Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(2): 1469-1475
Received: 16-01-2020
Accepted: 18-02-2020

SK Rehana
College of Horticulture, Dr. YSR Horticultural University, Venkataramannagudem, West Godavari, Andhra Pradesh, India

M Madhavi
College of Horticulture, Dr. YSR Horticultural University, Venkataramannagudem, West Godavari, Andhra Pradesh, India

AVD Dorajee Rao
College of Horticulture, Dr. YSR Horticultural University, Venkataramannagudem, West Godavari, Andhra Pradesh, India

P Subbaramamma
College of Horticulture, Dr. YSR Horticultural University, Venkataramannagudem, West Godavari, Andhra Pradesh, India

Corresponding Author:
SK Rehana
College of Horticulture, Dr. YSR Horticultural University, Venkataramannagudem, West Godavari, Andhra Pradesh, India

Effect of cutting types and IBA treatments on success of vegetative propagation in crossandra (*Crossandra infundibuliformis* L.) Var. Arka shravya

SK Rehana, M Madhavi, AVD Dorajee Rao and P Subbaramamma

Abstract
The present investigation entitled "Effect of cutting types and IBA treatments on success of vegetative propagation in crossandra (*Crossandra infundibuliformis* L.) var. Arka Shravya" was conducted at College of Horticulture, Venkataramannagudem, West Godavari district, Andhra Pradesh during 2018-2019. The experiment was carried out in a Factorial Randomized Block Design comprising fourteen treatment combinations with two replications from two factors i.e. cutting types at two levels (viz., terminal and semi hardwood) and IBA treatments at seven levels (100, 200, 300 ppm in prolonged dip method for 24 hours, 1000, 2000 and 3000 ppm in quick dip method for 10 seconds and 0 ppm (control). Among the treatments under study, terminal cuttings, IBA quick dip @ 3000 ppm for 10 seconds and combination of these two treatments performed the best with respect to different root and shoot characters as well as field establishment of rooted cuttings.

Keywords: Cutting types, IBA treatments, crossandra, root parameters and shoot parameters

Introduction
Crossandra (*Crossandra infundibuliformis* L.) belongs to the family Acanthaceae with basic chromosome number of n = 10. It is commonly called as "Tropical flame" or "Fire cracker plant" or "Kanakambaram". The flowers are offered to temple deities and mostly used as loose flowers for hair adornment and making garlands, gajras and venis. Crossandra is commercially cultivated as loose flower crop in Karnataka, Tamil Nadu and Andhra Pradesh.
Crossandra is commercially propagated by seed. But the commercial triploid varieties of crossandra such as Delhi Crossandra, Arka Shreeya and Arka Shravya are high yielders with good keeping quality and produce flowers throughout the year irrespective of the season. These varieties do not set the seed. So, there is a great demand from farmers for planting material of the above-mentioned varieties. Thus, production of planting material in bulk through vegetative propagation by using cuttings is peremptory to meet the great demand of planting material of crossandra.

Material and Methods
The experiment was carried out under shade net at College of Horticulture, Venkataramannagudem, West Godavari district of Andhra Pradesh during 2018-2019. The experiment was laid out in a factorial randomized block design with two replications comprising fourteen treatments from two factors i.e. cutting types (2 levels) and IBA treatments (7 levels). The growing media was comprised of Coco peat, Vermicompost, Red soil and well decomposed farm yard manure (FYM) mixed in the ratio of 2:2:2:1. To control the nematodes in soil media, Carbofuran 3G granules @ 5g/kg of growing media was added. The media was thoroughly mixed and filled in polybags of 8" × 10" size. Terminal and semi hardwood cuttings of crossandra were collected from healthy mother plants, which were maintained at horticultural farm, College of Horticulture, Venkataramannagudem, Andhra Pradesh, India.

Preparation of cuttings: The terminal cuttings were taken from top portion of shoot and semi hardwood cuttings from one-year old shoots and made into small pieces each having 2 nodes. A slant cut was given at the basal end of cuttings to expose maximum absorbing surface area for induction of effective rooting. The basal ends of cuttings were dipped in Copper Oxy Chloride (COC) @ 3g/L solution and air dried for 5 minutes to prevent the fungal diseases.

Preparation of growth regulator solutions: The required concentrations of growth regulator i.e., IBA solutions (100, 200, 300, 1000, 2000 and 3000 ppm) were prepared by dissolving a quantity of 100, 200, 300, 1000, 2000 and 3000 mg of IBA separately in a small quantity of 0.1N Sodium Hydroxide (NaOH) solution and the final volume was made up to 1000 ml by addition of distilled water.

Planting: The basal part of cuttings (about 2 cm depth from basal end) were dipped in respective IBA solutions 100, 200 and 300 ppm for 24 hrs (Prolonged dip method) and 1000, 2000 and 3000 ppm for 10 sec (Quick dip method) and subsequently the cuttings were air dried for 5 minutes. The treated cuttings were planted in a slanting manner in polybags containing the growing media up to one node depth (i.e., 2.5 cm) and pressed gently. The cuttings were watered at regular intervals with rose can for maintaining optimum soil moisture. The medium was drenched with Copper Oxy Chloride (COC) @ 3g/L at weekly intervals to check the incidence of soil borne diseases. The observations on various root and shoot parameters were recorded up to 75 DAP and subjected to statistical analysis as per method suggested by Panse and Sukhatame (1967) [15] and the results are presented below.

Results and Discussion
Root parameters
Rooted cuttings (%)
Terminal cuttings were found superior over semi hardwood cuttings in terms of rooting percentage. Though both the types of cuttings rooted better but terminal cuttings recorded highly significant rooting percentage (74.42) which was about 7.35% more than semi hardwood cuttings (67.07). IBA quick dip @ 3000 ppm recorded highest (86.25%) rooting percentage followed by IBA quick dip @ 2000 ppm (79.00) and it was least (56.50%) in control (IBA @ 0 ppm). The interaction of terminal cuttings with IBA quick dip @ 3000 ppm recorded highest rooting percentage (88.50%) followed by (84.00%) semi hardwood cuttings treated with IBA quick dip @ 3000 ppm and it was lowest (53.00%) in semi hardwood cuttings treated with IBA @ 0 ppm (control).

Table 1: Effect of cutting types and IBA treatments on rooted cuttings (%) in crossandra variety Arka Shravya at 75 days after planting

IBA treatments (G)	Rooted cuttings (%)		
	Cutting types (C)		
	Terminal cutting (C_1)	Semi hardwood cutting (C_2)	Mean
100 ppm (G_1)	67.00 (54.91)	62.50 (52.21)	64.75 (53.56)
200 ppm (G_2)	69.00 (56.14)	64.00 (53.10)	66.50 (54.62)
300 ppm (G_3)	72.00 (58.02)	64.50 (53.40)	68.25 (55.71)
1000 ppm (G_4)	81.00 (64.14)	67.00 (54.91)	74.00 (59.52)
2000 ppm (G_5)	83.50 (66.00)	74.50 (59.64)	79.00 (62.82)
3000 ppm (G_6)	88.50 (70.15)	84.00 (66.39)	86.25 (68.27)
0 ppm (G_7)	60.00 (50.74)	53.00 (46.70)	56.50 (48.72)
Mean	74.42 (60.02)	67.07 (55.19)	70.75 (57.60)
Factor	C	G	C x G
SE (m) ±	0.13	0.25	0.36
CD at 5%	0.42	0.80	1.13

G_1, G_2 and G_3 are IBA treatments with prolonged dip method for 24 hrs
G_4, G_5 and G_6 are IBA treatments with quick dip method for 10 sec
* The figures in parenthesis indicate angular transformed values

Number of roots per cutting
Number of roots produced per cutting is an important factor for plant survivability. In the present study it was found maximum (12.93) in terminal cuttings followed by (10.75) semi hardwood cuttings. IBA quick dip @ 3000 ppm recorded maximum (17.75) number of roots followed by (15.50) IBA quick dip @ 2000 ppm and minimum (6.37) with IBA @ 0 ppm (control). Treatment of terminal cuttings with IBA quick dip @ 3000 ppm proved best with maximum (18.50) number of roots per cutting followed by (17.00) semi hardwood cuttings treated with IBA quick dip @ 3000 ppm and minimum (5.75) was observed in semi hardwood cuttings treated with IBA @ 0 ppm (control).

Root length (cm) per cutting
Root length is also an important factor of successful propagation through cuttings which helps in nutrient uptake through strong root system and helps in plant growth and development by improving the plant metabolic processes. Terminal cuttings noticed the pronounced increase of root length (31.21 cm) throughout the study which was about 5.32 cm longer than semi hardwood cuttings (25.89 cm). Maximum root length was achieved by dipping the cuttings in IBA @ 3000 ppm for 10 seconds (42.75 cm) followed by IBA quick dip @ 2000 ppm (36.62 cm) and the root length was minimum (11.50 cm) in (IBA @ 0 ppm) control. The better root growth was observed in terminal cuttings treated with IBA quick dip @ 3000 ppm (46.00 cm) followed by (39.50 cm) semi hardwood cuttings treated with IBA quick dip @ 3000 ppm and minimum (10.00 cm) was recorded in semi hardwood cuttings treated with IBA @ 0 ppm (control).

Table 2: Effect of cutting types and IBA treatments on number of roots and root length (cm) per cutting in crossandra variety Arka Shravya at 75 days after planting

IBA treatments (G)	Number of roots			Root length (cm)		
	Cutting types (C)			Cutting types (C)		
	Terminal cutting (C_1)	Semi hardwood cutting (C_2)	Mean	Terminal cutting (C_1)	Semi hardwood cutting(C_2)	Mean
100 ppm (G_1)	9.50 (3.24)	7.50 (2.91)	8.50 (3.07)	27.25	21.75	24.50
200 ppm (G_2)	11.00 (3.46)	8.00 (2.99)	9.50 (3.23)	29.50	22.00	25.75
300 ppm (G_3)	13.00 (3.74)	9.00 (3.16)	11.00 (3.45)	30.75	24.25	27.50
1000 ppm (G_4)	15.50 (4.06)	13.00 (3.74)	14.25 (3.90)	33.25	29.25	31.25
2000 ppm (G_5)	16.00 (4.12)	15.00 (4.00)	15.50 (4.06)	38.75	34.50	36.62
3000 ppm (G_6)	18.50 (4.41)	17.00 (4.24)	17.75 (4.32)	46.00	39.50	42.75
0 ppm (G_7)	7.00 (2.82)	5.75 (2.59)	6.37 (2.71)	13.00	10.00	11.50
Mean	12.93 (3.69)	10.75 (3.37)	11.84 (3.60)	31.21	25.89	28.55
Factor	C	G	C x G	C	G	C x G
SE (m) ±	0.02	0.03	0.05	0.21	0.39	0.56
CD at 5%	0.06	0.12	0.17	0.65	1.23	1.74

G_1, G_2 and G_3 are IBA treatments with prolonged dip method for 24 hrs
G_4, G_5 and G_6 are IBA treatments with quick dip method for 10 sec
* The figures in parenthesis indicate square transformed values

Fresh weight of roots (g)
The data recorded at 75 days after planting revealed that terminal cuttings recorded the maximum fresh weight of roots (3.81 g) followed by semi hardwood cuttings (3.23 g). IBA Quick dip @ 3000 ppm strength resulted in maximum root fresh weight (6.95 g) followed by IBA quick dip @ 2000 ppm (6.18 g) and minimum (1.39 g) with IBA @ 0 ppm (control). Maximum root fresh weight was recorded by terminal cuttings treated with IBA quick dip @ 3000 ppm (7.12 g) and it was on par with (6.79 g) semi hardwood cuttings treated with quick dip in IBA quick dip @ 3000 ppm and minimum (1.21 g) was recorded in semi hardwood cuttings treated with IBA @ 0 ppm (control).

Dry weight of roots (g)
Maximum root dry weight was recorded in terminal cuttings (1.225 g) followed by semi hardwood cuttings (0.967 g). IBA quick dip @ 3000 ppm recorded maximum (2.098 g) root dry weight followed by IBA quick dip @ 2000 ppm (1.575 g) and it was low (0.450 g) in control (IBA @ 0 ppm). The interaction of terminal cuttings with IBA quick dip @ 3000 ppm recorded highest root dry weight (2.335 g) followed by (1.860 g) terminal cuttings treated with IBA quick dip @ 3000 ppm and minimum (0.400 g) in semi hardwood cuttings treated with IBA @ 0 ppm (control).

Table 3: Effect of cutting types and IBA treatments on fresh weight (g) and dry weight (g) of roots in crossandra variety Arka Shravya at 75 days after planting

IBA treatments (G)	Fresh weight of roots (g)			Dry weight of roots (g)		
	Cutting types (C)			Cutting types (C)		
	Terminal cutting (C_1)	Semi hardwood cutting (C_2)	Mean	Terminal cutting (C_1)	Semi hardwood cutting (C_2)	Mean
100 ppm (G_1)	1.70	1.67	1.68	0.680	0.520	0.600
200 ppm (G_2)	2.41	1.86	2.136	0.790	0.685	0.738
300 ppm (G_3)	3.24	2.06	2.65	0.880	0.715	0.798
1000 ppm (G_4)	4.11	3.22	3.66	1.600	1.230	1.415
2000 ppm (G_5)	6.55	5.82	6.18	1.790	1.360	1.575
3000 ppm (G_6)	7.12	6.79	6.95	2.335	1.860	2.098
0 ppm (G_7)	1.57	1.21	1.39	0.500	0.400	0.450
Mean	3.81	3.23	3.52	1.225	0.967	1.096
Factor	C	G	C x G	C	G	C x G
SE (m) ±	0.04	0.08	0.11	0.013	0.025	0.035
CD at 5%	0.13	0.24	0.35	0.041	0.077	0.108

G_1, G_2 and G_3 are IBA treatments with prolonged dip method for 24 hrs
G_4, G_5 and G_6 are IBA treatments with quick dip method for 10 sec

The root formation process on the cuttings is a complicated one which is regulated by many internal factors like concentration of endogenous auxins, rooting cofactors, carbohydrate substances stored in the cuttings as well as nitrogen content. These may interact to influence the rooting percentage, root length, root diameter and root weight.

Among the two cutting types, terminal cuttings rooted better than semi hardwood cuttings. The better rooting of terminal cuttings was most probably due to presence of higher concentration of root promoting substances in the terminal portion of shoots, which were translocated towards the base of shoot and initiated the rooting. The delayed rooting in semi hardwood cuttings might be due to lack of nutrition, insufficient auxin production or due to accumulation of other inhibitory substances in the stem (Nanda, 1975) [14].

The promotion and development of roots showed an increasing trend by the increase of growth regulators concentration from 100 to 3000 ppm. Treatment of cuttings with increasing concentrations of IBA coupled with endogenous auxins present in the cuttings could improve the percentage of rooting in cuttings (Melgarejo *et al.*, 2015) [13].

Higher amount of growth promoting substances, presence of sufficient auxin levels in leaves, better mobilization of food reserves and earliness in rooting might be the reason for production of more number of roots as well as maximum root length in terminal cuttings. Similar results were reported by

Ullah *et al.* (2013) [21] in African marigold and Kumar *et al.* (2014) [9] in carnation.

The enhanced hydrolytic activity in the presence of exogenously applied hormones leads to differentiation of meristematic cells into root primordium and hastens the process of root initiation. And it was followed by increased rate of respiration, accumulation of higher level of amino acids at their bases. The enhanced tissue sensitivity by means of increased internal free auxin resulted in increased number and size of roots (Ingle, 2008) [6].

Auxin causes the hydrolysis and translocation of carbohydrates and nitrogenous substances and synthesis of new proteins at the base of cuttings and resulted in accelerating the process of cell elongation and cell division leading to maximum root length (Singh *et al*., 2003) [20].

Auxin treatment increases number of primary and secondary roots per cutting through cell division and cell elongation and consequently accounting for more fresh weight and thus dry weight of roots which was reported by Sharma (2014) [19] in African marigold, Gowda (2017) [5] in carnation and Shahi (2017) [18] in magnolia.

Shoot Parameters

Days to first sprouting of cutting

Terminal cuttings showed the earliest sprouting (8.82 days) of cuttings than semi hardwood cuttings (9.50 days). IBA quick dip @ 3000 ppm performed the best with significant earliest sprouting of 7.25 days followed by IBA quick dip @ 2000 ppm (8.50 days) and maximum delay (10.75 days) was observed with IBA @ 0 ppm (control). Minimum number of days to sprouting (7.00) was noticed in terminal cuttings treated with IBA quick dip @ 3000 ppm followed by 7.50 days in semi hardwood cuttings treated with IBA quick dip @ 3000 ppm and maximum delay (11.00 days) was observed in semi hardwood cuttings treated with IBA @ 0 ppm (control).

Table 4: Effect of cutting types and IBA treatments on days to first sprouting of cutting in crossandra variety Arka Shravya

IBA treatments (G)	Days to first sprouting of cutting		
	Cutting types (C)		
	Terminal cutting (C_1)	Semi hardwood cutting (C_2)	Mean
100 ppm (G_1)	9.50 (3.24)	10.00 (3.31)	9.75 (3.27)
200 ppm (G_2)	9.50 (3.24)	10.00 (3.31)	9.75 (3.27)
300 ppm (G_3)	9.00 (3.16)	9.50 (3.24)	9.25 (3.20)
1000 ppm (G_4)	8.25 (3.04)	9.50 (3.31)	8.87 (3.17)
2000 ppm (G_5)	8.00 (3.00)	9.00 (3.16)	8.50 (3.08)
3000 ppm (G_6)	7.00 (2.82)	7.50 (2.91)	7.25 (2.87)
0 ppm (G_7)	10.50 (3.39)	11.00 (3.46)	10.75 (3.42)
Mean	8.82 (3.12)	9.50 (3.24)	9.16 (3.18)
Factor	C	G	C x G
SE (m) ±	0.01	0.02	0.02
CD at 5%	0.03	0.06	0.09

G_1, G_2 and G_3 are IBA treatments with prolonged dip method for 24 hrs
G_4, G_5 and G_6 are IBA treatments with quick dip method for 10 sec
* The figures in parenthesis indicate square transformed values

Number of shoots per cutting

Terminal cuttings recorded highest number of shoots per cutting (2.58) followed by semi hardwood cuttings (2.06). IBA quick dip @ 3000 ppm recorded maximum (4.10) number of shoots per cutting followed by (2.90) IBA quick dip @ 2000 ppm and minimum (0.60) was recorded with IBA @ 0 ppm (control). The highest number of shoots per cutting (4.60) was observed in terminal cuttings treated with IBA quick dip @ 3000 ppm followed by (3.60) semi hardwood cuttings with IBA quick dip @ 3000 ppm and minimum number of shoots (0.40) was observed in semi hardwood cuttings treated with IBA @ 0 ppm (control).

Number of leaves per cutting

Maximum number of leaves per cutting was recorded in terminal cuttings (37.44) followed by semi hardwood cuttings (34.41). The number of leaves per cutting was highest (56.15) with IBA quick dip @ 3000 ppm followed by (48.70) IBA quick dip @ 2000 ppm and lowest (21.35) with IBA @ 0 ppm (control). Treatment of terminal cuttings with IBA quick dip @ 3000 ppm recorded maximum (58.20) number of leaves per cutting followed by (54.10) semi hardwood cuttings with IBA quick dip @ 3000 ppm and minimum (20.50) was observed in semi hardwood cuttings treated with IBA @ 0 ppm (control).

Table 5: Effect of cutting types and IBA treatments on number of shoots and number of leaves per cutting in crossandra variety Arka Shravya at 75 days after planting

IBA treatments (G)	Number of shoots			Number of leaves		
	Cutting types (C)			Cutting types (C)		
	Terminal cutting (C_1)	Semi hardwood cutting (C_2)	Mean	Terminal cutting (C_1)	Semi hardwood cutting (C_2)	Mean
100 ppm (G_1)	1.80 (1.67)	1.70 (1.64)	1.75 (1.65)	26.100 (5.20)	24.300 (5.03)	25.200 (5.11)
200 ppm (G_2)	2.20 (1.78)	1.80 (1.67)	2.00 (1.73)	28.500 (5.43)	26.300(5.22)	27.400 (5.32)
300 ppm (G_3)	2.80 (1.94)	1.95 (1.71)	2.37 (1.83)	32.000 (5.74)	30.600 (5.62)	31.300 (5.68)
1000 ppm (G_4)	2.90 (1.97)	2.20 (1.78)	2.55 (1.88)	44.200 (6.72)	38.600 (6.29)	41.400 (6.50)
2000 ppm (G_5)	3.00 (2.00)	2.80 (1.94)	2.90 (1.97)	50.900 (7.20)	46.500 (6.89)	48.700 (7.04)
3000 ppm (G_6)	4.60 (2.36)	3.60 (2.14)	4.10 (2.25)	58.200 (7.69)	54.100 (7.42)	56.150 (7.55)
0 ppm (G_7)	0.80 (1.34)	0.40 (1.18)	0.60 (1.26)	22.200 (4.81)	20.500 (4.63)	21.350 (4.72)
Mean	2.58 (1.87)	2.06 (1.72)	2.32 (1.79)	37.440 (6.11)	34.410 (5.87)	35.920 (5.99)
Factor	C	G	C x G	C	G	C x G

SE (m) ± CD at 5%	0.01 0.03	0.02 0.06	0.02 0.08	0.014 0.042	0.026 0.079	0.036 0.112

G_1, G_2 and G_3 are IBA treatments with prolonged dip method for 24 hrs
G_4, G_5 and G_6 are IBA treatments with quick dip method for 10 sec
* The figures in parenthesis indicate square transformed values

Leaf area (cm^2) per cutting
Maximum leaf area per cutting (cm^2) was gained by terminal cuttings (99.36) followed by semi hardwood cuttings (91.47). IBA quick dip @ 3000 ppm recorded the maximum leaf area per cutting (150.23 cm^2) followed by IBA quick dip @ 2000 ppm recorded 127.53 cm^2 while the minimum(45.68 cm^2) was revealed in IBA @ 0 ppm (control). The maximum leaf area per cutting (157.46 cm^2) was observed in terminal cuttings treated with IBA quick dip @ 3000 ppm followed by (143.00 cm^2) semi hardwood cuttings treated with IBA @ 3000 ppm and minimum (41.66 cm^2) was recorded in semi hardwood cuttings treated with IBA @ 0 ppm (control).

Total leaf chlorophyll content (SPAD)
Highest total leaf chlorophyll content (46.82) was noticed in terminal cuttings followed by semi hardwood (45.63) cuttings. IBA quick dip @ 3000 ppm significantly performed the best with maximum (49.79) total leaf chlorophyll content followed by (47.39) IBA quick dip @ 2000 ppm and minimum (43.05) was recorded with IBA @ 0 ppm (control). The total leaf chlorophyll content (51.41) was recorded highest in terminal cuttings treated with IBA quick dip @ 3000 ppm followed by (48.17) semi hardwood cuttings with IBA quick dip @ 3000 ppm and minimum (42.29) in semi hardwood cuttings treated with IBA @ 0 ppm (control).

Table 6: Effect of cutting types and IBA treatments on leaf area per cutting (cm^2) and total leaf chlorophyll content (SPAD) in crossandra variety Arka Shravya at 75 days after planting

IBA treatments (G)	Leaf area per cutting (cm^2)			Total leaf chlorophyll content (SPAD)		
	Cutting types (C)			Cutting types (C)		
	Terminal cutting (C_1)	Semi hardwood cutting (C_2)	Mean	Terminal cutting (C_1)	Semi hardwood cutting(C_2)	Mean
100 ppm (G_1)	66.50	61.05	63.77	44.54	44.55	44.54
200 ppm (G_2)	78.85	73.84	76.34	45.30	44.75	45.02
300 ppm (G_3)	99.61	90.72	95.17	47.00	46.19	46.59
1000 ppm (G_4)	110.81	107.54	109.17	47.70	46.70	47.20
2000 ppm (G_5)	132.56	122.50	127.53	47.99	46.79	47.39
3000 ppm (G_6)	157.46	143.00	150.23	51.41	48.17	49.79
0 ppm (G_7)	49.71	41.66	45.68	43.81	42.29	43.05
Mean	99.36	91.47	95.41	46.82	45.63	46.23
Factor	C	G	C x G	C	G	C x G
SE (m) ± CD at 5%	0.25 0.77	0.47 1.45	0.66 2.05	0.08 0.25	0.15 0.48	0.22 0.68

G_1, G_2 and G_3 are IBA treatments with prolonged dip method for 24 hrs
G_4, G_5 and G_6 are IBA treatments with quick dip method for 10 sec

Fresh weight of shoots (g)
Terminal cuttings recorded the maximum fresh weight of shoots (5.74 g) than semi hardwood cuttings (5.03 g). IBA Quick dip @ 3000 ppm resulted in maximum shoot fresh weight (10.61 g) followed by IBA quick dip @ 2000 ppm (7.80 g) and minimum (2.64 g) with IBA @ 0 ppm (control). Maximum shoot fresh weight was gained by terminal cuttings treated with IBA quick dip @ 3000 ppm (12.09 g) followed by (9.13 g) semi hardwood cuttings treated with IBA quick dip @ 3000 ppm and minimum (2.51 g) was recorded in semi hardwood cuttings treated with IBA @ 0 ppm (control).

Dry weight of shoots (g)
Maximum shoot dry weight was recorded in terminal cuttings (1.886 g) followed by semi hardwood cuttings (1.590 g). IBA quick dip @ 3000 ppm recorded maximum (2.615 g) shoot dry weight followed by IBA quick dip @ 2000 ppm (2.193 g) and it was low (1.138 g) in control (IBA @ 0 ppm) treatment. The interaction of terminal cuttings with IBA quick dip @ 3000 ppm resulted in highest shoot dry weight (2.720 g) followed by (2.510 g) terminal cuttings treated with IBA quick dip @ 3000 ppm and minimum (1.065 g) in semi hardwood cuttings treated with IBA @ 0 ppm (control).

Table 7: Effect of cutting types and IBA treatments on fresh weight (g) and dry weight of shoots (g) in crossandra variety Arka Shravya at 75 days after planting

IBA treatments (G)	Fresh weight of shoots (g)			Dry weight of shoots (g)		
	Cutting types (C)			Cutting types (C)		
	Terminal cutting (C_1)	Semi hardwood cutting (C_2)	Mean	Terminal cutting (C_1)	Semi hardwood cutting (C_2)	Mean
100 ppm (G_1)	3.09	3.05	3.07	1.245	1.245	1.245
200 ppm (G_2)	3.58	3.15	3.36	1.395	1.265	1.330
300 ppm (G_3)	3.96	4.84	4.40	1.795	1.350	1.573
1000 ppm (G_4)	6.75	4.95	5.85	2.410	1.740	2.075
2000 ppm (G_5)	7.99	7.62	7.80	2.430	1.955	2.193
3000 ppm (G_6)	12.09	9.13	10.61	2.720	2.510	2.615
0 ppm (G_7)	2.76	2.51	2.64	1.210	1.065	1.138
Mean	5.74	5.03	5.39	1.886	1.590	1.738
Factor	C	G	C x G	C	G	C x G
SE (m) ± CD at 5%	0.15 0.47	0.28 0.88	0.40 1.25	0.010 0.032	0.019 0.059	0.027 0.084

G_1, G_2 and G_3 are IBA treatments with prolonged dip method for 24 hrs
G_4, G_5 and G_6 are IBA treatments with quick dip method for 10 sec

Root to shoot ratio (on dry weight basis)

Maximum root to shoot ratio was recorded by terminal cuttings (0.60) which was on par with (0.56) semi hardwood cuttings. IBA quick dip @ 3000 ppm recorded the highest root to shoot ratio of 0.78 which was on par with (0.71 and 0.68) IBA quick dip @ 2000 ppm and 1000 ppm respectively and lowest root to shoot ratio was observed with IBA @ 0 ppm (0.39 which was on par with 0.47) IBA prolonged dip @ 100 ppm. Highest root to shoot ratio (0.85) was recorded in terminal cuttings treated with IBA quick dip @ 3000 ppm which was on par with (0.73) terminal cuttings treated with @ IBA quick dip @ 2000 ppm and (0.73) semi hardwood cuttings treated with IBA quick dip @ 3000 ppm respectively. The minimum root to shoot ratio (0.41) was recorded in semi hardwood cuttings treated with IBA @ 0 ppm (control).

Mortality percentage of rooted cuttings

Terminal cuttings performed the best with minimum mortality percent of 3.21 which was followed by semi hardwood cuttings (5.32%). IBA quick dip @ 3000 ppm recorded the lowest mean mortality percentage of 0.00 followed by (1.12) IBA quick dip @ 2000 ppm and highest mortality percentage (15.00) was recorded with IBA @ 0 ppm (control). The lowest mortality of about 0.00% was recorded in terminal cuttings treated with IBA quick dip at the concentrations of 3000 and 2000 ppm as well as semi hardwood cuttings treated with IBA quick dip @ 3000 ppm respectively. This was significantly followed by semi hardwood cuttings treated with IBA quick dip @ 2000 ppm (2.25%) and highest mortality percentage (17.50) was noticed in semi hardwood cuttings treated with IBA @ 0 ppm (control).

Table 8: Effect of cutting types and IBA treatments on root to shoot ratio (on dry weight basis) at 75 days after planting and mortality percentage of rooted cuttings at 30 days after transplanting of crossandra variety Arka Shravya

IBA treatments (G)	Root to shoot ratio (on dry weight basis) 75 days after planting			Mortality percentage of rooted cuttings 30 days after transplanting		
	Cutting types (C)			Cutting types (C)		
	Terminal cutting (C_1)	Semi hardwood cutting (C_2)	Mean	Terminal cutting (C_1)	Semi hardwood cutting (C_2)	Mean
100 ppm (G_1)	0.54 (4.21)	0.41 (3.66)	0.47 (3.94)	2.50 (9.09)	5.00 (12.91)	3.75 (11.00)
200 ppm (G_2)	0.56 (4.29)	0.53 (4.19)	0.54 (4.24)	2.50 (9.04)	5.00 (12.91)	3.75 (10.98)
300 ppm (G_3)	0.48 (3.99)	0.52 (4.15)	0.50 (4.07)	2.50 (9.04)	5.00 (12.91)	3.75 (10.98)
1000 ppm (G_4)	0.66 (4.65)	0.70 (4.79)	0.68 (4.72)	2.50 (9.09)	2.50 (9.04)	2.50 (9.07)
2000 ppm (G_5)	0.73 (4.91)	0.69 (4.76)	0.71 (4.83)	0.00 (0.00)	2.25 (8.61)	1.12 (4.30)
3000 ppm (G_6)	0.85 (5.30)	0.73 (4.91)	0.78 (5.11)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
0 ppm (G_7)	0.41 (3.66)	0.37 (3.48)	0.39 (3.57)	12.50 (20.69)	17.50 (24.71)	15.00 (22.70)
Mean	0.60 (4.43)	0.56 (4.28)	0.58 (4.35)	3.21 (8.14)	5.32 (11.58)	4.26 (10.47)
Factor	C	G	C x G	C	G	C x G
SE (m) ±	0.02	0.04	0.06	0.14	0.27	0.38
CD at 5%	0.07	0.13	0.19	0.45	0.84	1.19

G_1, G_2 and G_3 are IBA treatments with prolonged dip method for 24 hrs
G_4, G_5 and G_6 are IBA treatments with quick dip method for 10 sec
* The figures in parenthesis indicate angular transformed values

Better establishment of terminal cuttings with vigorous and profuse root system might have resulted in earliest sprouting as reported by Bharathi (2001) [1] in carnation and Kumar *et al*. (2018) [11] in coleus. Auxin application to the cuttings reported an increase in sprouting of cuttings, highlighting the role of certain material produced in the roots, which are responsible for sprouting (Ganjure, 2012) [4].

The development of maximum number of shoots in terminal cuttings might be due to the better root growth which augmented absorption and translocation of nutrients from soil and which take active part in various plant metabolic processes and helps in development of more number of shoots per cuttings as reported by Mehraj (2013) [12] in bougainvillea. Better utilization of stored carbohydrates, nitrogen and other factors with the aid of growth regulators might be the reason for earliness to sprouting, increase in the number of sprouts and sprout length (Chandramouli, 2001) [2]. Since auxins were applied to the base of cuttings, the basipetal translocation of auxins from leaves may be lower which in turn diverted towards shoot and helps in shoot growth as outlined by Rani *et al*. (2018) [16] in guava.

Better nutrient absorption could have encouraged production of a greater number of leaves in terminal cuttings (Kumar and Ahmed, 2013) [10] of scented geranium and *Tabernaemontana coronaria* (Rawat *et al*., 2014) [17]. Increased activity of photosynthesis and respiration in leaves led to increased number of leaves per cutting resulting in increased leaf area per cutting. The translocation of hormone along the way of cell division and cell elongation enhanced the enzymatic activity (Debnath and Maiti, 1990) [3] which activated the shoot growth leading to an increasing number of nodes that leads to development of a greater number of leaves. The increase in number of leaves per cutting might be due to fact that the plant might have diverted maximum assimilate quantities to the leaf buds, since the leaves are one of the production sites of natural auxins in them besides being very important for vital processes like photosynthesis and respiration (Wahab *et al*., 2001) [22].

Rani *et al*. (2018) [16] reported that cuttings with more number of leaves enhanced more nutrients uptake by means of increasing the photosynthates production and providing sufficient food contents for the metabolic activities of the plants by means of mounting the levels of light harvesting pigments especially chlorophylls as observed in IBA treated terminal cuttings.

The higher shoot length coupled with increased leaf number and leaf area per shoot resulted in higher fresh and dry weight of shoots in IBA treated terminal cuttings as reported by Kumar and Ahmed (2013) [10] in scented geranium and Rani *et al*. (2018) [16] in guava.

Significant differences were observed among the cutting types and IBA treatments for root to shoot ratio which might be due to increase in production of leaves and leaf area which ultimately increased the photosynthesis, relative growth rate and growth of lateral branching of shoots, which finally resulted in increase in the fresh and dry biomass of the shoots and the root to shoot ratio (Khapare *et al*., 2012) [7]. Similar findings were observed in guava by Rani *et al*. (2018) [16].

The lowest mortality percentage during field establishment was recorded in plants propagated from terminal cuttings than semi hardwood cuttings which may be due to the fact that a good rooted cutting could have reasonable amount of dry matter partitioned into roots and could win the race in better search and imbibition of food material from the ground thus leading to better survival as well as field establishment. The positive effect of IBA on survival percentage and field establishment was revealed by the corresponding superiority on rooting percentage, number of roots, root length, fresh and dry weight of roots, root to shoot ratio which was attributed to the promotive effect of auxins (Kumar, 2009) [8]. Similar findings were reported by Rani *et al*. (2017) [16] in guava.

Conclusion

From the present investigation, it was evident that use of terminal cuttings, pre treatment of cuttings with IBA @ 3000 ppm in quick dip method for 10 seconds and their combination exhibited pronounced effect on root and shoot formation in cuttings as well as superior field establishment of rooted cuttings. It clearly indicated its effectiveness on profound increase of success in vegetative propagation through cuttings in crossandra var. Arka Shravya.

References

1. Bharathi PV. The effect of plant growth regulators on rooting of cuttings in carnation (*Dianthus caryophyllus* L.). M.Sc. Thesis. Mahatma Phule Krishi Vidyapeeth, Ahmednagar, Maharashtra, 2001.
2. Chandramouli H. Influence of the growth regulator on the rooting of different types of cuttings in *Bursera penicilliata* (DC). M.Sc. (Agri.) Thesis. University of Agricultural Sciences, Bangalore, 2001.
3. Debnath GC, Maiti SC. Effect of the growth regulators on rooting of softwood cuttings of guava (*Psidium guajava* L.) under mist. Haryana Journal of Horticultural Sciences. 1990; 19:79-85.
4. Ganjure SL, Gawande MB, Golliwar VJ. Response of IBA and rooting media on rooting of cuttings in chrysanthemum. International Journal of Science and Research. 2012; 3(7).
5. Gowda PG, Dhananjaya MV, Kumar R. Effect of Indole butyric acid (IBA) on rooting of different carnation (*Dianthus caryophyllus* L.) genotypes. International Journal of Pure and Applied Bioscience. 2017; 5(2):1075-80.
6. Ingle MR. Effect of growth regulators and environments on rooting of stevia cuttings (*Stevia rebaudiana* Bertoni). M.Sc. Thesis. Department of Agriculture, College of Agriculture, Dharwad, 2008.
7. Khapare LS, Dahale MH, Bhusarii RB. Propagational studies in fig as affected by plant growth regulator. The Asian Journal of Horticuluture. 2012; 7(1).
8. Kumar M. Effect of IBA on the success of stooling in jackfruit (*Artocarpus heterophyllus* L.) cv. Pant Garim. Haryana Journal of Horticulture Science. 2009; 38(1, 2):23-25.
9. Kumar R, Ahmed N, Sharma OC, Lal S. Influence of auxins on rooting efficacy in carnation (*Dianthus caryophyllus* L.) cuttings. Journal of Horticultural Science. 2014; 9(2):157-60.
10. Kumar R, Ahmed N. Quality of *Pelargonium graveolens* L. stem cuttings as affected by rooting substrates and IBA concentrations. International Journal of plant research. 2013; 26(2):138-44.
11. Kumar YKB, Rajamani K, Kumar MKK, Adivappar N. Influence of type of cuttings and growth regulators on rooting in Indian borage (*Coleus aromaticus* L.). Journal of Pharmacognosy and Phytochemistry. 2018; 3:182-85.
12. Mehraj H, Shiam IH, Taufique T, Shahrin S, Uddin AFMJ. Influence of Indole-3-butyric acid (IBA) on sprouting and rooting potential of *Bougainvillea spectabilis* cuttings. Bangladesh Research Publications Journal. 2013; 9(1):44-49.
13. Melgarejo P, Martinez J, Amoros A, Martinez R. Study of the rooting capacity of ten pomegranate clones (*Punica granatum* L.). Options Mediterraneennes. Serie A, Seminaires Mediterraneens. 2015; (42):163-67.
14. Nanda KK. Propagation through cuttings. In: Vegetative Propagation of Plants (Eds. Nanda KK, Kochhar VK.), Kalyani Publishers. 1975, 145.
15. Panse VG, Sukhatme PV. Statistical methods for Agricultural workers. ICAR, New Delhi. 1967, 145-55.
16. Rani TD, Srihari D, Dorajeerao AVD, Subbaramamma P. Effect of rooting media and IBA treatments on shoot production and survival of terminal cuttings in guava (*Psidium guajava* L.) cv. Taiwan Pink. International Journal of Current Microbiology and Applied Sciences. 2018; 7(11):231-42.
17. Rawat JMS, Singh KK, Rawat V, Singh B. Effect of methods of IBA application on rooting performance of crape jasmine (chandani) softwood cuttings. Hort Flora Research Spectrum. 2014; 3(2):146-49.
18. Shahi ZGG, Zarei H, Alizadeh M, Babarabie M. Evaluation of rooting of stem cuttings of *Magnolia soulangeana* under influence of time and IBA treatment. Journal of Chemical Health Risks. 2017; 7(4):259-72.
19. Sharma R. Study on the effect of auxins on rooting, growth and flowering of African marigold (*Tagetes erecta* L.) propagated through stem cuttings. M.Sc. (Hort.) thesis. Indira Gandhi Krishi Vishwavidyalaya, Raipur, 2014.
20. Singh AK, Singh R, Mittal AK, Singh YP, Jauhari S. Effect of growth regulator in long pepper (*Piper longum* L.). Progressive Horticulture. 2003; 35:208-11.
21. Ullah Z, Abbas SJ, Naeem N, Lutfullah G, Malik T, Khan MAU *et al*. Effect of Indole butyric acid (IBA) and Naphthalene acetic acid (NAA) plant growth regulators on marigold (*Tagetes erecta* L.). African Journal of Agricultural Research. 2013; 8(29):4015-19.
22. Wahab F, Nabi G, Ali N, Shah M. Rooting response of semi-hardwood cuttings of guava (*Psidium guajava* L.) to various concentrations of different auxins. Journal of Biological Sciences. 2001; 1(4):184-87.