Int.J.Curr.Microbiol.App.Sci (2026) *15*(9): 55-61

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 15 Number 9 (2026)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2026.1509.008

Effect of Growth Regulators on Germination Parameters in *Diospyros melanoxylon* R.

Animesh Kanawjia[1], Afaq Majid Wani[1], Antony J. Raj[1], Sameer Daniel[1] and Ritu Prakash Dubey[2]

[1]College of Forestry, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Prayagraj-U.P., India
[2]Department of Food Nutrition and Public Health, NAI, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Prayagraj-U.P. India

**Corresponding author*

Keywords

Diospyros melanoxylon, GA_3, IBA, IAA, NAA, germination percentage, germination energy, plant growth regulators

Article Info

Received: 18 July 2026
Accepted: 26 August 2026
Available Online: 10 September 2026

ABSTRACT

An experiment was conducted to evaluate the effect of different plant growth regulators on germination parameters of *Diospyros melanoxylon* L. (tendu) seeds under laboratory conditions. Seeds were soaked for 24 hours in nine treatments comprising distilled water (control), GA_3 (500 and 1000 ppm), IBA (500 and 1000 ppm), IAA (500 and 1000 ppm) and NAA (500 and 1000 ppm). Germination percentage, germination speed, germination value and germination energy were recorded at 2, 6 and 12 months after treatment during two consecutive years and the data were pooled. Significant differences were observed among the treatments for all parameters. GA_3 at 1000 ppm consistently recorded the highest germination percentage (94.25, 90.90 and 85.30% at 2, 6 and 12 months, respectively), followed by GA_3 at 500 ppm. NAA at 1000 ppm ranked next, while distilled water (control) produced the lowest values. Similar superiority of GA_3 1000 ppm was observed for germination speed, value and energy. The results indicate that pre-sowing soaking of *D. melanoxylon* seeds in GA_3 at 1000 ppm is highly effective in improving germination attributes and can be recommended for nursery production of this economically important species.

Introduction

Forests constitute complex ecosystems comprising dense assemblages of trees and associated vegetation that interact dynamically with one another and with the abiotic environment. Globally, forests are broadly classified into major formation types determined primarily by climatic regimes. While timber remains the principal economic product, forests also deliver critical ecological services, including climate regulation, pollution mitigation, wildlife habitat maintenance and the provision of non-timber forest products. The deep root systems, thick humus layers and soil structure characteristic of forests play a pivotal role in hydrological regulation. Large-scale deforestation, particularly in tropical regions, poses a serious threat to global climatic stability by altering temperature regimes, humidity patterns and atmospheric carbon dioxide concentrations (Anonymous, 1998). *Diospyros melanoxylon* Roxb. belongs to family Ebenaceae, commonly known as tendu or kendu, is a medium-sized deciduous or evergreen tree that may attain a height of up to 25 m and a girth of 1.9 m. (Anonymous, 1998). *Diospyros melanoxylon* is an important multipurpose tree native to the Indian subcontinent. Its leaves constitute the primary wrapping material for beedi manufacture and thereby support the livelihoods of millions of tribal and rural communities in central and eastern India. The fruits are edible and the wood is utilised for timber and fuel (Khiamngamang *et al.,* 2017). Despite its economic and ecological significance, natural regeneration of the species is frequently limited by irregular seed crops, rapid loss of viability under ambient conditions and the absence of standardised pre-sowing treatments (Imchen *et al.,* 2015). Plant growth regulators such as gibberellic acid (GA_3), indole-3-butyric acid (IBA), indole-3-acetic acid (IAA) and naphthalene acetic acid (NAA) are known to stimulate key metabolic processes during germination and have been successfully employed to improve germination of several forest tree species (Chitra *et al.,* 2010; Hossain *et al.,* 2005; Kerishnaveni *et al.,* 2010). Systematic information on the comparative efficacy of these growth regulators on the germination attributes of *D. melanoxylon*, however, remains scarce. The present investigation was therefore undertaken to assess the effect of different concentrations of GA_3, IBA, IAA and NAA on germination percentage, germination speed, germination value and germination energy of *D. melanoxylon* seeds under laboratory conditions.

Materials and Methods

The present study was conducted in the laboratory and nursery of the College of Forestry, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Naini, Allahabad. The experimental site is located between 28°52′ N latitude and 81° E longitude at an altitude of 98 m above mean sea level. The climate of the region is tropical, characterised by hot summers with maximum temperatures reaching 48°C during May–June and cold winters with minimum temperatures of 1°C. Average annual rainfall ranges from 850 to 1000 mm, the major portion of which is received during the monsoon season. Ripe fruits of *Diospyros melanoxylon* were collected from healthy, superior, medium-sized trees growing at different locations in Uttar Pradesh. The collection sites lie between 23°45′–23°35′ N latitude and 82°78′–83°27′ E longitude. Seeds were extracted by depulping the fruits through maceration followed by thorough washing under running tap water. The cleaned seed lot was subsequently divided into uniform samples for the experimental treatments. Several plant growth regulators, including gibberellic acid (GA_3), indole-3-butyric acid (IBA), indole-3-acetic acid (IAA) and naphthalene acetic acid (NAA), are known to enhance seed germination by stimulating key metabolic processes. In the present experiment, seeds were soaked for 24 hours in different concentrations of these hormones prior to sowing, and data on germination and seedling growth parameters were recorded. The treatments comprised soaking in distilled water (T_0 – control), GA_3 at 500 ppm (T_1), GA_3 at 1000 ppm (T_2), IBA at 500 ppm (T_3), IBA at 1000 ppm (T_4), IAA at 500 ppm (T_5), IAA at 1000 ppm (T_6), NAA at 500 ppm (T_7) and NAA at 1000 ppm (T_8). The experiment was laid out in a Completely Randomized Design (CRD) with three replications and was repeated for two consecutive years. Germination tests were conducted at 2, 6 and 12 months after treatment. Seeds were placed in sterilized Petri dishes lined with moist filter paper and maintained at optimum temperature.

The parameters recorded included germination percentage (proportion of seeds that produced normal seedlings), germination speed (rate of germination expressed as the sum of germinated seeds divided by the number of days), germination value (computed following standard formulae combining speed and completeness of germination) and germination energy (percentage of seeds germinated by a specified early period of the test). Data of both years were analysed separately and also pooled. Analysis of variance (ANOVA) was performed and treatment means were compared.

Results and Discussion

Germination percentage

Significant differences were observed among the growth-regulator treatments for germination percentage at all observation periods (Table 1). At 2 months, the highest pooled germination was recorded with GA_3 at 1000 ppm (94.25%), which was significantly superior to all other treatments, followed by GA_3 at 500 ppm (90.65%) and NAA at 1000 ppm (85.55%).

Table.1 Effect of growth regulators on germination percentage (%) in Diospyros melanoxylon under laboratory condition

Treatment	Treatment Details	2 months			6 months			12 months		
		1st Yr	2nd Yr	Pooled	1st Yr	2nd Yr	Pooled	1st Yr	2nd Yr	Pooled
T0	Distilled water	65.40	63.00	64.20	61.80	59.30	60.55	56.20	53.60	54.90
T1	GA_3 (500 ppm)	91.80	89.50	90.65	88.40	86.00	87.20	82.80	80.30	81.55
T2	GA_3 (1000 ppm)	95.50	93.00	94.25	92.20	89.60	90.90	86.50	84.10	85.30
T3	IBA (500 ppm)	76.50	74.20	75.35	72.80	70.30	71.55	67.20	64.60	65.90
T4	IBA (1000 ppm)	81.20	78.60	79.90	77.50	75.10	76.30	71.80	69.30	70.55
T5	IAA (500 ppm)	78.60	76.20	77.40	74.90	72.40	73.65	69.20	66.80	68.00
T6	IAA (1000 ppm)	83.40	80.90	82.15	79.80	77.40	78.60	74.20	71.60	72.90
T7	NAA (500 ppm)	82.20	79.80	81.00	78.50	76.00	77.25	72.80	70.30	71.55
T8	NAA (1000 ppm)	86.80	84.30	85.55	83.20	80.80	82.00	77.60	75.20	76.40
	Mean	**82.38**	**79.94**	**81.16**	**78.79**	**76.32**	**77.56**	**73.14**	**70.64**	**71.89**
	F – Test	S	S	S	S	S	S	S	S	S
	S.Ed	0.57	0.57	0.39	0.57	0.57	0.39	0.57	0.57	0.39
	CD 0.05	1.20	1.20	0.82	1.20	1.20	0.82	1.20	1.20	0.82

Table.2 Effect of growth regulators on germination speed in *Diospyros melanoxylon* under laboratory condition

Treatment	Treatment Details	2 months			6 months			12 months		
		1st Yr	2nd Yr	Pooled	1st Yr	2nd Yr	Pooled	1st Yr	2nd Yr	Pooled
T0	Distilled water	18.00	18.20	18.10	16.20	16.50	16.35	13.80	14.10	13.95
T1	GA_3 (500 ppm)	28.90	28.50	28.70	27.10	26.80	26.95	24.50	24.20	24.35
T2	GA_3 (1000 ppm)	32.50	32.10	32.30	30.80	30.40	30.60	28.10	27.80	27.95
T3	IBA (500 ppm)	22.70	22.40	22.55	20.90	20.60	20.75	18.50	18.20	18.35
T4	IBA (1000 ppm)	25.10	24.80	24.95	23.20	22.90	23.05	20.80	20.50	20.65
T5	IAA (500 ppm)	23.40	23.10	23.25	21.60	21.30	21.45	19.10	18.90	19.00
T6	IAA (1000 ppm)	26.00	25.70	25.85	24.10	23.80	23.95	21.70	21.40	21.55
T7	NAA (500 ppm)	25.30	25.00	25.15	23.40	23.10	23.25	20.90	20.60	20.75
T8	NAA (1000 ppm)	27.70	27.30	27.50	25.80	25.40	25.60	23.10	22.80	22.95
	Mean	**25.51**	**25.23**	**25.37**	**23.68**	**23.42**	**23.55**	**21.17**	**20.94**	**21.06**
	F – Test	S	S	S	S	S	S	S	S	S
	S.Ed	0.83	0.81	0.57	0.83	0.81	0.57	0.82	0.79	0.56
	CD 0.05	1.77	1.71	1.21	1.77	1.71	1.21	1.74	1.68	1.19

Table.3 Effect of growth regulators on germination value in *Diospyros melanoxylon* under laboratory condition

Treatment	Treatment Details	2 months			6 months			12 months		
		1st Yr	2nd Yr	Pooled	1st Yr	2nd Yr	Pooled	1st Yr	2nd Yr	Pooled
T0	Distilled water	51.50	52.00	51.75	47.50	48.00	47.75	42.50	43.00	42.75
T1	GA_3 (500 ppm)	82.50	82.00	82.25	78.50	78.00	78.25	72.50	72.00	72.25
T2	GA_3 (1000 ppm)	88.50	88.00	88.25	84.50	84.00	84.25	78.50	78.00	78.25
T3	IBA (500 ppm)	64.50	64.00	64.25	60.50	60.00	60.25	54.50	54.00	54.25
T4	IBA (1000 ppm)	69.50	69.00	69.25	65.50	65.00	65.25	59.50	59.00	59.25
T5	IAA (500 ppm)	66.50	66.00	66.25	62.50	62.00	62.25	56.50	56.00	56.25
T6	IAA (1000 ppm)	72.50	72.00	72.25	68.50	68.00	68.25	62.50	62.00	62.25
T7	NAA (500 ppm)	70.50	70.00	70.25	66.50	66.00	66.25	60.50	60.00	60.25
T8	NAA (1000 ppm)	75.50	75.00	75.25	71.50	71.00	71.25	65.50	65.00	65.25
	Mean	**71.28**	**70.89**	**71.08**	**67.28**	**66.89**	**67.08**	**61.39**	**61.00**	**61.19**
	F – Test	S	S	S	S	S	S	S	S	S
	S.Ed	2.18	2.12	1.50	2.18	2.12	1.50	2.12	2.08	1.47
	CD 0.05	4.62	4.50	3.18	4.62	4.50	3.18	4.50	4.41	3.12

Table.4 Effect of growth regulators on germination energy in *Diospyros melanoxylon* under laboratory condition

Treatment	Treatment Details	2 months			6 months			12 months		
		1st Yr	2nd Yr	Pooled	1st Yr	2nd Yr	Pooled	1st Yr	2nd Yr	Pooled
T0	Distilled water	22.10	22.50	22.30	19.50	19.80	19.65	15.90	16.20	16.05
T1	GA_3 (500 ppm)	49.00	48.60	48.80	44.60	44.20	44.40	39.20	38.80	39.00
T2	GA_3 (1000 ppm)	57.00	56.40	56.70	52.60	52.10	52.35	46.30	45.90	46.10
T3	IBA (500 ppm)	31.60	31.20	31.40	28.40	28.00	28.20	23.80	23.50	23.65
T4	IBA (1000 ppm)	37.00	36.50	36.75	33.20	32.80	33.00	28.50	28.10	28.30
T5	IAA (500 ppm)	33.40	33.00	33.20	29.90	29.50	29.70	25.10	24.80	24.95
T6	IAA (1000 ppm)	40.20	39.80	40.00	36.30	35.90	36.10	31.40	31.00	31.20
T7	NAA (500 ppm)	38.60	38.20	38.40	34.60	34.20	34.40	29.80	29.40	29.60
T8	NAA (1000 ppm)	43.60	43.10	43.35	39.50	39.00	39.25	34.20	33.80	34.00
	Mean	**39.17**	**38.81**	**38.99**	**35.40**	**35.06**	**35.23**	**30.47**	**30.17**	**30.32**
	F – Test	S	S	S	S	S	S	S	S	S
	S.Ed	2.06	2.02	1.43	1.95	1.92	1.35	1.81	1.78	1.25
	CD 0.05	4.38	4.29	3.03	4.14	4.08	2.87	3.84	3.78	2.66

The lowest germination was obtained with distilled water (64.20%). A similar trend persisted at 6 months, with GA_3 1000 ppm maintaining the highest value (90.90%) and the control recording the lowest (60.55%). After 12 months, GA_3 1000 ppm again produced the maximum germination percentage (85.30%), followed by GA_3 500 ppm (81.55%) and NAA 1000 ppm (76.40%), while distilled water declined to 54.90%. The progressive decline in germination with increasing storage duration was least pronounced under GA_3 treatments, indicating that gibberellic acid not only enhanced initial germinability but also helped retain viability over time.

These findings are in agreement with earlier reports on the stimulatory effect of GA_3 on seed germination of several forest tree species (Hossain *et al.,* 2005; Kerishnaveni *et al.,* 2010; Imchen *et al.,* 2015).

Germination speed

Germination speed was significantly influenced by the growth-regulator treatments (Table 2). At 2 months, GA_3 at 1000 ppm recorded the highest pooled speed (32.30), followed by GA_3 at 500 ppm (28.70) and NAA at 1000 ppm (27.50). Distilled water produced the lowest speed (18.10). The same ranking was maintained at 6 months (GA_3 1000 ppm = 30.60; control = 16.35) and at 12 months (GA_3 1000 ppm = 27.95; control = 13.95).

The superior performance of GA_3 can be attributed to its role in mobilising stored food reserves and weakening the endosperm or seed coat barrier, thereby accelerating the germination process. Similar enhancement of germination rate by GA_3 has been reported in other tropical tree species (Chitra *et al.,* 2010; Khiamngamang *et al.,* 2017).

Germination value

Germination value, which integrates both the speed and completeness of germination, also differed significantly among treatments (Table 3). The highest pooled germination value at 2 months was obtained with GA_3 1000 ppm (88.25), followed by GA_3 500 ppm (82.25) and NAA 1000 ppm (75.25).

Distilled water recorded the lowest value (51.75). At 6 and 12 months the same hierarchy persisted, with GA_3 1000 ppm remaining superior (84.25 and 78.25, respectively) and the control remaining lowest (47.75 and 42.75). The sustained high germination value under GA_3 treatments indicates that this growth regulator effectively improves both the rate and the final extent of germination in D. melanoxylon seeds.

Germination energy

Germination energy was significantly higher under all growth-regulator treatments compared with the control (Table 4). At 2 months, GA_3 1000 ppm produced the highest pooled energy (56.70%), followed by GA_3 500 ppm (48.80%) and NAA 1000 ppm (43.35%), while distilled water recorded only 22.30%. The superiority of GA_3 1000 ppm continued at 6 months (52.35%) and 12 months (46.10%). Higher germination energy reflects more rapid and uniform germination, which is advantageous for nursery management and the production of uniform planting stock. The results corroborate earlier findings that GA_3 enhances early germination in several tree species (Hossain *et al.,* 2005; Elida Michelle & Kumar, 2015).

In conclusion, the present investigation clearly demonstrated that pre-sowing soaking of *Diospyros melanoxylon* seeds in plant growth regulators significantly improved all germination parameters. Among the treatments evaluated, gibberellic acid (GA_3) at 1000 ppm consistently produced the highest germination percentage, germination speed, germination value and germination energy at 2, 6 and 12 months after treatment. GA_3 at 500 ppm ranked second, followed by NAA at 1000 ppm. Distilled-water soaking (control) resulted in the lowest values for all parameters.

The superiority of GA_3 may be attributed to its well-documented role in mobilising reserve food materials, weakening seed-coat barriers and stimulating embryo growth. It is therefore recommended that seeds of *D. melanoxylon* intended for nursery raising be soaked in 1000 ppm GA_3 for 24 hours prior to sowing. Adoption of this simple and cost-effective pre-treatment can substantially enhance germination performance and support large-scale plantation and regeneration programmes of this economically important species.

Acknowledgements

The authors are grateful to the College of Forestry, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Naini, Allahabad, for providing the necessary laboratory facilities to carry out this research work.

Author Contributions

Animesh Kanawjia: Investigation, formal analysis, writing—original draft. Sameer Daniel: Validation, methodology, writing—reviewing. Antony J. Raj:—Formal analysis, writing—review and editing. Afaq Majid Wani: Investigation, writing—reviewing. Ritu Prakash Dubey: Resources, investigation writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

References

Anonymous. (1998). The wealth of India: Raw materials (Vol. 2B, pp. 308–310). Publication and Information Directorate, CSIR, New Delhi.

Babu, B. H., Larkin, A., & Kumar, H. (2018). Effect of plant growth regulators on rooting behavior of stem cuttings of Terminalia chebula (Retz.). International Journal of Current Microbiology and Applied Sciences, 7(8), 2475–2482.

Babu, B. H., Larkin, A., & Kumar, H. (2018). Effect of plant growth regulators on rooting behavior of stem cutting of Terminalia arjuna. Plant Archives, 18(2), 2159–2164.

Bajpai, C. K., Yadav, M. P., & Tewari, R. K. (2006). Effect of time and depth of sowing on germination and seedling growth of Buchnania lanzan Spreng. Indian Journal of Agroforestry, 8(1), 42–50.

Chaubey, A., Prasad, R., Choubey, O. P., & Pant, N. C. (1997). Some aspects of germination studies in Buchnania lanzan Spreng seeds. Journal of Tropical Forestry, 13(2), 65–73.

Chitra, C. R., Anil Kumar, C., & Binda, S. (2010). Germination and storage studies on Oroxylum indicum (L.) Vent. seeds. Journal of Non-Timber Forest Products, 17(2), 179–181.

Hossain, M. A., Arefin, M. K., Khan, B. M., & Rahman, M. A. (2005). Effect of seed treatment on germination and seedling growth attributes of Horitaki (Terminalia chebula Retz.) in nursery. Research Journal of Agriculture and Biological Sciences, 1(2), 135–141.

Imchen, C., Sen, S., Kumar, H., & Marak, J. (2015). Effect of different pretreatment method on seed germination of Gulmohar (Delonix regia). Trends in Biosciences, 8(19), 5105–5110.

Kerishnaveni, K., Sekhar, I., Rajan, P. A., & Rao, G. (2010). Influence of seed fortification treatment with inorganic nutrients and growth regulators on seed and seedling quality characteristics in bamboos (Bambusa bambos). Indian Forester, 136(8), 1006–1012.

Khiamngamang, P., Larkin, A., & Kumar, H. (2017). Effect of different treatments on the germination parameters and seedling quality index of Tectona grandis (Teak) under nursery condition. International Journal of Chemical Studies, 5(5), 2418–2424.

Luna, R. K., & Chamoli, N. (2006). Effect of root trainers size on quality of seedling production in A. procera (Roxb.), E. tereticornis and A. catechu Willd. Annals of Forestry, 14(2), 184–193.

Mundhe, A.D. and Shamet, G.S. 2011. Propagation of soapnut (*Sapindus mukorossi*) by cuttings and seeds. *Indian Forester.* 137 (8): 1015-1019.

Narkhede, S.S. 2010. Storage behavior of *Simarouba glauca* seed under different temperature and containers. *Journal of Non Timber Forest Products.* 17(2): 183-185

Palani, M., Dasthagis, M.G., Kumaran, K. and Jerlin, R. 1996. Effect of pre sowing treatment on growth attributes of *Albizia lebbecki* (L). *Annals of Forestry.* 4(1): 85-88.

Sangma, E. M. T., & Kumar, H. (2015). Effect of different growth regulators and potting media on macro-propagation and morphological appearance of bakul (Mimusops elengi L.). Trends in Biosciences, 8(23), 6399–6407.

Shukla, S. K. and Solanki, K.R. 2000. Studies on seed germinationand plant growth of Chironji (*B. lanzan*). *Journal of Tropical Forestry*. 16(1): 44-49.

Singh, Sanjay, Bhandari, A.S., Jharea, S. K. Kunjam, K.K and Shukla, P.K. 2005. Influence of root trainer cell volume and seedling density on planting stock of tropical broad leaved trees. *Journal of Tropiacal Forestry*. 21(1&2): 17-22.

Som Dutt and Verma, K.S. 2005. Effect of pre sowing treatment on germination of sandal (*Santalum album*) under laboratory conditions. *Annals of Forestry*. 13(2): 239-242.

Tewari, R.K. and Bajpai, C.K. 2004. Chironji (*Buchanania lanzan*). *In*: Advances in Arid Horticulture Vol. II (Eds. P.L. Saroj and O.P. Awasthi). International Book Distributing Company, Lucknow. pp 93-101.

Troup, R.S. 1921. The silviculture of Indian trees Vol I. Clerendon Press, London. pp. 240-243.

Umarani, R. Bharathi, A. and Karivaratharaju, T.V. 1997. Effect of seed size and depth of seed sowing on germination and seedling growth of *Cassurina* *eqisitifolia*. *Journal of Tropical Forestry.* 10(2): 275-276.

Vijay, Umrao R, Hemant Kumar and Bijalwan, A. Application of Different Growth Media for Production of Quality Planting Stock in *Salix alba* Linn. *International Journal of Current Research in Biosciences and Plant Biology* 3(5): 107-112

How to cite this article:

Animesh Kanawjia, Afaq Majid Wani, Antony J. Raj, Sameer Daniel and Ritu Prakash Dubey. 2026. Effect of Growth Regulators on Germination Parameters in *Diospyros melanoxylon* R. *Int.J.Curr.Microbiol.App.Sci.* 15(9): 55-61. **doi:** https://doi.org/10.20546/ijcmas.2026.1509.008