The Pharma Innovation Journal 2022; 11(12): 1363-1367

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(12): 1363-1367

www.thepharmajournal.com
Received: 24-10-2022
Accepted: 28-11-2022

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Effect of plant growth regulators and coconut water on survival percentage and economics of bougainvillea (*Bougainvillea spectabilis* L.) production

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Abstract
An experiment to assess two plant growth regulators IBA and NAA at three different concentrations 1000 ppm, 1500 ppm and 2000 ppm treated in combination with two concentrations of coconut water 50 ml and 100 ml and control (treated alone with coconut water) on semi hardwood cuttings of Bougainvillea (*Bougainvillea spectabilis* L) was conducted at College of Horticulture, Mojerla during 2017-18. The experiment was laid out in Factorial Completely Randomized Design with three replications. Cuttings were obtained from healthy, vigorous growing shrubs which were 15-20 cm long and 2-3 nodes. Leaves were removed from the cuttings and were treated with IBA and NAA in combination with coconut water, then planted in plastic bags filled with mixture of Red soil, sand and Compost with the ratio of 1:2:1. Data were collected on survival percentage and economics. The results showed that the treatment of cuttings with IBA 2000 ppm was significantly better than the control and all the other treatments with respect to survival percentage and economics (B:C ratio).

Keywords: Coconut water, plant growth, horticulture, bougainvillea

Introduction
Bougainvillea is a spectacular ornamental plant which is appraised for its attractive blossoms, evergreen and variegated showy foliage. It is thorny hardy ornamental vine, bush and tree. It is quick growing evergreen plant in rainfall area or deciduous in dry season and is of the genus of flowering plants native to South America. Bougainvillea is one of the members of Nyctaginaceae (Four-o'clock) family. It's wide adaptability and eclectic usage has made this plant very prominent all over the world (Fatma *et al*., 2007) [3]. Due to its ornamental importance (Gordon, 2002) [5], bougainvillea is considered to be excellent ornamental for utility and beauty. Because of its economic importance and good aesthetic value and its demand among the landscape architects and horticulturists as a garden plant insists huge production of bougainvillea plants with ease of propagation at cheaper cost is need of the hour. The low genetic and physiological capacity for root formation (Céline *et al*., 2006) [2], is limiting its commercial production, and making it as a difficult to root species. Hence, exploring the methods to increase the production is highly imperative owing to its economic importance.

Rooting hormone hastens root initiation, increases number and percentage of cutting rooted (Okunlola and Oyedokun, 2016) [10]. Exogenous application of auxins is the best-known growth stimulation in induction of rooting. Commercial use of auxins is popularized by synthetic forms like Indole butyric acid (IBA) and Naphthalene Acetic acid (NAA). The use of IBA and NAA playan important role in stimulation and initiation of roots in bougainvillea (Nathulal *et al*., 1972 and Maurya *et al*., 1974) [8].

Along with auxins, the natural compounds are also identified to stimulate rooting, which can be used alternatively as their prevalence and ease of availability is major advantage (Ibironke, 2017) [11]. Further, it was reported by Ognawa (2011) [9] that a natural product coconut water influenced root initiation in cuttings of *B. spectabilis* and showed significant effects on the rooting ability. Coconut water serves as a natural reservoir of nutrients to promote tissue growth. The nutritional composition of coconut water is rich in proteins, amino acids sugars, vitamins, minerals and growth hormones essential to promote tissue growth (George and Sherrington 1993) [4]. The use of coconut water as a growth-promoting component was traced to more than half a century, when Van Overbeek *et al*. (1942) [4] introduced it as a new component of the nutrient medium for callus cultures.

Asma *et al*. (2008) [1] used coconut water in *In vitro* propagation of kiwi fruit (*Actinidia deliciosa*) and found that coconut water indirectly effected *In vitro* roots induction.
The research on these aspects was meagre and will certainly benefit the nursery growers in production of quality planting materials at cheaper cost as success rate will be more.

Materials and Methods
The bougainvillea semi hard wood cuttings of thickness of 7.5 mm and 15 cm long were taken, the length is measured by scale and thickness by Vernier caliper. Plant growth regulators of 1000 ppm, 1500 ppm and 2000 ppm of IBA and NAA were prepared by dissolving calculated quantity of chemical in small quantity of ethyl alcohol and volume was made up to one litre. Further, coconut treatment was prepared by dissolving 50 ml and 100 ml of coconut water in 100 ml of water. Treatments were evaluated in a factorial completely randomized design (FCRD) with three replications, each replication consisted of ten cuttings. Semi-hardwood bougainvillea cuttings used in this study were taken in November from shoots originating from branches without flowers. (Hartman *et al*. 2002) [6].
Red soil+ sand +vermicompost in the ratio of 1:2:1 was used as a rooting media. Auxins are widely used for promoting rooting of hardwood cuttings (Hartman *et al*. 2002) [6], IBA and NAA along with coconut water were used as a rooting hormones. The formulations of auxins were prepared by dissolving the pure compound in 95% ethanol and adding distillated water. And then 50 ml and 100 ml of coconut water was added to the respective solutions so as to study the individual effect of coconut water at both concentrations, control treatment was maintained without combination of auxins. Cutting of 4-5 buds were prepared after discarding the non-hardened upper parts, in order to reduce the transpiration, the leaf area was reduced to 50-80 per cent. The basal end of cuttings was dipped briefly in a fungicide solution 0.1% of Captan prior to imposing rooting hormone treatments.

Treatments: 14
Factor 1
G1- IBA - 1000 ppm
G2- IBA - 1500 ppm
G3- IBA - 2000 ppm
G4- NAA -1000 ppm
G5- NAA -1500 ppm
G6- NAA -2000 ppm
G7- Control (Coconut water alone)

Factor 2
C1 – Fresh coconut water – 50 ml in 100ml of distilled water
C2 – Fresh coconut water –100 ml in 100 ml of distilled water

Treatment combinations
T1 – IBA 1000 ppm in combination with Coconut Water 50 ml (G1 + C1)
T2 – IBA 1500 ppm in combination with Coconut Water 50 ml (G2 + C1)
T3 - IBA 2000 ppm in combination with Coconut Water 50 ml (G3 + C1)
T4 - NAA 1000 ppm in combination with Coconut Water 50 ml (G4 + C1)
T5 - NAA 1500 ppm in combination with Coconut Water 50 ml (G5 + C1)
T6 - NAA 2000 ppm in combination with Coconut Water 50 ml (G6 + C1)
T7 – Control with only Coconut Water 50 ml (G7 + C1)
T8 - IBA 1000 ppm in combination with Coconut Water 100 ml (G1 + C2)
T9 - IBA 1500 ppm in combination with Coconut Water 100 ml (G2 + C2)
T10 - IBA 2000 ppm in combination with Coconut Water 100 ml (G3 + C2)
T11 – NAA 1000 ppm in combination with Coconut Water 100 ml (G4 + C2)
T12 - NAA 1500 ppm in combination with Coconut Water 100 ml (G5 +C2)
T13 - NAA 2000 ppm in combination with Coconut Water 100 ml (G6 +C2)
T14 - Control with only Coconut Water 100 ml (G7 + C2)

Details of observations recorded
Five randomly chosen cuttings in each replication of all treatments were labelled and used for recording the observations. The mean of these five cuttings were used for statistical analysis.

a. Survival percentage of the cuttings (percent success)
Per cent survival of cuttings was recorded in each treatment after four months by counting the total number of surviving plants out of number of treated cuttings.

b. Economics of cuttings production
1. **Cost of producing single cutting:** The cost of inputs used in the experiment were calculated, and selling price of single cutting was recorded for each individual treatment and expressed in rupees.
2. **Survival rooting percentage:** Per cent rooting of cuttings in each individual treatment was recorded and expressed in percentage.
3. **Price of each cutting:** The selling price of single cutting was taken based on the nursery men price in rupees.
4. **Gross Income for 100 cuttings:** The gross income for 100 cuttings was obtained by multiplying survival percentage and price of each cutting and expressed in rupees.
5. **Expenditure for producing 100 cuttings:** The expenditure for producing 100 cuttings was obtained by multiplying cost of producing single cutting into 100 and expressed in rupees.
6. **Net income for 100 cuttings:** Net income was calculated by subtracting expenditure for producing 100 cuttings from gross income and expressed in rupees.
7. **Benefit : Cost ratio:** Benefit : Cost ratio was worked out by using formula

$$\text{Benefit: Cost ratio} = \frac{\text{Net income for 100 cuttings}}{\text{Expenditure for producing 100 cuttings}}$$

Results and Discussion
1. Survival percentage of cuttings (Percent success)
The data pertaining to the survival percentage of cuttings treated with growth regulator and coconut water is presented in the Table 1. Treatments of plant growth regulators exhibited significant difference in survival percentage of cuttings. The maximum survival percentage was observed in

IBA 2000 ppm (93.71) followed by NAA 2000 ppm (89.81) and minimum was observed in control (68.86) treated with 50 ml coconut water alone. A significant difference was observed between the concentrations of coconut water. Higher survival percentage was observed in 100 ml (82.52) than 50 ml coconut water (80.60). The interaction of plant growth regulators and coconut water was found significantly different. Higher survival percentage (94.95) was noticed in IBA 2000 ppm with 100 ml coconut water which was significantly followed by NAA 2000 ppm with 100 ml coconut water (90.67) and least was observed in control treated with 50 ml coconut water alone (68.05) which was on par with 100 ml coconut water treated alone (69.68). The increased survival percentage might be due to the better root growth and shoot growth which was augmented due to absorption and translocation of nutrients by IBA and NAA. (Singh, 2012) [13] and a synergistic effect of enhanced transportation and availability of the nutrients by coconut water at higher concentrations. The results were in confirmation with the previous work of Shalini Kaushik (2017), who reported that the maximum survival percentages (88.33%) of rooted cutting with 300 ppm of IBA. Further, Khatun *et al*. (2018) [7] reported adding coconut water as an organic addition in pots increased survival rate in carnation.

2. Benefit: Cost Ratio

The benefit cost ratio differed due to the treatments of rooting hormones (auxins) and coconut water as indicated in Table 2. The highest benefit cost ratio was obtained in NAA 2000 ppm in combination with 100 ml treated cuttings which was followed by IBA 2000 ppm with 50 ml coconut water (2.52). Even though the percentage of survival was recorded highest (94.95) in IBA 2000 ppm with 100 ml coconut water compared to NAA 2000 ppm with 100 ml coconut water (90.67) the benefit cost ratio was more in NAA due to the less cost than IBA, but with regard to the quality of the cuttings in respect of rooting parameters and survival percentage, the treatment IBA 2000 ppm with 100 ml coconut water was found to be the best treatment. From the economic analysis, it can be concluded that coconut water alone recorded lowest B:C ratio (1.70 and 1.75) in both the concentrations of 50 ml and 100 ml. Hence, coconut water when used with IBA and NAA at higher concentrations showed synergistic effect in increasing survival percentage and B:C ratio.

Table 1: Effect of plant growth regulators and coconut water on survival percentage of the Bougainvillea cuttings.

Plant growth regulators (G)	Coconut water 50 ml (C1)	Coconut water 100 ml (C2)	Mean
G_1 IBA 1000 ppm	76.67	78.48	77.57
G_2 IBA 1500 ppm	84.58	87.04	85.81
G_3 IBA 2000 ppm	92.48	94.95	93.71
G_4 NAA 1000 ppm	72.38	73.98	73.18
G_5 NAA 1500 ppm	81.06	82.87	81.96
G_6 NAA 2000 ppm	88.96	90.67	89.81
G_7 Control (Coconut water)	68.05	69.68	68.86
Mean	80.60	82.52	

G=Plant growth regulators C = Coconut water

Table 2: Benefit: cost ratio

Treatments	Cost of producing single cutting (Rs) (a)	Survival percentage (%) (b)	Price of each rooted cutting (Rs) (c)	Gross Income for 100 cuttings (b) x (c) =(d)	Expenditure for producing 100 cuttings (a) x 100 = (e)	Net income for 100 cuttings (d) - (e) = (f)	B:C (f) / (e)
G_1C_1	3.115	76.67	12	920.04	311.50	608.54	1.95
G_2C_1	3.165	84.58	12	1014.96	316.50	698.46	2.20
G_3C_1	3.215	92.48	12	1109.76	321.50	788.26	2.45
G_4C_1	3.018	72.38	12	868.56	301.80	566.76	1.87
G_5C_1	3.027	81.06	12	972.72	302.70	670.02	2.21
G_6C_1	3.031	88.96	12	1067.52	303.10	764.42	2.52
G_7C_1	3.015	68.05	12	816.60	301.50	515.10	1.70
G_1C_2	3.130	78.48	12	941.76	313.00	628.76	2.00
G_2C_2	3.180	87.04	12	1044.48	318.00	726.48	2.28
G_3C_2	3.230	94.95	12	1139.40	323.00	816.40	2.52
G_4C_2	3.038	73.98	12	887.76	303.80	583.96	1.92
G_5C_2	3.042	82.87	12	994.44	304.20	690.24	2.26
G_6C_2	3.046	90.67	12	1088.04	304.60	783.44	2.57
G_7C_2	3.030	69.68	12	836.16	303.00	533.16	1.75

G_1 = IBA 1000 ppm; G_2= IBA 1500 ppm; G_3= IBA 2000 ppm; G_4= NAA 1000 ppm; G_5= NAA 1500 ppm; G_6= NAA 2000 ppm; G_7 = Control
C_1= Coconut water 50 ml; C_2= Coconut water 100 ml

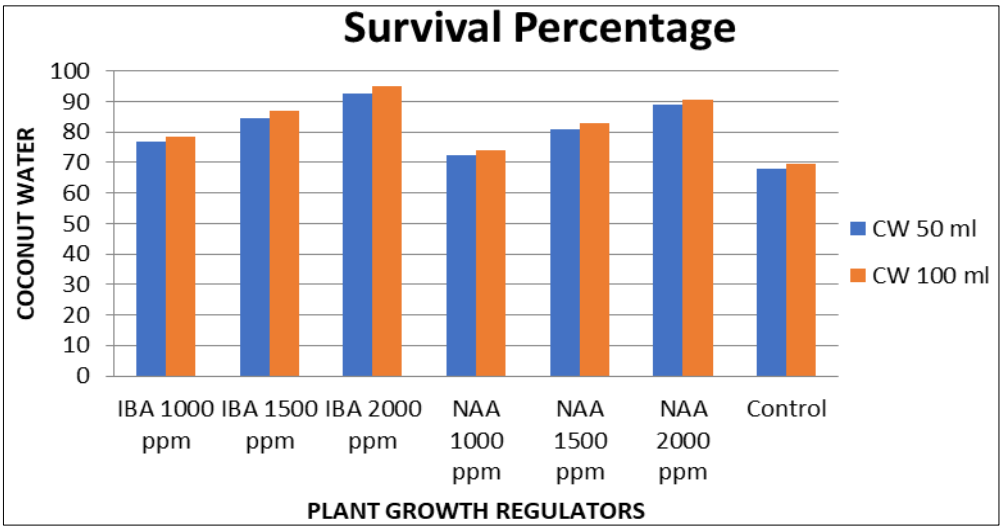
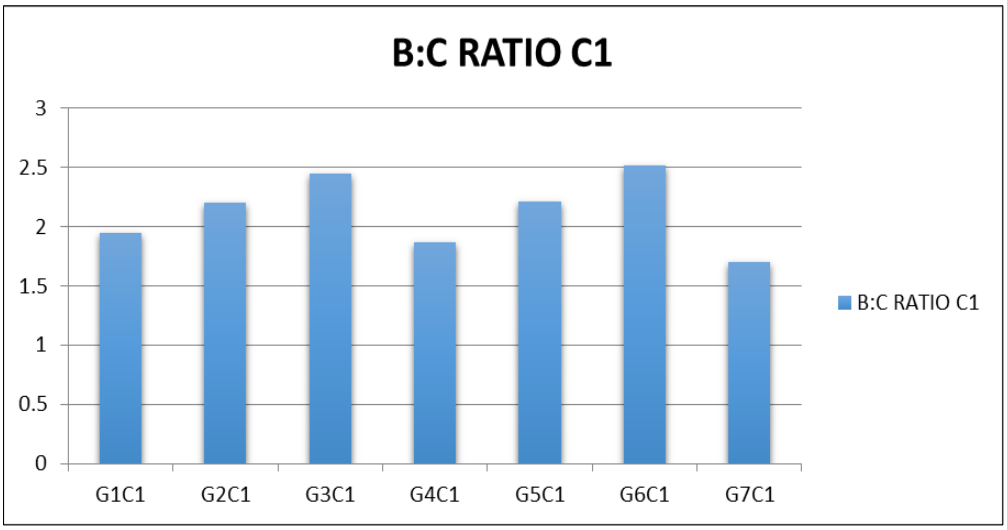
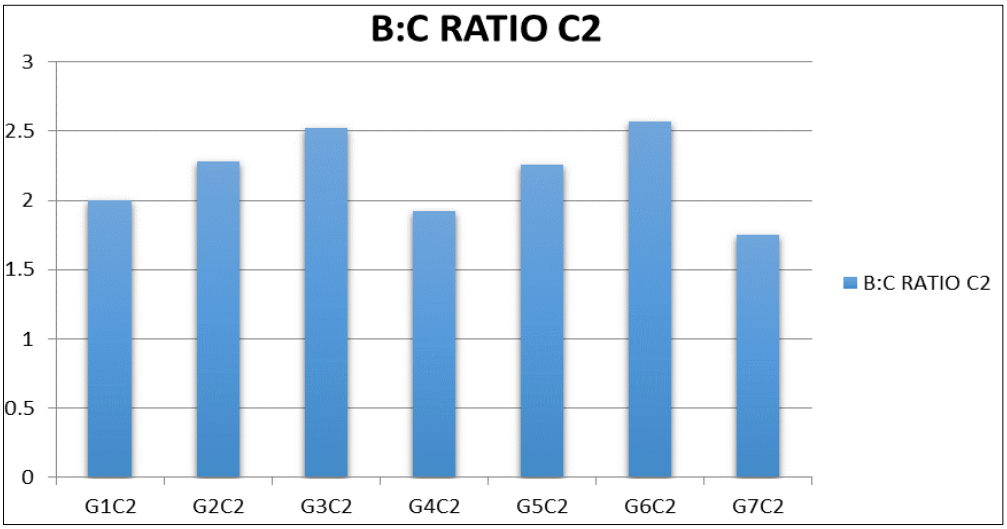


Fig 1: Effect of PGR and Coconut Water on Survival Percentage of Bougainvillea Stem Cuttings



G_1 = IBA 1000 ppm; G_2= IBA 1500 ppm; G_3= IBA 2000 ppm; G_4= NAA 1000 ppm; G_5= NAA 1500 ppm; G_6= NAA 2000 ppm; G_7 = Control
C_1= Coconut water 50 ml

Fig 2: Benefit cost ratio of plant growth regulators with 50 ml coconut water



G_1 = IBA 1000 ppm; G_2= IBA 1500 ppm; G_3= IBA 2000 ppm; G_4= NAA 1000 ppm; G_5= NAA 1500 ppm; G_6= NAA 2000 ppm; G_7 = Control
C_2= Coconut water 100 ml

Fig 3: Benefit cost ratio of plant growth regulators with 100 ml coconut water

Conclusion

Based on the results obtained from the investigation, the following conclusion can be made:

The study suggested that semi hard wood cuttings of B. spectabilis when dipped for two hours in IBA 2000 ppm in combination with 100 ml of coconut water is the best treatment for maximum survival percentage (94.95%) with B:C ratio 2.52. However, based on benefit cost ratio (2.57) NAA 2000 ppm with coconut water 100 ml is best as the cost of NAA is less than IBA on economic point of view. The coconut water when used in combination with growth regulator worked well and gave economic results in propagating bougainvillea, which showed synergistic effect both with IBA and NAA at higher concentrations.

Based on the experience gained and results obtained, following suggestions are made for future line of work Experiment should be repeated using different dipping durations with same or further higher concentrations of plant growth regulators.

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