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Modulation of Adventitious Root Formation in *Boswellia serrata* Stem Cuttings to Exogenous Application of different Root Promoting Hormones

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***Abstract*:** *Boswellia serrata* Roxb., commonly known as Salai in India and Indian frankincense globally, is widely distributed across 17 of the 28 Indian states. Despite its extensive range, the species is not having good status in India and at the same time it is Critically Endangered in Sri Lanka, primarily due to overexploitation and habitat loss. Given the species' current status, natural regeneration in the wild remains poor. Study was conducted to evaluate the rooting response of *B. serrata* cuttings treated with indole-3-butyric acid (IBA) and α-naphthalene acetic acid (NAA). In vegetative propagation trials, IBA at 5000 ppm produced 21.67% callusing and 11.67% rooting success, followed by IBA at 4000 ppm, with 18.33% callusing and 10.00% rooting. The highest sprouting rate (28.33%), number of roots (4.33), total mean root length (220.04 cm), and mean dry weight of roots (115.00 mg) were observed at IBA 4000 ppm. In contrast, NAA treatments showed peak rooting success (3.33%) at both 4000 and 5000 ppm, with lower concentrations (2000-3000 ppm) resulting in reduced rooting (1.67%). Control cuttings failed to produce any roots. This study highlights the efficacy of IBA, particularly at 4000 to 5000 ppm, in promoting effective vegetative propagation of *Boswellia serrata*, offering a promising approach to aid the conservation and sustainable management of this valuable species.

***Keywords*:** Overexploitation, Natural regeneration, Callusing, Sprouting, Rooting

Boswellia serrata Roxb., belongs to the family Burseraceae, commonly called Salai, is a species predominantly found in the dry deciduous forests of India. It is widely distributed across 17 of the 28 Indian states. The genus includes around 23 recognized species (Anonymous 2025). Globally, it is known as Indian Frankincense. The main non timber forest products obtained from this species is turpentine and resin. India is the world's sole exporter of Indian frankincense, having exported 74.56 metric tonnes in 2016-17 (Brendler et al., 2018). It is a medium-sized tree that can grow up to 15 meters tall (Brendler et al., 2018, Thulin 2020). It has imparipinnate compound leaves that fall in December. The tree remains leafless during its flowering and fruiting phase, which usually occurs from February to March. Bark is thin, papery, and yellowish, which eventually peels away to reveal green stems underneath.

Salai is known to be self-incompatible, a trait reflected in its low fruit set, with an average flower-to-fruit ratio of 18.5:1 (Sunnichan et al., 2005). Although the seeds are produced in large quantities ranging from 13,400 to 25,000 seeds per kilogram, however regeneration through seeds is surprisingly poor (Sharma et al., 2021), raising questions about seed viability under natural pollination conditions (Joshi et al., 1981). Besides seed propagation, the tree can also regenerate vegetatively through stem cuttings and root suckers (Thakur et al., 2021). Past research and experiences in this species advocated the planting of large cuttings (100-120 cm) resulted in significant effect on its rooting (Joshi 1981). Due to ecological and economic value of this tree and considering its poor natural regeneration status in India and critical endangerment in Sri Lanka (Anonymous 2012, Thulin 2020) vegetative propagation presents a promising conservation strategy to improve its chances of survival and ensure sustainable use. Therefore, this study is an attempt to find out the effect of different root promoting hormones on stem cuttings of *B. serrata.*

MATERIAL AND METHODS

The study was performed in the nursery unit of College of Forestry BUAT Banda in of July 2024 during the monsoon.

Field preparation: For the experiment nursery bed of size 10 m x 1.2 m was prepared**.** Soil was made light and pulverized by mixing adequate quantity of sand for easy rooting of the cuttings having sand and soil in ratio of 2:1.

Preparation of stem cutting: Stem cuttings of the Salai were taken from trees with dbh 30-40cm in Bahadurpura Forest Block of Banda Forest Division (Latitude: 25.03298, Longitude: 80.53363° and altitudinal range: 200m -300m) which falls within the Bundelkhand region of arid ecosystem. Size of the cuttings was in range of 20-25cm. Cutting was given a slanting cut to increase the surface area for the better absorption of the rooting hormone. Prepared cuttings were treated with 0.25% mancozeb for one hour. Each replication having 20 cuttings were eventually planted out. These cuttings

were kept in bed for 60 days and regular monitoring was done in this period. The experiment was treated weekly with mancozeb fungicide (0.25%) and chlorpyrifos insecticide (0.2%) to prevent fungal and termite infestation. The experiment comprises of 11 treatments, each replicated (20 cuttings/replication) thrice in completely randomized block design.

Treatment of cuttings: For the treatment, five concentrations of IBA and NAA (1000, 200, 3000, 4000 and 5000ppm) were prepared in solid form by mixing them in talcum powder. Slurry of the auxins was prepared for the even distribution of the hormone.

Observations recorded: Observation of the cuttings was recorded after 60 days of planting. Each cutting was uprooted and then the data was recorded. Root analyzer (WinRhizo STD4800) was used for more accurate results of number of roots and root length.

Statistical analysis: The statistical analysis of recorded data was done using SPSS version 15.0.

RESULTS AND DISCUSSION

There was no significant differences in sprouting percentages (Table 1), IBA treatments consistently outperformed NAA across all concentrations. The highest sprouting percentage was with IBA at 4000 ppm (28.33%), followed by 26.67% at 5000 ppm (In an experiment Anuradha et al.(2024) reported minimum 17.77% to maximum of 40.00% sprouting in Bougainvillea by using different treatment of IBA and NAA). In comparison, NAA showed 20% sprouting at 5000 ppm. Vaishnav and Janghel (2018) reported no growth or differentiation in 25 cm-long Salai cuttings even after 50 days of planting, though a few smaller cuttings sprouted after 65 days. Nale et al. (2024) observed maximum sprouting in *Ficus carica* with IBA at 2500 ppm. Sure et al. (2018) used IBA in *Commiphora wightii* and achieved 85% sprouting and 76.67% rooting at just 500 ppm. IBA 5000 ppm treatment induced significantly higher callusing (21.67%) compared to all other concentrations. In contrast, NAA at 1000 ppm resulted in minimal callusing, merely 1.67%.

IBA at 5000 ppm yielded the most effective rooting (11.67%) in Salai stem cuttings, followed by 10.00% rooting at 4000 ppm and thereafter decreased progressively with lower IBA concentrations. Among the NAA treatments, the highest rooting percentage of 5.00% was at 5000 ppm while 3.33% at 3000ppmn s. Moreover, the sprouting percent had a strong correlation (0.95) with the root number (Table 2). The control cuttings failed to produce any roots. These findings resonate with Patel et al. (2003), reported IBA at 4000 ppm as the most effective concentration for rooting fig cuttings, achieving 65% rooting. Kaur et al. (2022) found that higher concentration IBA 6000 ppm (35.72%) improved the rooting percentage in *Tecomella undulata*.

The highest average number of roots (4.33) occurred in cuttings treated with IBA at 4000 ppm (Table 1). The cuttings treated with NAA at 5000 ppm averaged 1.33 roots, while the lowest number (0.33 roots) was at NAA 1000 ppm. No rooting was observed in control cuttings. Similarly, Patel et al. (2003) reported an average of 8.8 roots per cutting in fig treated with IBA 4000 ppm, and Behera et al. (2018) observed 8.16 roots in *Boswellia serrata* cuttings treated with IBA at 1000 ppm. The callusing percent has a significant impact on the root number (Table 2).

The IBA at 4000 ppm resulted in the greatest mean root

Table 1. Effect of NAA and IBA of rooting behavior of Salai stem cuttings

Treatment	Sprouting (%)	Callusing (%)	Rooting (%)	No. of roots	Total root length (cm)	Root dry weight (mg)
NAA 1000 ppm	13.33	1.67	1.67	0.33	43.59	10.33
NAA 2000 ppm	15.00	5.00	1.67	1.00	39.10	14.00
NAA 3000 ppm	18.33	3.33	3.33	0.67	103.52	36.67
NAA 4000 ppm	16.67	5.00	3.33	1.00	116.13	47.33
NAA 5000 ppm	20.00	6.67	5.00	1.33	151.26	68.67
IBA 1000 ppm	21.67	11.67	3.33	2.33	66.42	25.67
IBA 2000 ppm	20.00	13.33	6.67	2.67	151.70	87.33
IBA 3000 ppm	25.00	15.00	8.33	3.00	143.78	57.33
IBA 4000 ppm	28.33	18.33	10.00	4.33	220.04	115.00
IBA 5000 ppm	26.67	21.67	11.67	3.67	188.55	114.67
Control	11.67	5.00	0.00	0.00	0.00	0.00
CD (p=0.05)	NS	6.47	4.92	2.16	106.14	54.38

Table 2. Correlation studies on various vegetative parameters indicating rooting behaviour of salai stem cuttings

Variables	Sprouting (%)	Callusing (%)	Rooting (%)	Root numbers	Root length	Root dry weight
Sprouting (%)	1.00					
Callusing (%)	0.90	1.00				
Rooting (%)	0.94	0.92	1.00			
Root numbers	0.95	0.96	0.93	1.00		
Root length	0.88	0.75	0.92	0.83	1.00	
Root dry weight	0.86	0.83	0.94	0.86	0.97	1.00

**Correlation is significant at the 0.01 level

length (220.04 cm), significantly outstripping other treatments (Table 1) followed by 188.55 cm in cuttings treated with IBA at 5000 ppm., Behera et al. (2018) recorded root lengths of 21.93 cm in *Commiphora wightii* cuttings, and Bhardwaj et al. (2025) reported an average root length of 25.28 cm in *Punica granatum* treated with IBA at 2500 ppm. IBA 500 ppm, showed highest sprouting percentage (85.00%), rooting percentage (76.67%) and average roots (7.36), root length (13.87 cm) was observed in semi hardwood cuttings of *Commiphora wightii* (Sure et al., 2018). The study demonstrate that cuttings treated with IBA produced the highest mean dry root weights, with the maximum value of 115.00 mg observed at 4000 ppm, followed by 114.67 mg at 5000 ppm. Nale et al. (2024) also found the maximum root dry weight of 4.75 g in *Ficus carica* cuttings treated with IBA at 2500 ppm. All pairs of vegetative parameters exhibit a strong positive correlation, with all values exceeding 0.75 (Table 2).

CONCLUSION

Challenging the long-held belief that only large cuttings of *Boswellia serrata* can regenerate, this study proves that small cuttings are also viable when treated with a high concentration of IBA. This finding offers a promising new approach to bolstering the species' regeneration, which is crucial for a sustainable oleo-resin supply for the pharmaceutical industry. However further research is needed to enhance efficacy.

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