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Comparative analysis of survival and rooting in hardwood cuttings of varying lengths of *Bougainvillea glabra*

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Abstract
An experiment was conducted to study the influence of varying length of hardwood cuttings of Bougainvillea on its survival and various rooting parameters in the experimental site of Hi-tech Unit, College of Horticulture, Dapoli under the aegis of Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli during December 2024 to April 2025. This study aimed to standardize the length of hardwood cutting of Bougainvillea suitable for the Konkan environmental conditions, addressing the challenges faced by nurserymen and landscapers in establishing Bougainvillea cuttings, as quality planting material is prerequisite for achieving success. The experiment was laid out in a Factorial Randomized Block Design comprising two replications and sixteen treatment combinations consisting of eight different bougainvillea varieties and two length of hardwood cuttings viz., 10 cm (L_1) and 15 cm (L_2). Among the two different levels of length of hardwood cuttings under study, parameters like minimum days required for initiation of sprouting (13.85 days), maximum sprouting percentage (76.88%) and survival percentage were observed in hardwood cuttings of length 15 cm. Besides, maximum number of roots per cutting (27.08 roots), length of longest root (11.40 cm), fresh and dry weight of roots (11.70 g and 2.19 g, respectively) and shoot: root (1.29) were also recorded in 15 cm long hardwood cuttings. Therefore, the study recommends the use of hardwood cuttings of length 15 cm as the most effective option for enhancing the survival and rooting of Bougainvillea, making it a viable choice for commercial cultivation in the Konkan region of Maharashtra.

Keywords: Bougainvillea, length of cutting, hardwood, rooting, survival, propagation, Konkan

Introduction
Hardwood cuttings serve as a primary technique for the asexual propagation of various ornamental shrubs, including *Bougainvillea glabra*. This method facilitates the rapid clonal reproduction of preferred genotypes, which is essential for commercial horticulture. However, the success of this propagation technique is influenced by several factors, such as the physiological condition of the parent plant, the timing of cutting collection and the characteristics of the cuttings themselves. Among these characteristics, cutting length is believed to be particularly significant, as longer cuttings may provide a larger reserve of carbohydrates and auxins necessary for root initiation and sustaining the cutting until it develops a self-sufficient root system. On the other hand, increased length may also lead to greater water loss through transpiration, especially if leaves are present, or necessitate more material per plant. This study conducts a comparative analysis of survival and rooting success in hardwood cuttings of *B. glabra* at different lengths. By examining the impact of cutting length on survival rates, rooting percentages and root system quality such as average root number and length, this research seeks to refine the propagation protocol for this commercially valuable species. The results will offer horticulturists evidence-based guidance on optimal cutting lengths, enhancing propagation efficiency and minimizing material waste in nursery practices.

Materials and Methods
The present experiment was carried out at the Hi-tech unit of the College of Horticulture, Dapoli, Dist. Ratnagiri, India. The experiment employed a Factorial Randomized Block Design (FRBD) with two replications, focusing on two cutting lengths: L_1 (10 cm) and L_2

(15 cm), alongside eight varieties of bougainvillea. The cuttings utilized in this study were sourced from the College of Horticulture, Dapoli. and were treated with an IBA solution (1000 ppm) for 60 seconds prior to being planted in polybags. To facilitate observation, five cuttings from each plot were randomly selected and labeled as sample cuttings. Throughout the study, various parameters were monitored, including the days required for initiation of sprouting, sprouting percentage, survival percentage, number of roots per cutting, length of longest root, fresh and dry weight of roots and shoot: root. The collected data were analyzed statistically using the methods outlined by Panse and Sukhatme (1995) [3].

Results and Discussion

Days required for initiation of sprouting

The variation among the different length of cuttings showed significant difference and minimum days for initiation of sprouting (13.85 days) was seen in longer length hardwood cuttings i.e. 15cm (L_2) whereas, the shorter length hardwood cuttings i.e. 10cm (L_1) took maximum days for sprout initiation (15.83 days). Hardwood cuttings typically show a higher success rate and faster root initiation, evidenced by quicker sprout emergence. The length of a bougainvillea hardwood cutting significantly influences sprouting due to the availability of stored resources and hormone distribution. Longer cuttings generally have more carbohydrates and auxins, essential for root and shoot development. These reserves allow the cutting to sustain itself longer and provide energy for growth, leading to earlier sprout initiation compared to shorter cuttings. Quick sprout initiation indicates effective mobilization of internal resources, crucial for long-term survival. Additionally, maintaining high humidity is vital to prevent wilting and support a robust root system, especially in the favorable conditions of the Konkan region. Bhardwaj *et al.* (2020) [1] in bougainvillea, Savant *et al.* (2021) [6] and Raibole *et al.* (2023) [5] in Indian plumeria and Prasanna *et al.* (2024) [4] in jasmine observed similar variations regarding the days required for sprout initiation.

Percentage of sprouting and survival

Significant variation was observed among the different length of cuttings for percentage of sprouting and survival. In particular, the 15 cm hardwood cuttings (L_2) achieved the highest sprouting percentage (76.88%), while the 10 cm cuttings (L_1) exhibited the lowest sprouting percentage (69.79%). Similarly, L_2 i.e. 15 cm hardwood cuttings achieved highest survival percentage (60.42%), whereas L_1 i.e. 10 cm hardwood cuttings exhibited lowest survival percentage (52.29%). As discussed earlier, the higher sprouting and survival percentage in longer (15 cm) hardwood cuttings of bougainvillea is attributed to their greater availability of stored carbohydrates, nutrients and water, which are essential for root initiation. These cuttings likely have more nodes and axillary buds, enhancing opportunities for root and shoot development. Additionally, the increased vascular tissue volume improves nutrient and water transport, further supporting sprouting and survival of the longer sized cuttings. The effective distribution of rooting hormones alongside carbohydrate reserves in longer cuttings may also contribute to improved sprouting and survival rates, allowing for more efficient use of auxins and other rooting enhancers. In contrast, shorter cuttings have limited resources that can be quickly depleted, hindering root establishment, especially in the challenging Konkan region. This scarcity makes them more vulnerable to drying out and pathogens, resulting in lower survival rates.

Root parameters

The variation among the different length of cuttings with respect to various root parameters such as number of roots per cutting, length of longest root, fresh and dry weight of roots, was found to be significant. Among the different length of cuttings maximum number of roots per cutting (27.08), length of longest root (11.40 cm), fresh weight of roots (11.70 g) and dry weight of roots (2.19 g) were registered in longer hardwood cuttings of length 15 cm i.e. L_2 (27.08) and the shorter hardwood cuttings of length 10 cm i.e. L_1 recorded minimum number of roots per cutting (19.06), length of longest root (10.44 cm), fresh weight (9.73 g) and dry weight of roots (1.49 g). The significantly enhanced rooting performance observed in the longer hardwood cuttings (15 cm) compared to the shorter ones (10 cm) can be primarily attributed to the increased reserve carbohydrate and nutrient content, as well as a greater quantity of endogenous rooting cofactors (like auxins and phenols) stored within the larger cutting biomass. The greater surface area and volume of the 15 cm cuttings, provided a more substantial resource base, leading to significantly higher values for various root parameters. This aligns with the principle that cuttings require sufficient energy reserves to fuel the metabolic processes and cell division necessary for successful adventitious root initiation and subsequent growth, a requirement better met by the physiologically more robust, longer cutting material. The results are in line with those reported by Eed *et al.* (2015) [2], Bhardwaj *et al.* (2020) [1] and Shinde *et al.* (2021) [7] in bougainvillea.

Shoot: Root (on fresh weight basis)

Significant variation was observed among the different length of cuttings for shoot to root ratio. The shoot to root ratio was recorded maximum (1.29) in the hardwood cuttings of length 15 cm i.e. L_2. However, the minimum ratio (1.25) was noticed in the 10 cm hardwood cuttings i.e. L_1. The significant variation in shoot-to-root ratio among different cutting lengths, with the maximum ratio observed in 15 cm hardwood cuttings, suggests a length-dependent partitioning of biomass that may be driven by the initial storage reserves and hormonal balance within the cutting. As previously discussed, longer cuttings typically possess more stored carbohydrates and nutrients, which are initially mobilized to support vigorous shoot growth, resulting in a higher shoot to root ratio, as the developing shoot is the primary sink for these resources. Conversely, the shorter cuttings, having fewer reserves, may allocate proportionally more resources toward root initiation and development to establish water and nutrient uptake capacity more quickly under stress, or they simply may not have enough reserve material to sustain the level of shoot development observed in 15 cm hardwood cuttings, leading to a relatively lower shoot to root ratio, thereby illustrating that the initial mass and physiological state of the cutting critically influence the early growth strategy and biomass allocation pattern. Similar results were reported by Savant *et al.* (2021) [6] in Indian plumeria.

Table 1: Effect of varying lengths of hardwood cuttings on various parameters viz., sprouting, survival, rooting and shoot to root ratio

Length of hardwood cuttings	Sprouting and Survival				
	Days required for initiation of sprouting		Sprouting (%)		Survival (%)
L_1-10 cm	15.83		69.79 (56.66)*		52.29 (46.31)
L_2-15 cm	13.85		76.88 (61.26)		60.42 (51.01)
S.Em.(±)	0.10		2.15		1.99
C.D. @ 5%	0.29		6.48		6.00
Result	SIG		SIG		SIG
	Root parameters				Shoot: Root
	No. of roots/cutting	Length of longest root (cm)	Fresh weight of roots (g)	Dry weight of roots (g)	
L_1-10 cm	19.06	10.44	9.73	1.49	1.25
L_2-15 cm	27.08	11.40	11.70	2.19	1.29
S.Em.(±)	0.16	0.03	0.02	0.01	0.01
C.D. @ 5%	0.48	0.08	0.07	0.02	0.02
Result	SIG	SIG	SIG	SIG	SIG

Note: *Figures in parentheses are arcsine transformation values.

Conclusion

The study on the performance of various lengths of Bougainvillea glabra cuttings revealed that hardwood cuttings measuring 10 cm and 15 cm yielded satisfactory results. Notably, the 15 cm hardwood cuttings demonstrated superior performance in several key metrics, including the time taken for sprout initiation, sprouting percentage, survival rate, number of roots per cutting, length of the longest root, fresh and dry weight of roots, as well as the shoot to root ratio. Consequently, utilizing hardwood cuttings of approximately 15 cm in length for propagating bougainvillea plants can generate an abundance of planting material, thereby ensuring a sufficient supply of plantlets to meet market demands.

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