as evidenced in dragon fruit in the present experiment (Frick and Strader, 2018).

Fresh weight and dry weight of shoots : Application at 6000 ppm IBA on par with 8000 ppm has resulted into maximum increase in fresh weight of shoots. However, least increment was observed in control and 1000 ppm IBA. Similar trend was also observed in dry weight of shoots at 20 DAP. Whereas at 60 DAP, IBA @8000 ppm on par with 6000 ppm resulted in highest increase in fresh weight of shoots and lowest was recorded in control and 1000 ppm IBA. IBA @6000 ppm on par with 8000 ppm produced shoots with greater biomass on dry weight basis in soil + FYM medium and lower biomass reported in control. Similar observations were also recorded in soil medium and IBA at higher concentrations (6000 and 8000ppm) performed better compared to control (Table 3&4). In field experiment too, the highest shoot fresh weight (78.52g) was seen in dragon fruit cuttings treated with IBA 6000 ppm and it was lowest in control (56.61g) (Table 5). Similar trend was observed in case of dry weight of shoots in field experiment. The enhancement of shoot biomass with the application of Indole-3-butyric acid (IBA) can be attributed to several key physiological effects of this hormone. Higher shoot biomass results from increased sprouting, the emergence of new shoots, and an expanded leaf area. Studies have confirmed similar outcomes in various plants, such as carrot (Khadr *et al.*, 2020). The application of IBA, particularly at a concentration of 3000 ppm, has been shown to significantly enhance root fresh weight, with the lowest root biomass observed in untreated control plants (Khajehpour *et al*., 2014). This increase in root biomass facilitates the uptake of more water and essential nutrients from the soil, providing the necessary raw materials for photosynthesis. Enhanced photosynthetic activity leads to greater production of shoot growth-promoting hormones (Ghanem *et al*., 2011) and supports quicker adaptation and overall plant vigour. Furthermore, Seran and Thiresh (2015) reported that applying IBA at a concentration of 6000 ppm in dragon fruit resulted in higher shoot biomass on both a fresh and dry weight basis. IBA is known to promote the development of shoot initials and their subsequent growth, as demonstrated in citron (Kako Al-Zebari and Al-Brifkany, 2014). Thus, the application of IBA enhances root development, which in turn boosts water and nutrient uptake. This leads to increased photosynthetic efficiency and hormone production, ultimately resulting in greater shoot biomass.

CONCLUSION

The results of present pot and field experiment showed that, IBA@6000 ppm on par with 8000 ppm performed better in root and shoot growth improvement, reducing number days to sprout in dragon fruit stem cuttings compared to lower concentrations of IBA or no IBA. Therefore, application of IBA @6000 ppm can be used for multiplying stem cuttings of dragon fruitby nurserymen and growers.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES :

Arya, A. and Husen, A. 2022. Role of various auxins in adventitious root formation. In: Husen A, editor. Environmental, physiological and chemical controls of adventitious rooting in cuttings, a volume in *plant biology, sustainability and climate change.* London,: Academic; p. 213–38.

Braun, L. and Wyse, D. 2019. Optimizing IBA concentration and stem and segment size for rooting of hybrid hazelnuts from hardwood stem cuttings. *Journal of Environmental Horticulture*, **37**(1): 1-8. https://doi.org/10.24266/0738-2898-37.1.1

Britton, N.L. and Rose, J.N. 1963.The Cactaceae: *Descriptions and illustrations of plants of the Cactus family.* Courier Corporation. ISBN 0486211924, 9780486211923, pp. 589.

Chander, S. and Kumar, K. 2023. Optimization of IBA dose for rooting in fig (*Ficus carica* L.) cuttings. *International Journal of Minor Fruits, Medicinal and Aromatic Plants*. **9**(1):105-108. DOI:10.53552/ijmfmap.9.1.2023.

Elobeidy, A.A. 2006. Mass propagation of pitaya (dragon fruit). *Fruits*, **61**:313-319https://doi.org/10.1051/fruits:2006030

Frick, E.M. and Strader, L.C. 2018. Roles for IBA-derived auxin in plant development. *Journal of Experimental Botany*, **69**(2):169-177. doi: 10.1093/jxb/erx298. PMID: 28992091; PMCID: PMC5853464.

Gehlot, A., Gupta, R., Tripathi, A., Arya, I.D. and Arya, S. 2014.Vegetative propagation of *Azadirachta indica*: effect of auxin and rooting media on adventitious root induction in mini-cuttings. *Science Advances*, **1**(1):1-9. DOI: 10.34062/afs.v1i1.1357

Ghanem, M.E., Albacete, A., Smigocki, A.C. 2011. Root-synthesized cytokinins improve shoot growth and fruit yield in salinized tomato (*Solanum lycopersicum* L.) plants. *Journal of Experimental Botany*, **62**(1):125-140.https://doi.org/10.1093/jxb/erq266.

Kakade, V. D., Jinger, D., Dayal, V., Charan, S., Nangare, D.D., Wakchaure, G.C. and Dinesh, D. 2020. Dragon fruit: wholesome and remunerative fruit crop for India. *Food and Scientific Reports*, **1**(12): 44–48.

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*) *Indian Journal of Agricultural Sciences*, **89**(11): 1895–99. DOI:10.56093/ijas.v89i11.95337

Kako Al-Zebari, S.M. and Al-Brifkany, A.-A.A.M. 2014. Effect of cutting type and iba on rooting and growth of citron (*Citrus medica* L). *Journal of Experimental Agriculture International*, **5**(2), 134-138. https://doi.org/10.9734/AJEA/2015/10973

Khadr, A., Wang, G.L., Wang, Y.H., Zhang, R.R., Wang, X.R., Xu, Z.S., Tian, Y.S. and Xiong, A.S. 2020. Effects of auxin (indole-3-butyric acid) on growth characteristics, lignification, and expression profiles of genes involved in lignin biosynthesis in carrot taproot. *PeerJ*. Dec 8;8:e10492. doi: 10.7717/peerj.10492. PMID: 33354430; PMCID: PMC7731654.

Khajehpour, G., Jam'eizadeh, V. and Khajehpour, N. 2014. Effect of different concentrations of IBA (indulebutyric acid) hormone and cutting season on the rooting of the cuttings of Olive (*Olea Europaea* var Manzanilla). *International Journal of Advanced Biological and Biomedical Research*, **2**(12): 2920-2924.

Madhavan, S., Sivasankar, S., Elakkuvan, S., Gayathri, M. 2021. Effect of IBA on rooting of grapes cuttings (*Vitis vinifera*). *International Journal of Botany Studies*, **6**(5): 288-289.

Nordstrom, A.C., Jacobs, F.A. and Eliasson, L. 1991. Effect of exogenous indole-3-acetic acid and indole-3-butyric acid on internal levels of the respective auxins and their conjugation with aspartic acid during adventitious root formation in pea cuttings. *Plant Physiology*, **96**:856-861 https://doi.org/10.1104/pp.96.3.856

Patil, Y.B., Saralch, H., Chauhan, S. and Dhillon, G.P. 2017. Effect of growth hormone (IBA and NAA) on rooting and sprouting behaviour of *Gmelina arborea* (Roxb.). *Indian Forester*, **143**: 81-85.

Pincelli-Souza, R.P., Tang, Q., Miller, B.M. and Cohen, J.D.. 2024. Horticultural potential of chemical biology to improve adventitious rooting. *Horticulture Advances*, **2**(12): 1-25. https://doi.org/10.1007/s44281-024-00034-7

Rahad, M.A.B.K., Islam, M.A., Rahim, M.A. and Monira, S. 2016. Effects of rooting media and varieties on rooting performance of dragon fruit cuttings (*Hylocereus undatus* Haw.). *Research in Agriculture, Livestock and Fisheries*, **3**(1):67-77. https://doi.org/10.3329/ralf.v3i1.27859.

Rahbin, A., Aboutalebi, A. and Hasanzadeh, H. 2012. Study on the effect of cutting location on shoot and IBA on rooting of 'Night Jessamine' (*Cestrum nocturnum*) stem cuttings. *The International Journal of Sciences: Basic and Applied Research*, **3**(11):2345-2348.

Rahman, N., Awan, A.A., Nabi, G. and Ali, Z. 2002. Root initiation in hard wood cuttings of olive cultivar Coratina using different concentration of IBA. *Asian Journal of Plant Sciences*, **1**:563-564. DOI: 10.3923/ajps.2002.563.564

Sabatino, L., D'Anna, F. and Iapichino, G. 2014. Cutting type and IBA treatment duration affect *Teucrium fruticans* adventitious root quality. *Notulae Botanicae Horti Agrobotanici*, **42**(2):478-481. DOI: 10.15835/nbha4229611

Seran, T.H. and Thiresh, A. 2015. Root and shoot growth of dragon fruit (*Hylocereus undatus*) stem cutting as influenced by indolebutytic acid. *Research journal of agriculture and biological sciences*, **1**(2):27-30.

Shiri, M., Ruvimbo, M., Marjory, T., Collen, M. and Tsvakai, G. 2019. Effects of rooting media and indole-3-butyric acid (IBA) concentration on rooting and shoot development of *Duranta erecta* tip cuttings. *African Journal of Plant Science*, **13**:279-285. DOI:10.5897/AJPS2019.1851.

Sulusoglu, M. and Cavusoglu, A. 2010. Vegetative propagation of Cherry laurel (*Prunuslaurocerasus* L.) using semi-hardwood cuttings. *African Journal of Agricultural Research*, **5**(23):3196-3202. DOI:10.5897/AJAR10.554

Zimmerman, P.W. and Wilcoxon, F.1935. Several chemical growth substances which cause initiation of roots and other responses in plants. Contributions from Boyce Thompson Institute, **7**: 209-229.