

Seasonal Influence on the Effect of Indole Butyric Acid (IBA) on Survival and Branch Development in Culm Cuttings of *Bambusa balcooa* Roxb. and *Dendrocalamus stocksii* Munro.

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ABSTRACT

The experiment investigates the impact of various concentrations of Indole-3-butyric acid (IBA) treatments on plant survival percentage and branch production during two distinct seasons, the rainy (S₁) and summer (S₂) periods. The experiment was conducted using a completely randomized design with a factorial arrangement (FRBD), consisting of 12 treatment combinations based on two factors. In the rainy season, survival rates ranged from 16.67% (control) to 80.00% (2500 ppm), with the highest survival at 2500 ppm in culm cuttings of B₂. The number of branches per plant varied from 0.67 to 2.67 across treatments. No significant interaction was observed between the factors for both survival and branching in this season. During the summer season, survival rates were higher, ranging from 59.00% (control) to 96.67% (2500 ppm). The number of branches also increased significantly, reaching up to 9.00 branches in the 2000 ppm treatment for culm cuttings of B₂. A significant interaction was noted for survival percentage between IBA concentration and branches in the summer season, while branching was not significantly affected by the interaction. Overall, the application of IBA, especially at higher concentrations, positively influenced survival and branching, with more pronounced effects in the summer season compared to the rainy season.

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Key words: *Indole-3-butyric acid (IBA)*, *plant survival*, *branch production*, *concentrations*, *rainy season*, *summer season*, *survival rate*.

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INTRODUCTION

Bamboo species are perennial woody grasses. These are significant multipurpose plants that develop quickly and produce a large amount of biomass. The more than than 1,250 species exist in more temperature or tropical climates, and they differ greatly in terms of structure and form. They also have substantially varied ecological circumstances (Banik 1995). Vegetative propagation of bamboo involves using part of the parent plant to produce a new plant (Hamalton *et al.*, 2022). Vegetative propagation of bamboos involves various procedures, most of which aim at transforming the innumerable buds present at every node into planting material (Banik, 1980). Among these procedures, propagation through adventitious

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rhizogenesis of culm/branch cuttings is a viable option having the advantage of obtaining enormous number of cuttings from a clump and low costs of transport, handling and labour (Dransfield and Widjaja, 1995).

The demand for bamboo has increased in recent years in several Asian countries as a raw material for furniture making, as panel boards in lieu of wood, as a vegetable, and for other uses apart from the traditional agriculture and construction-related uses. Plantation development has come to focus on high-demand bamboo species (Saad *et al.*, 2016). Auxins, mainly IBA and NAA, have been employed with variable success in different types of bamboo cuttings e.g. *Bambusa vulgaris* (Uchimara 1978). However, the different seasons of culm cuttings also behave differentially for growth of seedlings. Thus, we examined the influence of seasonal variation and indole-3- butyric acid (IBA) on survival and branch development in culm cuttings of *Bambusa balcooa* Roxb. and *Dendrocalamus stocksii* Munro. with the view of evolving efficient clonal multiplication procedures for both species.

MATERIALS AND METHODS

Two economically bamboo species of Maharashtra viz. were selected for the investigation. Superior culms of bamboo were collected from healthy clumps of two different types of bamboo species using a sharp axe from Agroforestry research farm, Nagpur involving 12 treatment combination (2 different bamboo culm cuttings X 6 different concentrations of IBA) in Factorial RBD with 3 replications and 10 cuttings of each bamboo species were planted in each replication. Different bamboo species that were used in this experiment are as follows: *Bambusa balcooa* and *Dendrocalamus stocksii*. Collection was done in two seasons i.e. rainy (S₁) and summer (S₂) for IBA treatments of bi-nodal cuttings different concentrations i.e. 0 ppm (control), 500 ppm, 1000 ppm, 1500 ppm, 2000 ppm and 2500 ppm, solution was prepared. Round shaped hole was made in between the culms using an electrical drill so that IBA hormone solution can be filled inside. In order to plant the bi-nodal culms appropriate solution of IBA (20-25 ml) was poured inside the prepared hole and it was covered with a fresh soil so that the complete circumference of the hole can be covered. A light irrigation was given just after planting with drip irrigation. The entire beds were subjected to watering everyday with exception to extreme hot weather and shower. During extreme hot days irrigation was double and during rainy days it was skipped. The observations were recorded at 90 days after planting (DAP).

RESULTS AND DISCUSSION

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1. Survival percentage

Interaction (season X culm cuttings X IBA)

Season I: Rainy

The data regarding survival percentage as influenced by different concentrations of IBA doses and species was recorded at 90 days after planting in *bambusa balcooa* and *Dendrocalamus stocksii* and presented in Table 1. The sprouting percentage varied from 16.67 (T₁B₁) to 80.00 (T₆B₂). The treatment combination of (T₆B₂) gave significantly highest survival percentage of 80.00 in bamboo cuttings of *D. stocksii* treated with 2500 ppm IBA.

The interaction effect of different concentrations of IBA doses and species were found non-significant in respect of survival percentage. Similar findings were also reported by Banik (1989); Pattanaik *et al.*, (2004); Othman (2005); Hossain *et al.*, (2006); Islam *et al.*, (2011) and Ilorkar *et al.*, (2021).

Season II: Summer

Data pertaining to interaction effect between application of different concentrations of IBA and species on survival percentage is given in Table 1. There was a significant difference between application of different concentrations of IBA and species on survival percentage. The sprouting percentage varied from 59.00 (T₁B₁) to 96.67 (T₆B₂). The treatment combination of (T₆B₂) gave significantly highest survival percentage of 96.67 in bamboo cuttings of *D. stocksii* treated with 2500 ppm IBA.

The interaction effect of different concentrations of IBA doses and species were found significant in respect of survival percentage. The survival rate of IBA treated plantlets was higher in comparison to control. Kaushal *et al.*, (2011) explained that the application of IBA greatly increased the seedling survival percentage. Similar result was reported by Pandey *et al.*, (2011); Vamil *et al.*, (2011); Bhol and Nayak (2012); Padekar *et al.*, (2018) and Kalanzi *et al.*, (2023).

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Table 1. Seasonal influence on the effect of IBA on survival percentage in culm cuttings of *Bambusa balcooa* and *Dendrocalamus stocksii* (90 days after planting).

Variables	A	characteristics		
		Survival (%)		
		B ₁	B ₂	Mean
Season	Factor A (IBA Concentrations)			
S₁ Rainy	T ₁ : Control	16.67	23.33	20.00
	T ₂ (500 ppm)	23.33	26.67	25.00
	T ₃ (1000 ppm)	30.00	23.33	26.67
	T ₄ (1500 ppm)	36.67	46.67	41.67
	T ₅ (2000 ppm)	43.33	43.33	43.33
	T ₆ (2500 ppm)	43.33	80.00	61.67
	Avg.	32.22	40.56	36.39
	Interaction (A X B)			
	F test	NS		
	SE±	6.74		
	CD=(P=0.05)	-		
S₂ Summer	T ₁ (Control)	59.00	72.00	65.50
	T ₂ (500 ppm)	64.00	84.67	74.33
	T ₃ (1000 ppm)	66.33	88.67	77.50
	T ₄ (1500 ppm)	75.00	93.00	84.00
	T ₅ (2000 ppm)	77.00	94.00	85.50
	T ₆ (2500 ppm)	81.00	96.67	88.83
	Avg.	70.39	88.17	79.28
	Interaction (A X B)			
	F test	S		
	SE±	1.22		
	CD=(P=0.05)	3.58		

Notes: B₁ *Bambusa balcooa* cuttings ; B₂ *Dendrocalamus stocksii* culm cuttings.

2. Development of branches

Interaction (season X culm cuttings X IBA)

Season I: Rainy

Data regarding number of branches as influenced by species are presented in Table 2 and showed the significant differences among the various growth regulators in both bamboo species. The number of branches per plant varied from 0.67 (T₁B₁) to 2.67 (T₆B₂). The treatment combination of (T₆B₂) gave significantly highest number of branches per plant of 2.67 in bamboo cuttings of *D. stocksii* treated with 2500 ppm IBA.

The interaction effect of different concentrations of IBA doses and species were found non-significant in respect of number of branches. The results confirm with the findings reported by Pandey *et al.*, (2011).

Season II:Summer

Data regarding number of branches as influenced by species are presented in Table 2. Number of branches increased progressively with the advancement of culm cuttings age and there was marked increase as the culm cuttings proceeded towards physiological growth during summer season. The number of branches per plant varied from 1.33 (T₁B₁) to 9.00 (T₅B₂). The treatment combination of (T₅B₂) gave significantly highest number of branches per plant of 9.00 in bamboo cuttings of *D. stocksii* treated with 2000 ppm IBA.

The interaction effect of different concentrations of IBA doses and species were found non-significant in respect of number of branches. Similar findings are also reported by Naiem *et al.*, (2010) in *Dendrocalamus giganteus*, munro and Ilorkar *et al.*, (2023) in *Bambusa balcooa*.

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Table 2. Seasonal influence on the effect of IBA on branch development in culm cuttings of *Bambusa balcooa* and *Dendrocalamus stocksii* (90 days after planting).

Variables	characteristics			Mean
	A	B ₁	B ₂	
Season	Factor A (IBA Concentrations)			
S₁ Rainy	T ₁ : Control	0.67	1.67	1.17
	T ₂ (500 ppm)	1.67	1.33	1.50
	T ₃ (1000 ppm)	2.33	2.33	2.33
	T ₄ (1500 ppm)	1.33	2.00	1.67
	T ₅ (2000 ppm)	2.67	2.33	2.50
	T ₆ (2500 ppm)	1.33	2.67	2.00
	Avg.	1.67	2.06	1.86
	Interaction (AXB)			
	F test	NS		
	SE±	0.31		
	CD=(P=0.05)	-		
S₂ Summer	T ₁ (Control)	1.33	6.00	3.67
	T ₂ (500 ppm)	2.00	6.67	4.33
	T ₃ (1000 ppm)	2.67	7.00	4.83
	T ₄ (1500 ppm)	3.00	7.67	5.33
	T ₅ (2000 ppm)	3.33	9.00	6.17
	T ₆ (2500 ppm)	3.67	8.00	5.83
	Avg.	2.67	7.39	5.03
	Interaction (A X B)			
	F test	NS		

SE±
CD=(P=0.05)

0.34
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Notes: B₁ *Bambusa balcooa* cuttings ; B₂ *Dendrocalamus stocksii* culm cuttings.

CONCLUSION

The experiment demonstrates that the application of Indole-3-butyric acid (IBA) significantly improves plant survival and branch production, particularly at higher concentrations. Survival rates and branch numbers were notably higher during the summer season compared to the rainy season. The optimal concentration of IBA was 2500 ppm, which resulted in the highest survival rate in both seasons. Additionally, a significant interaction between IBA concentration and survival was observed during the summer season, while no such interaction was found for branching. Overall, these findings highlight the beneficial effects of IBA treatments, particularly at higher concentrations, in improving plant resilience and growth across different seasons.

REFERENCES

- Banik, R. L. (1995). *A manual for vegetative propagation of bamboos*. International Network for Bamboo and Rattan.
- Banik, R.L. 1980. Propagation of bamboo by clonal methods and by seeds. In: G, Lessard and A. Chouinard (Eds.). *Bamboo Research in Asia*. IDRC, Canada: 139-150.
- Banik, R.L. 1989. Techniques of bamboo propagation with special reference to pre- rooted and prerhizomed branch cuttings and tissue culture. In Rao, A.N. , Dhanaranjan, G. and Sastry, C.B. (Eds.) *Proc. International Bamboo Workshop, Hangzhou, People's Republic of China, 6-14 October 1985*. IDRC, Canada :160-169.
- Bhol, N. and Nayak, H., 2012. Effect of planting alignment and cutting size on propagation of *Bambusa vulgaris*. *J. Tree Sci.*, 31 (1&2): 69-75.
- Dransfield, S. and Widjaja, E.A. 1995. *Plant Resources of South-East Asia, Bamboos*. Backuys Publishers, Leiden: 39-40
- Hamalton, T., Khannam, A., Bhuvaneshwari, M., & Chandrakala, D. (2022). Vegetative propagation techniques for bamboo species: a review.
- Hossain, M.A., Jewel, M.E.U., Sen, M. and Serajuddoula, M. 2006. Rooting ability of *Bambusa vulgaris* var. *striata* branch cutting as influenced by cutting types and rooting hormones. *J. Bamboo and Rattan*, pp. 117-126.

- Ilorkar, V.M., Raut, P.D., Atram, P.C. and Deshmukh, A.P. 2021. Effect of growth hormones IBA on clonal propagation of bamboo in nursery condition. *Journal of Pharmacognosy and Phytochemistry*,10(1): 369-370.
- Ilorkar. V.M., Raut.P.D. and Deshmukh, A.P. 2023. Effect of the different concentration of growth regulator on vegetative propagation of *Bambusa balcooa* Bamboo.pp.332-333. In: Proceedings of the NAU-IES-IUFRO Conference on Tree Based Diversified Land-use System: Augmenting Livelihood Security and Industrial Growth (February 15-17, 2023 at Nausari Agricultural University, Nausari, Gujrat, India.
- Islam, M.S., Bhuiyan, M.K., Hossain, M.M. and Hossain, M.A. 2011. Clonal propagation of *Bambusa vulgaris* by leafy branch cuttings. *Journal of Forestry Research* 22(3): 387–392.
- Kalanzi, F., Kalembe, and Mwanja, C.K. 2023. Effect of nodal cutting position and plant growth regulator on bud sprouting of *Dendrocalamus giganteus* Wall. Ex Munro in Uganda. *Advances in Bamboo Science* 2 (2023) 100016.
- Kaushal, R., Gulabrao, Y. A., Tewari, S.K., Chaturvedi, S. and Chaturvedi O.P. 2011. Rooting behaviour and survival of bamboo species propagated through branch cuttings. *Indian Journal of Soil Conservation*,39(2): 171-175
- Naiem, E.M., El-Keltawi, Sayed, S.A. and Abdel-Rahman .2010. Propagation of bamboo (*Dendrocalamus giganteus*, Munro) through culm-branch cuttings in Egypt. *Assiut J. of Agric. Sci.*, 41 (1): 59-80.
- Othman, A.R. 2005. Growth of *Gigantochloa levis* branch cuttings in nursery and field planting in response to indole butyric acid rooting hormone. *J. Bamboo and Rattan*, 4(2): 163–172
- Padekar, V. J., Garande, V. K., Dodake, S. S., Sawant, S. V., Shinde, U. S., Sonawane, P. N. and Dhupal, S. S. 2018. Effect of IBA, types of cutting and rooting media on sprouting, survival percentage and growth of cuttings of Kartoli (*Momordica dioica* Roxb.). *Int. J. Curr. Microbiol. App. Sci*, 7(10): 1246-1260.
- Pandey, A., Tamta, S. and Giri, D. 2011. Role of auxin on adventitious root formation and subsequent growth of cutting raised plantlets of *Ginkgo biloba* L. *International Journal of Biodiversity and Conservation*, 3(4): 142-146.
- Pattanaik, S., Das, P., Borah, E., Kaur, H. and Borah, K. 2004. Vegetative multiplication of *Bambusa balcooa* Roxb. using branch cuttings. *Journal of Bamboo and Rattan* 3: 301–412.

- Saad, M., Kumar, H., & Umrao, R. (2016). Effect of the different growth regulators on vegetative propagation of Buddha belly bamboo. *Advances in Life Sciences*, 5(4), 1310-1314.
- Uchimara E. 1978. Ecological Studies on the Cultivation of Bamboo Forest in Philippines. *Bulletin of Forestry and Forest Products Research Institute*, 301: 79–118
- Vamil, R., Aniat-ul-haq, R., Agnihotri, K. and Sharma, R. 2011. Effect of certain plant growth regulators on the seedling survival, biomass production and proline content of *Bambusa arundinacea*. *Science Research Reporter*, 1(2): 44-48.

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