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Interaction of seasons and rooting hormone on sprouting and root length of bamboo seedlings (*Bambusa balcooa* Roxb. and *Dendrocalamus stocksii* Munro)

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Abstract
This study investigates the effects of Indole-3-butyric acid (IBA) treatments at various concentrations (500, 1000, 1500, 2000, and 2500 ppm) on sprouting percentage and root length in different seasons (rainy, winter, and summer). An experiment was laid out in completely randomized design with factorial concept (FRBD) having 12 treatment combinations, comprising with two factors. Significant interactions were observed between the seasons and the IBA treatments (A x B). During the rainy season (S_1), the highest sprouting percentage was achieved with a 2500 ppm IBA treatment (87.67% in A and 88.67% in B), with a root length of 9.23 cm (A) and 8.77 cm (B). During the winter season (S_2), the sprouting percentage reached a maximum of 35.00% (A) and 36.33% (B) with the 2500 ppm IBA treatment, along with a root length of 5.53 cm (A) and 4.44 cm (B). In the summer season (S_3), the 2500 ppm IBA treatment yielded the highest sprouting percentage of 86.33% (A) and 94.33% (B), with corresponding root lengths of 11.37 cm (A) and 14.53 cm (B).The study reveals that higher concentrations of IBA generally promoted sprouting and root growth, with significant variations across different seasons. The interactions between the treatments and seasons were significant across all seasons and for both bamboo species. Propagation of bamboo through culm cuttings during the summer season, particularly when treated with Indole-3-butyric acid (IBA), has been shown to be highly effective in summer season (March to May).

Keywords: Indole-3-butyric acid, sprouting, propagation, root length, culm cutting, vegetative propagation

Introduction
Bamboos, the most diverse group of plants in the grass family belong to the family Poaceae. Bamboos are fast growing perennial plants and are found in the tropical, sub-tropical and mild temperature regions of the world. Large tracts of natural bamboo forest are found in tropical Asian countries between 15° and 25° North latitudes. In India, bamboo is found naturally almost throughout the country except in Kashmir region (FAO 2007) [3]. There are about 1,200 species of bamboo in 90 genera across the world. India has about 125 indigenous and 11 exotic species of bamboo from 23 genera. Bamboos are found in abundance in the deciduous and semi-evergreen forests of the north-eastern region of the country and the tropical moist deciduous forest of Northern and Southern India (ISFR 2021).

Propagation through macro proliferation technique for many bamboo species is a major break-through but it has again the limitation of requirement of seeds to begin with. The propagation through offset planting is difficult and labour intensive as well as only limited number of plants can be produced by this method. So, vegetative propagation methods can cater to the increasing demand of its planting stock (Razvi *et al.*, 2011) [11]. Since bamboo seeds are limited and short-lived, hence, bamboo species are mainly propagated vegetatively using rhizome cuttings and, in some cases, air layering. Vegetative propagation by rhizome or offset cuttings is an age-old practice but the method is not suitable for raising large-scale plantations due to limited supply of rhizomes and offsets along with bulkiness and difficulties in extraction and transportation (Pattanaik *et al.*, 2004) [9]. *Dendrocalamus stocksii* is economically and ecologically significant and is endemic to Central Western Ghats of India (12° to 17.5° North latitudes). *Bambusa*

balcooa originated in the north-eastern section of India, from which it spread to other locations due to its numerous applications (Banik, 2000) [2]. IBA could induce rooting and very effective to enhance the vegetative propagation and growth (Kochhar *et al*., 2008) [7]. Cavity method which involves pouring the solution of IBA / water (control) into the culm cavity, gave very good sprouting and rooting in cuttings the advantages of cavity method could be to keep the cuttings moistened and maintain certain degree of humidity (Gulabrao *et al.*, 2011) [5].

Materials and Methods

The field experiment was conducted during 2023 to 2024 at Agroforestry Research Farm, College of Agriculture (Dr. PDKV) Nagpur during growing season i.e. rainy (S_1-July to September), winter (S_2-November to January) and summer (S_3-March to May). Two years aged culms each of *Bambusa balcooa* and *Dendrocalamus stocksii* were cut into required numbers from the Bamboo germplasm. Bi- nodal cuttings were cut from each species of bamboo with the help of a sharp boat shaped saw, cuttings were sterilized for 5 min. with 15g of Bavistin (Carbendazim 50% WP in 10 litre of water solution). Round shaped hole was made in between the culms using an electrical driller so that IBA hormone solution can be filled inside. The treated cuttings were horizontally placed in raised beds (10 cm deep the opening facing of hole upwards). In order to plant the bi-nodal culms appropriate solution of IBA (20- 25 ml) was poured inside the prepared hole, it was covered with a fresh soil so that the complete circumference of the hole can be covered. The culm cuttings collected were treated with different concentrations of IBA with the help of injection in all three seasons (rainy, winter and summer season) as given following hormonal treatments:

Treatments	Factor A (concentrations)	Factor B (species)
		Treatment Combinations
T_1	Only water no IBA	Species + water (*B. balcooa, D. stocksii*)
T_2	500 ppm	Species + 500 ppm (*B. balcooa, D. stocksii*)
T_3	1000 ppm	Species + 1000 ppm (*B. balcooa, D. stocksii*)
T_4	1500 ppm	Species +1500 ppm (*B. balcooa, D. stocksii*)
T_5	2000 ppm	Species + 2000 ppm (*B. balcooa, D. stocksii*)
T_6	2500 ppm	Species + 2500 ppm (*B. balcooa, D. stocksii*)

The different concentrations of IBA with three replications were prepared fresh by dissolving desired amount of IBA (0:0, 0.5 g., 1 g., 1.5 g., 2 g. and 2.5 g.) and then volume made to 1 litre by addition of distilled water.

The experiment was laid out by Factorial Randomized Block Design (FRBD). The data were recorded during the course of investigations and loaded in Microsoft excel for data analysis.

Results

Effect of season: The culm cuttings collected in March (*Bambusa balcooa* and *Dendrocalamus stocksii*) showed significantly maximum sprouting percentage and growth of adventitious roots. Besides, *Bambusa balcooa* and *Dendrocalamus stocksii* had less sprouting percentage and root length in rainy season as compare to summer season and the poor results were recorded in winter season regarding sprouting percentage and root length (Table 1). The effectiveness of IBA observed in summer season of both species (Table 1) indicates that the hormone becomes active only when the target cells or tissues acquire sensitivity towards auxin. The acquisition of this sensitivity depends upon several external and internal factors, including environmental conditions. Similar result was reported by Kumar *et al.*, (1988) [8]; Agnihotri and Ansari (2000) [1] who reported similar trend of vegetative propagation of bamboo using growth promoting substances.

The culm cuttings collected in March *Bambusa balcooa* and *Dendrocalamus stocksii* showed significantly maximum sprouting percentage. Besides, *Bambusa balcooa* and *Dendrocalamus stocksii* had less sprouting percentage in rainy season as compare to summer season, Poor results were observed in winter season (Table 1 & Fig. 1).

Interactive effects of different concentrations of IBA Treatments (T) and Species (B)

Mean number of sprouting percentages

From the data, it is revealed that there was a significant difference between application of different concentration of IBA and species on sprouting percentage in all three seasons. In rainy season sprouting percentages varied from 36.33% (T_1B_1) to 88.67% (T_6B_2). The treatment combination of (T_6B_2) gave significantly maximum sprouting percentage in bamboo cuttings of *D. stocksii* treated with 2500 ppm IBA. However, in summer season the sprouting percentages varied from 68.00% (T_1B_1) to 94.33 (T_6B_2) with the combination of (T_6B_2) in bamboo cuttings of *D. stocksii* treated with 2500 ppm IBA.

Mean number of root length (cm)

The interactive effect of treatment and species revealed a significant effect in all three seasons (5% level) in rainy season root length varied from 5.43 cm (T_1B_2) to 12.03 cm (T_4B_1). The treatment combination of (T_4B_1) gave significantly maximum root length in bamboo cuttings of *B. balcooa* treated with 1500 ppm IBA. However, in summer season the root length varied from 4.07 cm (T_1B_2) to 31.57 cm (T_5B_2) with the combination of (T_5B_2) in bamboo cuttings of *D. stocksii* treated with 2000 ppm IBA gave significantly maximum root length (Fig. 2).

Interaction effects: The present study established that for adventitious root length formation and growth, seasonal variation dominates over other factors such as IBA application in both species (Table1). This is conceivable as the competence of vegetative cells to respond to rooting stimuli is conferred during specific period of the year due to external factors, especially temperature and length of the photoperiod. Similar findings were also reported by Singh *et al*., (2006; 2011) [12-13]; Kaushal *et al.*, (2011) [6]; Razvi *et al*., (2017) [10].

Table 1: Influence of different IBA concentrations and seasons on sprouting and rooting of culm cuttings of *Bambusa balcooa* and *Dendrocalamus stocksii*.

		Characteristics			
		Sprouting (%)		Root length (cm)	
	A	B_1	B_2	B_1	B_2
Season	**IBA treatment**				
S_1 Rainy	T_1 :(Control)	36.33	43.33	5.70	5.43
	T_2 :(500 ppm)	63.67	62.67	9.10	5.90
	T_3 :(1000 ppm)	65.00	72.00	8.03	7.47
	T_4:(1500 ppm)	72.33	87.00	12.03	8.37
	T_5 :(2000 ppm)	84.00	88.00	9.80	8.80
	T_6 :(2500 ppm)	87.67	88.67	9.23	8.77
	Avg.	68.17	73.61	8.98	7.46
	Interaction	**A XB**		**AXB**	
	F test	**S**		S	
	SE±	1.02		0.25	
	CD=(P=0.05)	3.00		0.73	
S_2 Winter	T_1 :(Control)	6.67	11.00	3.60	2.17
	T_2 :(500 ppm)	15.00	18.00	3.57	3.60
	T_3 :(1000 ppm)	21.67	23.67	4.17	5.13
	T_4:(1500 ppm)	31.33	32.00	4.53	4.10
	T_5 :(2000 ppm)	33.00	32.00	4.23	6.23
	T_6 :(2500 ppm)	35.00	36.33	5.53	4.44
	Avg.	23.77	25.5	4.27	4.28
	Interaction	**A X B**		**A X B**	
	F test	S		S	
	SE±	0.66		0.12	
	CD=(P=0.05)	1.95		0.34	
S_3 Summer	T_1 :(Control)	68.00	71.67	8.07	4.07
	T_2 :(500 ppm)	75.67	74.00	9.87	14.10
	T_3 :(1000 ppm)	69.00	76.67	19.77	18.53
	T_4:(1500 ppm)	79.67	83.00	11.97	11.43
	T_5 :(2000 ppm)	85.33	88.33	13.20	31.57
	T_6: (2500 ppm)	86.33	94.33	11.37	14.53
	Avg.	77.33	81.33	12.37	15.71
	Interaction	**AXB**		**AXB**	
	F test	S		S	
	SE±	0.79		0.51	
	CD=(P=0.05)	2.32		1.51	

Notes: *Significant at <0.05, B_1 *Bambusa balcooa* cuttings; B_2 *Dendrocalamus stocksii* cuttings.

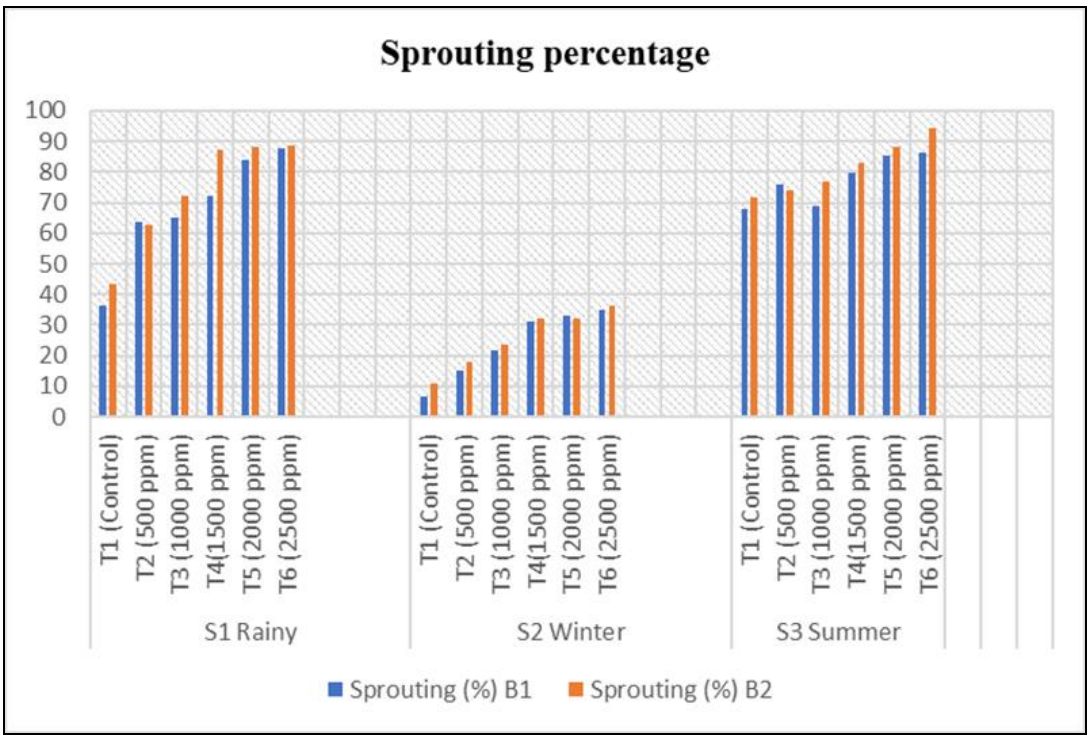

Fig 1: Effect of IBA treatments and season on sprouting in culm cuttings of bamboo species

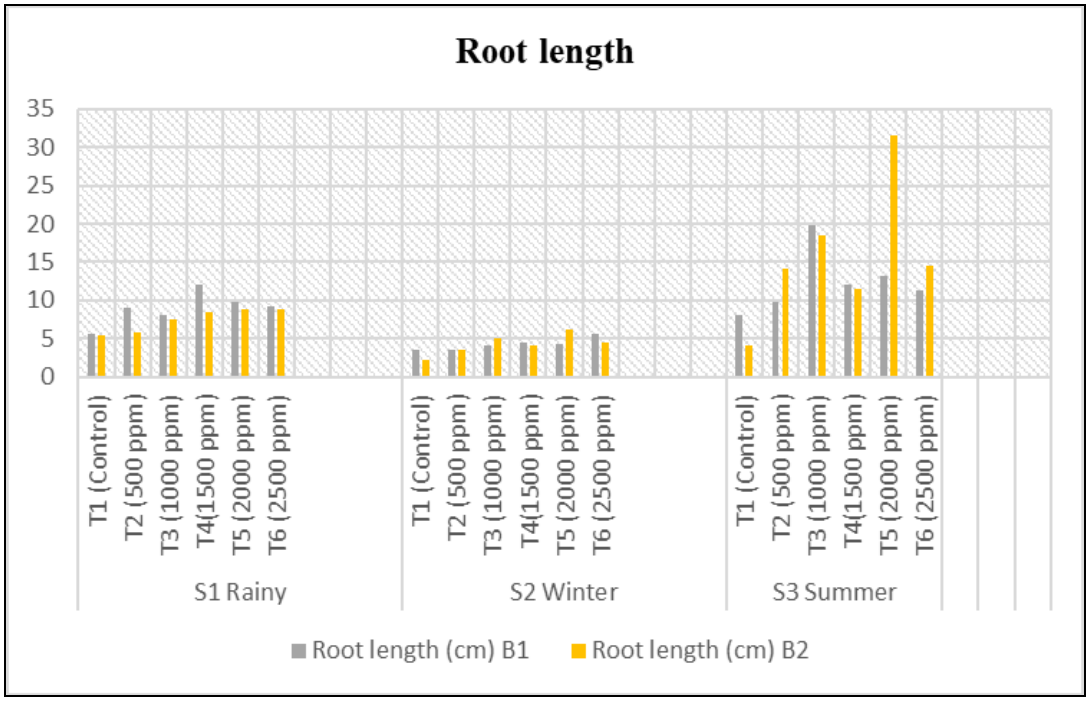

Fig 2: Effect of IBA treatments and season on rooting in culm cuttings of bamboo species

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Conclusion
This study demonstrates that the application of Indole-3-butyric acid (IBA) at various concentrations significantly enhances sprouting percentage and root length in bamboo culm cuttings, with notable variations across different seasons. The highest effectiveness was observed during the summer season, particularly with higher concentrations of IBA, where both sprouting and root growth were maximized. The findings suggest that propagating bamboo using culm cuttings treated with IBA, especially in the summer months, can be a highly effective strategy for promoting growth. These results underscore the importance of considering the season and IBA concentration in optimizing bamboo propagation**.**

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