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Comparative evaluation of hardwood and semi hardwood cutting with different rooting hormone in (*Bougainvillea buttiana*) cv. Mahara

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Abstract
An experiment on "comparative evaluation of hardwood and semihard wood cutting with different rooting hormone in (*Bougainvillea buttiana*) cv. Mahara" using three different rooting hormones (IAA, IBA and NAA) was conducted under shade net, at Department of horticulture research field of Sam Higginbottom University of Agriculture, Technology and Sciences, from the month of April to July 2019. The experiment was laid out in a Completely Randomized Design (CRD) with three replicates. Data were collected on Days to first Sprout, no of vegetative buds sprouted/cutting, sprouting percentage number of leaves /cutting, number of shoots / cutting, plant height, stem girth, length of longest shoot/ cutting, number of roots / cutting, length of longest root/cutting, mortality rate. The results showed that hardwood cuttings were found to give significantly better results than semihardwood cuttings treated with different rooting hormones (12hrs). A long dip (12hrs) treatment of IBA1500ppm for hardwood cuttings showed significantly better results than control and all the other treatments with respect to minimum Days to first Sprout (15.723), maximum no of vegetative buds sprouted /cutting (4.000), maximum sprouting percentage(60.000%), number of leaves /cutting(52.333), number of shoots/cutting((3.667), length of longest shoot/ cutting (42.270cm), plant height (45.603cm), maximum stem girth (1.227cm), number of roots/cutting (26.943), length of longest root/ cutting (19.267cm), minimum mortality rate (40.000%) whereas in case of semi hardwood cutting the long dip (12hrs) treatment with IBA1500ppm cuttings was significantly better than control and all the other treatments with respect to minimum days to first sprout (17.167), maximum sprouting percentage (40.000%), maximum number of leaves /cutting (31.500), maximum length of longest shoot (31.030cm), maximum plant height (33.697cm), maximum Stem girth (0.827 cm) maximum number of roots (22.833), longest root(17.500cm), minimum mortality rate (60.000%) whereas maximum vegetative buds sprouted (3.000) was obtained in cuttings treated with NAA(1500ppm), maximum number of shoots per cutting (3.000) was obtained in cuttings treated with IAA(1000ppm), IAA(1500ppm) and IBA(500ppm).

Keywords: Bougainvillea, IBA, NAA, growth regulators, ppm, rooting hormone

Introduction
The genus bougainvillea is endemic to south America and was firstly reported in Brazil in 1778 before being introduced to Europe, by French military commander Louis Antoine de Bougainville from Rio De janeiro, Brazil after whom it is being named. They are bushes spread in vines or small ornamental trees. Bougainvillea was first collected by commerson, a French botanist. Bougainvillea is a genus of native flowering plant in south America, originated from west Brazil to southern Argentina. Belonging to the family Nyctaginaceae it has ten species of which only three species are of horticultural importance namely, *B. spectabilis, B. glabra* and *B. peruviana.* However, in addition to above three *B. buttiana* is a natural hybrid between *B peruviana* and *B. glabra* (Holttum, 1970) [12]. It is a quick growing shrub and varies in height according to different species. They possess stout spines for climbing and posess three brightly colored petal like bracts. In recent years, some multibracted bougainvillea's have been introduced where the number of bracts is more than three and in such cultivar there is no true flower. One such cultivar is 'Mahara' (syn. 'Million dollar', 'Manila magic red', 'Manila red'). Flowers appear in large clusters. It is a free bloomer. The peak flowering time is September to December and again from February to June. In the horticultural industry most of perennial ornamental plants are multiplied and propagated vegetatively through cuttings, layering or grafting. Generally, the most commonly applied

technique is the use of cuttings obtained from stems, leaves, roots or terminal buds, due to its practicability and simplicity.
Bougainvillea, because of its special characteristics, such as; high variation in type of foliage, production of many flowering inflorescence on one plant and continuous blooming of flowers with short production cycle has been very useful in the ornamental industry. They are widely cultivated as porch, adornments, arbour and ornaments. Their growth habits and beautiful showy bracts make them popular for landscapes. They are also used in mass planting, as shrubs or bushes, ground covers, as hedge plants, barrier plants and slope coverings, in hanging baskets, and in containers for Bonsai.
Though bougainvillea are primarily propagated by stem cutting and ground layering, the success of propagation by stem cutting is very limited; growers observed poor rooting percentage due to lack of competence
to form adventitious roots by cuttings which occurs routinely and is an obstacle for their vegetative propagation.
Adventitious root formation is a key step in vegetative propagation of woody or horticultural species, and problems associated with rooting of cuttings frequently result in significant economic losses, preventing growers from realizing the full potential of propagation. The key to overcoming this challenge is the application of exogenous auxin/rooting hormones.
The commercially available exogenous auxins that aids the formation of adventitious roots are; Indole- 3-acetic acid (IAA), Indole-3-butyric acid (IBA) and Naphthalene Acetic acid (NAA). IBA or NAA or combination of both is recommended for rooting of cuttings and are available in liquid, talc, tablet, and gel formulations. Other than this (IAA, IBA) naturally occurring auxins favours apical dominance, helps control xylem differentiation and help in cell division. NAA is a synthetic plant hormone in the auxin family and is an ingredient in many commercial plant rooting horticultural products; it is a rooting agent and used for the
vegetative propagation of plants from stem and leaf cuttings, it is also used for plant tissue culture.

Materials and Methods

The experiment was carried out under shade net in department of horticulture research field of Sam Higginbottom University of Agriculture, Technology and Sciences. The hardwood cuttings (20cm length, pencil thickness) of *B. buttiana cv.* mahara, were prepared in April, and long dip (12 hrs.) treatment with different concentrations of IAA (Indole-3-acetic acid), IBA (Indole-3 butyric acid), NAA (Naphthalene acetic acid) were applied. The stock solution of ppm was prepared by dissolving IAA, NAA or IBA 1mg/liter distilled water. IAA, IBA and NAA directly does not dissolve in distilled water so ethyl alcohol was used. The required concentrations were prepared by diluting the stock solution with distilled water. The pH was adjusted to 5.8-6.0 by using the 1N NaOH. The hard wood and semihardwood cuttings were treated with growth regulator with different concentrations as given below:

Details of Treatments

The cuttings were planted in poly bag with mixture of sand, soil, FYM (1:1:1) in month of April to June and kept in shade net conditions. The experiment was laid out in completely randomized design with three replications to determine the statistical significance of treatment effects. Results were considered significant at 5% level of significance.

T1: IAA 500ppm T2: IAA 1000ppm T3: IAA 1500ppm T4: IBA 500ppm T5: IBA 1000ppm T6: IBA 1500ppm T7: NAA 500ppm T8: NAA 1000ppm T9: NAA 1500ppm T10: Control (Without Hormones)

Results and Discussion

Effect on shoot characters

The results showed that a long dip (12hrs) treatment of IBA1500ppm for hardwood showed significantly better results than control and all the other treatments with respect to minimum Days to first Sprout (15.723), maximum no of vegetative buds sprouted /cutting (4.000), maximum sprouting percentage(60.000%), number of leaves /cutting(52.333), number of shoots/cutting((3.667), length of longest shoot/ cutting (42.270cm), plant height (45.603cm), maximum stem girth (1.227cm). In case of semi hardwood cutting the long dip (12hrs) treatment with IBA1500ppm cuttings was significantly better than control and all the other treatments with respect to minimum days to first sprout (17.167), maximum sprouting percentage (40.000%), maximum number of leaves /cutting (31.500), maximum length of longest shoot (31.030), maximum plant height (33.697), maximum Stem girth (cm**)** (0.827) whereas maximum vegetative buds sprouted (3.000) was obtained in cuttings treated with NAA(1500ppm), maximum number of shoots per cutting (3.000) was obtained in cuttings treated with IAA(1000ppm), IAA(1500ppm) and IBA(500ppm).
The earliest sprouting of cuttings treated with IBA (1500ppm) is attributed to better absorption of nutrient from root to shoot. Ibironke OA. (2013) [13] taking into consideration number of days to sprouting, plant height, stem girth, stem length, wet root weight, dry root weight, the number of leaves per cutting and length of longest roots reported that root initiation in cuttings of *Boungainvillea* could be enhanced with Indole -3-butyric acid (IBA) or dipped in coconut water for 5 minutes and growth was also enhanced using the hard wood cuttings.
The maximum number of sprouts per cutting with optimum IBA treatments might be attributed to better root growth which initiated absorption and translocation of nutrients from soil which take active part in various plant metabolic processes.Similar result also reported by Deshmukh *et al.* (2006) [6] where IBA at 6000ppm was found significantly superior for increasing sprouting percentage of *Bougainvillea buttiana* cv. Mahara.
The application of IBA which initiates root formation by increasing internal free IBA, or synergistically modifying action of IAA or endogenous synthesis of IAA could be a reason for high sprouting percentage. Alshammary *et al* (2013) [3] reported in *Bougainvillea peruviana* cv. Shubra and *Hamelia patens* that IBA (2000ppm) resulted in maximum establishment percentage (60.3% and 42.3%) respectively**.**
Increase in the new leaf production in cuttings might be assigned to an increased root number and root length in growth regulator treated cuttings that might have enabled cuttings to absorb more water and nutrients from rooting media, leading to better growth and production of new leaves. These results are in close agreement with the findings of Ingle and Venugopal (2009) [14] in *Stevia*. These observations in the present study are supported by the findings of Gandotra (1975) [7] who recorded higher number of leaves per cutting with the application of higher concentration of IBA (6000ppm) in Bougainvillea. Deshmukh *et al.* (2006) [6] reported that IBA at 6000ppm was found significantly superior for number of shoots of *Bougainvillea buttiana* cv. Mahara. Auxin enhanced cell division and cell enlargement

and promotion of protein synthesis which might have resulted in enhanced vegetative growth (Evans, 1973). Similar findings were observed by Nagraja *et al.* (1991) [18] in Jasmine.

Enhancement of vegetative growth by auxins may have contributed to overall increase in plant height. Awad *et al.* (1988) [4] reported that the branch length increases with the auxin concentration. These results are in conformity with the findings of Chovatia *et al.* (1995) [5] in cutting of Bougainvillea cv. "Mary Palmer'. Secondary growth is characterized by increase in girth of the plant which is attributed to auxinss promoting cell division in the lateral meristem.

Table 1: Comparative evaluation of hardwood and semi hardwood cutting for sprouting percentage, and plant growth characters with different rooting hormone in (*bougainvillea buttiana*) cv. Mahara

Treatments	Days to first sprout		Number of vegetative buds sprouted / cutting		Sprouting percentage		Number of leaves/ cutting	
	Hardwood cuttings	Semi hardwood cuttings	Hardwood cuttings	Semi hardwood	Hardwood cuttings	Semi hardwood Cuttings	Hardwood cuttings	Semi Hardwood cuttings
T1	25.833	29.500	2.500	2.500	33.333	33.333	37.500	23.000
T2	23.833	27.833	2.833	2.667	26.667	26.667	44.667	23.000
T3	23.167	26.167	3.000	2.333	26.667	26.667	46.167	22.167
T4	22.222	24.000	2.833	2.333	26.667	26.667	41.167	22.667
T5	18.833	19.333	3.500	2.333	53.333	33.333	50.890	20.667
T6	15.723	17.167	4.000	2.500	60.000	40.000	52.333	31.500
T7	27.833	38.000	2.833	0.333	26.667	6.667	50.500	3.333
T8	26.833	35.500	2.667	1.000	26.667	13.333	41.277	6.000
T9	17.833	18.167	3.500	3.000	46.667	26.667	46.000	31.333
T10	34.833	42.000	1.667	0.333	13.333	6.667	5.000	2.333
C.D.	2.585	2.005	1.140	1.015	18.789	18.789	14.270	11.053
SE(m)	0.870	0.675	0.384	0.342	6.325	6.325	4.804	3.720

Table 2: Comparative evaluation of hardwood and semi hardwood cutting for pant growth characters with different rooting hormone in (*bougainvillea buttiana*) cv. mahara.

Treatments	Number of shoots per cutting		Length of longest shoot per cutting		Plant height		Stem girth	
	Hardwood cuttings	Semi hardwood cuttings	Hardwood cuttings	Semi hardwood Cuttings	Hardwood cuttings	Semi hardwood cuttings	Hardwood cuttings	Semi hardwood cuttings
T1	2.833	2.667	29.515	21.319	32.515	24.319	1.117	0.717
T2	2.833	3.000	29.626	20.151	32.626	22.817	1.123	0.750
T3	2.833	3.000	27.940	27.982	30.940	30.982	1.180	0.813
T4	2.667	3.000	23.199	25.112	26.199	28.112	1.193	0.793
T5	3.333	2.667	40.352	22.394	43.352	25.394	1.170	0.770
T6	3.667	2.667	42.270	31.030	45.603	33.697	1.227	0.827
T7	2.833	0.333	35.992	12.243	38.992	15.243	1.163	0.763
T8	2.667	0.667	30.463	22.504	33.796	25.171	1.167	0.760
T9	2.833	2.500	41.063	21.700	44.397	24.700	1.147	0.747
T10	1.333	0.333	10.160	3.217	16.107	12.617	1.123	0.740
C.D.	0.952	0.939	11.822	5.799	11.152	5.266	0.046	0.046
SE(m)	0.321	0.316	3.979	1.952	3.754	1.773	0.015	0.016

Root Characters and Mortality Rate

The results showed that a long dip (12hrs) treatment of IBA1500ppm for hardwood as well as semihardwood cuttings showed significantly better results than control and all the other treatments with respect to number of roots/cutting (26.943), length of longest root/ cutting (19.267cm), minimum mortality rate (40.000%) in hardwood cuutings and maximum number of roots (22.833), longest root (17.500cm), minimum mortality rate (60.000%) in semihardwood cuttings respectively. IBA is the most effective on promoting root-initiation and adventitious root production in stem cuttings (Waisel, 1991) [29]**.** The first adventitious roots appear from callus and they are main roots for cuttings. Callus contains a high amount of auxins [Hartman *et al.* (2002); Ercisli *et al.* (2001)] [10]**.**

Rooting capacity for stem cuttings will be determined by the interaction of hereditary factors in stem cells and the following factors: auxin level, leaves and buds on the cuttings, the amount of carbohydrate reservoir in the cuttings, stage of plant growth, stem location and a type of the cutting tissue (Rosier *et al.*, 2006) [23]. Adventitious root formation is regulated by complex interactions between endogenous and exogenous factors which affect the various developmental stages of root formation.

Increased rooting response of IBA in cuttings may be attributed to induction of more vigorous cell division at the basal end of cutting and increases accumulation of sugars, which favours callus formation and subsequently rooting. This is in conformity with findings of Sundharai *et al*, (2002) [28]**.**

Beneficial effects of IBA 2000ppm to 6000ppm were also reported by Singh and Motilal (1979) [26] in Bougainvillea cv. Thimma, Awad *et al.* (1988) [4], Panwar *et al.* (1994) [20] and Chovatia *et al.* (1995) [5] for enhancing number of roots per cutting of Bougainvillea. These findings are also in agreement with the results recorded by Mishra and Sharma (1995) [16] in Bougainvillea and Nagaraja *et al.* (1991) [18] in *Jasminum.* Auxin application has been found to enhance the histological features like formation of callus and tissue and differentiation of vascular tissue (Mitra and Bose 1954) [17].

Gupta and Kher (1991) [9] also reported the maximum length of root in Bougainvillea cuttings with 4000ppm IBA. Panwar *et al.* (1994) [19] and Chovatia *et al.* (1995) [5] also found similar results with the application of 2000ppm IBA and 4000ppm IBA, respectively in Bougainvillea.

The present investigation was in confirmation with earlier findings. Mishra and Sharma (1995) [16] studied the effect of plant growth regulators on rooting of stem cuttings of *Bougainvillea* and concluded that higher concentration of IBA (2000 ppm) significantly increased the rooting performance in *Bougainvillea* cvs. Dr. R. R. Pal and Mrs. H. C. Buck, which were difficult to root and cv. Dr.R. R. Pal performed better than Mrs. H. C. Buck. Sahariya *et al* (2013) [24] studied the effect of IBA (0, 1000, 1500, 2000 ppm), on rooting of *Bougainvillea* var. Thimma and the treatment with IBA 2000 ppm resulted in the maximum number of rooted cuttings (6.33).

Table 3: Comparative evaluation of hardwood and semi hardwood cutting for rooting characters and mortality rate with different rooting hormone in (*bougainvillea buttiana*) cv. mahara.

Treatments	Number of roots /cutting		Length of longest root		Mortality rate	
	Hardwood cuttings	Semi hardwood cuttings	Hardwood cuttings	Semi hardwood cuttings	Hardwood cuttings	Semi hardwood cuttings
T1	20.333	16.833	11.933	13.000	66.667	66.667
T2	19.500	17.833	14.467	13.667	73.333	73.333
T3	19.167	18.833	13.567	14.200	73.333	73.333
T4	18.000	15.667	14.333	15.700	73.333	73.333
T5	22.083	20.667	15.967	15.767	46.667	66.667
T6	26.943	22.833	19.267	17.500	40.000	60.000
T7	19.833	5.333	17.610	15.277	73.333	93.333
T8	17.333	5.000	18.400	15.733	73.333	86.667
T9	26.333	21.333	16.867	16.700	53.333	73.333
T10	7.667	3.667	8.667	8.500	86.667	93.333
C.D.	4.241	7.804	0.904	1.161	18.789	18.789
SE(m)	1.428	2.627	0.304	0.391	6.325	6.325

Conclusion

The results showed that hardwood cuttings were found to give significantly better results than semihard wood cuttings treated with different rooting hormones (12hrs). A long dip(12hrs)treatment with IBA1500ppm for hardwood cuttings was significantly better results than control and all the other treatments in all the respective observations taken and in case of semihard wood cutting the long dip(12hrs)treatment with IBA1500ppm cuttings was significantly better than control and all the other treatments with respect to minimum days to first sprout, maximum sprouting percentage, maximum number of leaves /cutting, maximum length of longest shoot, maximum plant height, maximum Stem girth, maximum number of roots, longest root, minimum mortality rate whereas maximum vegetative buds sprouted was obtained in cuttings treated with NAA(1500ppm),maximum number of shoots per cutting was obtained in cuttings treated with IAA(1000ppm), IAA(1500ppm) and IBA(500ppm).

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