# Effect of Different Growth Regulators on the Rooting of Hardwood Cuttings of *Bougainvillea glabra* var. “Mohan”


## Abstract

An experiment about the effect of different growth regulators on the rooting of hardwood cuttings of *Bougainvilleaglabra* var. 'Mohan'" ~~titled "Effect of Different Growth Regulators on the Rooting of Hardwood Cuttings of Bougainvillea var. 'Mohan'"~~ was conducted during the year 2020-21 at the Faculty of Horticulture, Bidhan Chandra Krishi Vidyalaya, Mohanpur, Nadia, West Bengal, India. The study employed a completely randomized design with ten treatments, each replicated three times. The findings of this investigation revealed that among the various concentrations of IAA, IBA, and NAA, hardwood cuttings treated with IAA at 1500 ppm exhibited the earliest bud initiation (7 days). The best result for the first root initiation (7 days) was observed with IAA at 1000 ppm. IBA at 1500 ppm resulted in the highest number of leaves per cutting (25), while IBA at 1000 ppm produced the highest number of buds per cutting (4). Furthermore, the highest number of roots (9.2) and the greatest average root length (8.7 cm) were achieved with IBA at 1500 ppm.…….


## Introduction

*Bougainvillea* belongs to the dicot family Nyctaginaceae and is native to tropical and subtropical South America, making it well-adapted to similar climatic conditions. There are about 10 species of Bougainvillea, but only three are horticulturally important: B. spectabilis, B. peruviana, and B. glabra…... This plant can tolerate both semi-shaded areas and full sun, though it thrives best in full sunlight. A minimum of 5 hours of direct sunlight per day is required for good blooming, and more hours of sunlight are even better. Bougainvillea does not require a lot of water and is prized by gardeners for its wide range of habitats, prolonged flowering seasons, and variety of flower colours. It also has numerous uses in landscaping. (Bhardwaj *et al.*, 2020).

Bougainvillea blooms in the winter, starting in October when the weather becomes cool and pleasant, with a second flush of flowers in the summer. However, some varieties, like Snow Queen and Snow-White, only bloom once during the winter. The plant can be used as a shrub or climber and can be trained to grow in pergolas. It can grow over 30 feet high, with large, simple, mostly ovate leaves that may have rippling edges and hairs underneath. The flowers are usually surrounded by three brightly coloured bracts, while the actual flowers are small, tubular, and often inconspicuous, located in the centre of the bracts. Bract colours include white, light mauve, magenta, pink, deep mauve, orange, yellow, and red. Bougainvillea has a fragile root system that does not form a good root ball and has many adaptations to its climate and environment. (Bhardwaj *et al.*, 2020)

Betacyanin’s and flavanols are extracted from the bracts of *Bougainvillea glabra* (Heuer et al., 1994), and pinitol, an anti-diabetic compound, has been isolated from the leaves of *Bougainvillea spectabilis* (Narayanan *et al.*,1987). Bougainvillea is a valuable ornamental plant with culinary uses and is also utilized in traditional medicine for treating common ailments. It is traditionally used against several diseases, including diarrhoea, hypotension, intestinal disorders, stomach-ache, nausea, inflammation-related ailments, and pain



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**Comment [p5]:** This is the first mention of these abbreviations here, so the full name should be mentioned.

**Comment [p6]:** It is preferable to use the unit mg/L, which is equivalent to the unit parts per million(ppm). Expression in ppm is considered a somewhat old unit.

**Comment [p7]:** There are clear differences between the recorded characteristics for each treatment and each concentration. What recommendation do the authors consider useful for the farmer who wants to produce this plant (*Bougainvilleaglabra* var. 'Mohan') early? This recommendation can be written here in the A … [1]

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**Comment [p14]:** abbreviate the genus name (B. glabra)

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management (Saleem *et al.*,~~2020~~2021). The leaves have anti-inflammatory potential (Giri *et al.*,1988), and traditional practitioners in Mandsaur, India, use the leaves to treat various gastrointestinal disorders like diarrhoea and acidity. Additionally, the anti-diarrheal activity of *Bougainvillea glabra* is related to its antimicrobial properties.

……..

Adventitious root formation is a crucial step in the vegetative propagation of woody or horticultural species, and problems associated with rooting cuttings can result in significant economic losses. The application of exogenous auxin/rooting hormones can help overcome these challenges. Commercially available exogenous auxins that aid in the formation of adventitious roots include Indole-3-acetic acid (IAA), Indole-3-butyric acid (IBA), and Naphthalene ~~Acetic~~ acetic acid (NAA). Naturally occurring auxins like IAA and IBA favor apical dominance, help control xylem differentiation, and aid in cell division. NAA is a synthetic plant hormone in the auxin family and is an ingredient in many commercial plant rooting products. It is used as a rooting agent for the vegetative propagation of plants from stem and leaf cuttings and in plant tissue culture (Memon *et al.*, 2013). ……..

**Materials and methods**

The experiment was conducted at a site in Jalpaiguri, West Bengal, India, using hardwood cuttings of *B. glabra* var. "Mohan"collected from the premises of the Faculty of Horticulture, Bidhan Chandra Krishi Vidyalaya, Mohanpur, Nadia, West Bengal, India. The hardwood cuttings, each 15 cm in length and with the thickness of a pencil, were prepared in January. A quick dip treatment (10 seconds) at the basal portion with different concentrations of IAA, IBA (Indole-3-butyric acid), and NAA (Naphthalene acetic acid) was applied. The stock solutions were prepared by dissolving 1 mg/~~liter~~ l of NAA or IBA in distilled water, using ethyl alcohol to aid dissolution.

The experiment followed a Randomized Block Design (RBD) with three replications and ten treatments as follows:

- T1: IAA 500 ppm
- T2: IAA 1000 ppm
- T3: IAA 1500 ppm
- T4: IBA 500 ppm
- T5: IBA 1000 ppm
- T6: IBA 1500 ppm
- T7: NAA 500 ppm
- T8: NAA 1000 ppm
- T9: NAA 1500 ppm
- T10: Control (No chemical)

A total of 210 hardwood cuttings of *Bougainvillea* var. "Mohan," each 20 cm long and of pencil thickness, were prepared. The beds were drenched with fungicide before planting the cuttings, and black polythene was used below the bed for bottom heating to encourage faster rooting. IAA solutions of 500 ppm, 1000 ppm, and 1500 ppm were prepared by dissolving 0.5 g/l, 1 g/l, and 1.5 g/l, respectively, in distilled water. IBA and NAA solutions were prepared in the same manner~~. The cuttings were treated with the growth regulators at the basal portion and then planted in the beds following the Randomized Block Design~~.

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Please see this recent work:
*Horticulturae* **2022**, *8*(12), 1156; https://doi.org/10.3390/horticulturae8121156

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**Comment [p22]:** IAA and IBA are also used commercially in the field and in tissue culture, and this should also be noted.

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Hormone concentrations are better stated later, please delete this from here.

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The observations recorded included:

- Days taken for first bud initiation in cuttings
- Days taken for first rooting of cuttings
- Number of leaves per cutting
- Number of buds per cutting
- Number of roots per cutting
- Length of roots in cuttings

Final data for the parameters (number of leaves, number of buds per cutting, number of roots per cutting, and length of roots) were recorded after 8 weeks. Data were also collected in the 1st, 3rd, 4th, 6th, and 8th weeks after planting the cuttings.

Statistical analysis

## 4.RESULTS AND DISCUSSIONS

The experiment concluded that treatment $T_3$ (IAA 1500 ppm) showed the earliest bud initiation, taking the fewest days (7) for the first bud to appear. Treatments $T_9$ (NAA 1500 ppm) and $T_7$ (NAA 500 ppm) produced similar results, with the first buds appearing in 8 and 9 days, respectively. In contrast, the control treatment $T_{10}$, which did not use any hormones, resulted in late bud initiation (15 days). This suggests that the exogenous application of auxin helps break down starch into simple sugars, which are essential for new cell production and increased respiratory activity during the regeneration of tissue at the time of new primordial initiation. These results are consistent with the findings of Kumar *et al.* (2014) in cCarnation.

For the days taken for first rooting of cuttings, treatment $T_2$ (IAA 1000 ppm) gave the best results, with root initiation starting very quickly (7 days). However, this treatment did not produce a large number of roots later on. Treatments $T_4$ (IBA 500 ppm), $T_6$ (IBA 1500 ppm), $T_3$ (IAA 1500 ppm), and $T_5$ (IBA 1000 ppm) also performed well, with root initiation occurring in 8 to 9 days. This indicates that the appropriate concentration of plant growth regulators can enhance cell division, cell elongation, and early differentiation of callus tissue toward root formation, resulting in early growth in cuttings. These findings align with the observations of Netam *et al.* (2018) and Bhardwaj and Kumar (2020) in Bougainvillea.

The highest number of leaves was observed in treatment $T_6$ (IBA 1500 ppm) with 25 leaves. Treatments $T_5$ (IBA 1000 ppm) and $T_4$ (IBA 500 ppm) also performed well, with 22 and 19 leaves, respectively. However, treatments $T_1$ (IAA 500 ppm) and $T_7$ (NAA 500 ppm) produced fewer leaves (13 and 12, respectively), and the control treatment $T_{10}$ had the fewest leaves (10). The highest number of buds per cutting was found in treatment $T_5$ (IBA 1000 ppm) with 4 buds, followed closely by $T_4$ (IBA 500 ppm) and $T_6$ (IBA 1500 ppm). The control treatment performed poorly in this regard. This can be attributed to IBA's ability to produce healthier and longer roots, which absorb more nutrients and water, resulting in more leaves. Additionally, the vigorous growth and early root initiation induced by growth regulators allow for better nutrient absorption and increased leaf production. These results are consistent with the findings of Sahariya*et al.* (2013) and Kale and Bhujbal (1972) in Bougainvillea.

Treatment $T_6$ (IBA 1500 ppm) also produced the highest number of roots and had the best average root length. Treatments $T_4$ (IBA 500 ppm) and $T_5$ (IBA 1000 ppm) also performed

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well. In contrast, the control treatment had poor rooting results. This suggests that IBA increases cell wall plasticity, cell division, callus development, and root growth. Cuttings treated with the appropriate concentration of auxin showed early and better root initiation, leading to a higher number of roots per cutting. Increased root length in IBA-treated cuttings may be due to enhanced carbohydrate hydrolysis, new protein synthesis, cell enlargement, and cell division induced by auxins. Auxins also initiate the synthesis of structural enzyme proteins involved in adventitious root formation, increasing root length through acidification. These results align with the findings of Singh *et al.* (2017) in Bougainvillea and Bhatt and Chauhan (2012) in ~~Marigold~~marigold

.....

**Conclusion**

The experiment aimed to study the effect of growth regulators on the sprouting and rooting of *Bougainvillea* hardwood cuttings, and the findings were significant. It was observed that IAA at 1500 ppm resulted in the earliest bud initiation, while NAA at both 1500 ppm and 500 ppm produced similar results for bud initiation. For root initiation, IAA at 1000 ppm gave the best results. The highest number of leaves were seen in cuttings treated with IBA at 1500 ppm, and the most buds per cutting were observed with IBA at 1000 ppm. In terms of root development, the number of roots and the average root length were highest in cuttings treated with IBA at 1500 ppm. These results indicate that IBA at a higher concentration (1500 ppm) yielded the best overall outcomes for rooting *Bougainvillea* hardwood cuttings var. "Mohan," demonstrating a significant positive impact on both shoot and root growth.

**Table 1. Outcome of the different treatments**

| Treatment | Days taken to first bud | Days taken to first rooting of cutting | Number of leaves per cuttings~~:~~ | Number of buds per cuttings |
|---|---|---|---|---|
| **$T_1$** | 12 | 8 | 13 | 3 |
| **$T_2$** | 13 | 7 | 18 | 2.7 |
| **$T_3$** | 7 | 9 | 15 | 2.5 |
| **$T_4$** | 10 | 8 | 19 | 3.3 |
| **$T_5$** | 11 | 9 | 22 | 4 |
| **$T_6$** | 11 | 8 | 25 | 3.3 |
| **$T_7$** | 9 | 11 | 12 | 3 |
| **$T_8$** | 12 | 13 | 14 | 3.2 |
| **$T_9$** | 8 | 12 | 17 | 3 |
| **$T_{10}$** | 15 | 15 | 10 | 2 |
| SEm | 0.80 | 0.87 | 1.55 | 0.18 |
| CD ~~@~~ at 5% | 2.31 | 2.60 | 4.48 | 0.51 |



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**Comment [p36]:** The authors used 3 types of auxins and there are significant differences in the rooting response of the cuttings for these types. What is the reason for the superiority of auxin IBA over the other types in most variables (according to the authors' conclusion)?
It is known that auxin IAA is naturally present and therefore there is an internal enzyme that breaks it down and reduces its activity, what about auxin NAA which is synthetic? This should be explained with relevant references.

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**Table 2. Average root length in each treatment**

| Treatment | Number of roots per cuttings | Avg. root length (cm) |
|---|---|---|
| $T_1$ | 7 | 3.5 |
| $T_2$ | 8.2 | 5.2 |
| $T_3$ | 8.9 | 3 |
| $T_4$ | 9 | 5 |
| $T_5$ | 10 | 8.5 |
| $T_6$ | 15 | 8.7 |
| $T_7$ | 8.6 | 3 |
| $T_8$ | 9.2 | 3.5 |
| $T_9$ | 8 | 4 |
| $T_{10}$ | 5 | 3.2 |
| SEm | 0.85 | 0.72 |
| CD @ 5% | 2.46 | 2.09 |

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## REFERENCES

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