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Effect of IBA and growing media on rooting and growth parameters of black pepper (*Piper nigrum* L.) cuttings under shade-net conditions

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Abstract

The present study evaluated the effects of indole-3-butyric acid (IBA) and growing media on sprouting, rooting, growth and survival of black pepper (*Piper nigrum* L.) cuttings under shade-net conditions. The experiment was conducted during 2025-26 at the College of Horticulture and Research Station, Shankar-Patan, Durg, Chhattisgarh, India. A factorial completely randomized design was used with three IBA concentrations [I_0 , control; I_1 , 2000 ppm; and I_2 , 4000 ppm] and four growing media [M_0 , soil; M_1 , farmyard manure; M_2 , vermicompost; and M_3 , poultry manure], with three replications. Significant effects of IBA, growing media and their interaction were observed for several sprouting, growth and rooting traits. Among the IBA treatments, I_1 (2000 ppm) recorded the earliest sprouting (17.39 days), whereas I_2 (4000 ppm) recorded the highest shoot diameter (3.88 mm). Among the growing media, M_2 (vermicompost) resulted in earlier sprouting (19.21 days), greater shoot growth, higher numbers of primary and secondary roots, longer roots and higher survival than the other media. The interaction I_1M_2 (2000 ppm IBA + vermicompost) recorded the earliest sprouting (15.39 days), highest sprouting percentage (82.00%), shoot length (12.43 cm), shoot diameter (4.31 mm), number of leaves (12.03), primary roots (8.99), secondary roots (10.91), root length (25.76 cm) and survival (83.33%). The results indicate that the combination of 2000 ppm IBA and vermicompost provided favourable conditions for establishment and subsequent growth of black pepper cuttings under shade-net conditions.

Keywords: Black pepper, *Piper nigrum*, indole-3-butyric acid, vermicompost, rooting media, sprouting, adventitious rooting, vegetative propagation

1. Introduction

Black pepper (*Piper nigrum* L.), commonly known as the “King of Spices,” is an economically important perennial spice crop belonging to the family Piperaceae. Its dried berries are widely used as a culinary spice and as a raw material for pharmaceutical, food and value-added products. Black pepper is cultivated extensively in tropical and subtropical regions, and India is one of the important producers and exporters of the crop ^[1]. The crop is also gaining attention in nontraditional production areas, including parts of central India, where suitable nursery and production technologies are required for successful establishment.

The establishment of black pepper plantations depends largely on the availability of healthy, vigorous and genetically uniform planting material. Vegetative propagation through stem cuttings is commonly preferred because seed propagation may result in genetic variability and non-uniform plant establishment ^[2]. However, successful propagation from cuttings depends on rapid sprouting, adventitious root formation and subsequent shoot development. Poor rooting or delayed establishment can increase nursery losses and reduce the availability of quality planting material. Adventitious root formation in stem cuttings is influenced by endogenous physiological conditions, auxin concentration, environmental factors and the properties of the rooting medium. Indole-3-butyric acid (IBA) is widely used to promote adventitious root initiation and development. The response to IBA, however, depends on concentration, genotype, physiological condition of the cutting and environmental conditions. Previous studies have reported beneficial effects of growth regulators on rooting and sprouting of black pepper cuttings ^[3-5].

The growing medium is another important component of successful vegetative propagation. An appropriate medium should provide adequate moisture retention, aeration, drainage and physical support while maintaining a favourable environment for root initiation and development. Organic materials such as farmyard manure, vermicompost and poultry manure may improve the physical and nutritional conditions of the rooting environment. Studies involving black pepper and related *Piper* species have demonstrated differences in cutting performance under different rooting media [4, 6-8]. Protected nursery environments such as shade-net structures can provide relatively favourable conditions for propagation by moderating radiation and environmental fluctuations. Nevertheless, information on the combined effects of IBA concentration and different organic growing media on black pepper cuttings under shade-net conditions is comparatively limited for the conditions of central India.

Therefore, the present study was undertaken to evaluate the individual and combined effects of IBA concentration and growing media on sprouting, shoot growth, rooting and survival of black pepper cv. Panniyur-1 cuttings under shade-net conditions. The study aimed to identify a suitable combination of IBA concentration and growing medium for improving nursery establishment of black pepper cuttings.

2. Materials and Methods

2.1 Experimental site: The experiment was conducted during 2025-26 at the Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture and Research Station, Shankar-Patan, Durg, Chhattisgarh, India. The experiment was carried out under shade-net conditions.

2.2 Plant material: Healthy cuttings of black pepper (*Piper nigrum* L.) cv. Panniyur-1 were used as experimental material. The cuttings were selected from healthy mother plants and prepared uniformly before treatments. The following experimental details should be inserted from your original record: age of mother plants, type and length of cutting, number of nodes per cutting, source of cuttings and preparation procedure.

2.3 Experimental design: The experiment was laid out in a factorial completely randomized design (FCRD) with three replications. The experiment consisted of two factors: IBA concentration and growing medium. Three levels of IBA and four growing media resulted in 12 treatment combinations.

2.3 Experimental design: The experiment was conducted in a factorial completely randomized design (FCRD) with three replications, comprising three IBA concentrations (I_0 : control, I_1 : 2000 ppm and I_2 : 4000 ppm) and four growing media (M_0 : soil, M_1 : farmyard manure, M_2 : vermicompost and M_3 : poultry manure), resulting in 12 treatment combinations. The respective IBA concentrations were applied to cuttings planted in the designated growing media.

2.4 IBA treatment: IBA was used at concentrations of 2000 and 4000 ppm, while untreated cuttings served as the control. The cuttings were treated with the respective IBA solutions before planting in the designated growing media. The final manuscript should specify the exact IBA application procedure, including solvent, method of preparation, dipping duration and portion of cutting treated, based on the actual experimental procedure.

2.5 Nursery management: The treated cuttings were planted in the respective growing media and maintained under shade-net

conditions. Irrigation and other nursery-management practices were applied uniformly to all treatments.

2.6 Observations recorded: Observations were recorded on sprouting, shoot growth, leaf development, rooting and survival.

2.6.1 Days taken to sprouting: The number of days from planting to the appearance of the first visible sprout was recorded for each treatment.

2.6.2 Number of sprouts per cutting: The number of sprouts produced by each cutting was counted and expressed as the number of sprouts per cutting.

2.6.3 Sprouting percentage: Sprouting percentage was calculated using the following formula

2.6.4 Length of shoot (cm): Shoot length was measured at 30, 60 and 90 days after planting (DAP) using a suitable measuring scale and expressed in centimetres.

2.6.5 Diameter of shoot (mm): Shoot diameter was measured at 90 DAP and expressed in millimetres.

2.7 Statistical analysis: The data were subjected to analysis of variance appropriate for a factorial completely randomized design. The significance of the main effects of IBA concentration and growing media and their interaction was tested at the 5% probability level. Standard error of the mean [SE(m)±] and critical difference [CD at 5%] were calculated for comparison of treatment means.

3. Results and Discussion

3.1 Sprouting

3.1.1 Days taken to sprouting: The days required for sprouting differed significantly among IBA treatments, growing media and their interaction (Table 1). Among the IBA concentrations, I_1 (2000 ppm IBA) recorded the earliest sprouting at 17.39 days, whereas the control (I_0) required the longest period of 26.18 days. I_2 (4000 ppm IBA) recorded 19.82 days to sprouting. Among the growing media, vermicompost (M_2) recorded the earliest sprouting at 19.21 days, followed by poultry manure (M_3) at 20.04 days and farmyard manure (M_1) at 21.71 days. Soil (M_0) recorded the longest period of 23.57 days. The interaction between IBA and growing medium was significant. The combination I_1M_2 (2000 ppm IBA + vermicompost) recorded the earliest sprouting at 15.39 days, followed by I_1M_3 at 16.57 days and I_1M_1 at 17.96 days. The control combination I_0M_0 required the longest period (30.20 days).

The early sprouting associated with IBA application may be related to the role of auxin in the physiological processes associated with cutting establishment and adventitious root initiation. The favourable response obtained with vermicompost may reflect its physical and nutritional properties, which can provide a suitable environment for early establishment. Similar responses to growth regulators and rooting media have been reported in black pepper propagation studies [3-5, 8].

3.1.2 Number of sprouts per cutting

The number of sprouts differed significantly among IBA treatments and growing media, whereas the IBA × growing-medium interaction was non-significant (Table 1). Among the IBA treatments, I_1 recorded the highest number of sprouts (4.11), followed by I_2 (4.00), while I_0 recorded the lowest value (3.77).

Among the growing media, M₂ recorded the highest number of sprouts (4.32), followed by M₁ (3.96) and M₃ (3.83), whereas M₀ recorded the lowest value (3.03). Although I₁M₂ recorded the numerically highest number of sprouts (4.62) among the treatment combinations, the interaction effect was non-significant. Therefore, the numerical differences among IBA × growing-medium combinations should not be interpreted as statistically significant.

The improved sprout production under IBA treatment may be associated with enhanced establishment of treated cuttings. The favourable response of vermicompost may be related to improved physical conditions and nutrient availability in the rooting environment. Comparable responses of black pepper cuttings to growth regulators and rooting media have been reported previously [4, 5, 8].

3.1.3 Sprouting percentage

Significant differences were observed among IBA concentrations,

growing media and their interaction (Table 1). I₁ (2000 ppm IBA) recorded the highest sprouting percentage (74.50%), followed by I₂ (4000 ppm IBA) with 73.50%, whereas I₀ recorded the lowest value (53.70%). Among the growing media, M₂ (vermicompost) recorded the highest sprouting percentage (72.66%), followed by M₃ (70.00%) and M₁ (67.00%). M₀ recorded the lowest value (59.33%). The interaction was significant, and I₁M₂ recorded the highest sprouting percentage (82.00%), followed by I₂M₂ (79.00%) and I₂M₃ (77.00%). The lowest value was recorded in I₀M₀ (45.00%).

The greater sprouting percentage obtained with 2000 ppm IBA suggests that the intermediate IBA concentration provided a favourable response under the experimental conditions. The higher performance of vermicompost may be associated with favourable moisture, aeration and nutrient conditions around the cuttings. Similar effects of growth regulators and organic media on propagation of black pepper have been reported [4, 5, 8].

Table 1: Effect of IBA concentration and growing media on days taken to sprouting, number of sprouts, percentage of sprouting of black pepper cuttings under shade-net conditions

Treatments	Treatments details	Days taken to sprouting	Numbers of sprouts	Percentage of sprouting (%)
	IBA		30 DAP	90 DAP
I ₀	Control	26.18	3.77	53.70
I ₁	IBA 2000 ppm	17.39	4.11	74.50
I ₂	IBA 4000 ppm	19.82	4.00	73.50
	SE(m)±	0.10	0.08	0.14
	C.D. at 5%	0.30	0.24	0.42
	Growing Media			
M ₀	Control (Soil)	23.57	3.03	59.33
M ₁	Farm yard manures	21.71	3.96	67.00
M ₂	Vermicompost	19.21	4.32	72.66
M ₃	Poultry manures	20.04	3.83	70.00
	SE(m)±	0.12	0.09	0.16
	C.D. at 5%	0.35	0.28	0.48
Interaction effect between IBA and growing media (I × M)				
I ₀ M ₀	Control	30.20	3.48	45.00
I ₀ M ₁	Farm yard manure	26.64	3.66	54.00
I ₀ M ₂	Vermicompost	23.58	4.14	57.00
I ₀ M ₃	Poultry manure	24.30	3.80	59.00
I ₁ M ₀	IBA 2000 ppm + Soil	19.63	4.12	66.00
I ₁ M ₁	IBA 2000 ppm + Farm yard manure	17.96	4.16	72.00
I ₁ M ₂	IBA 2000 ppm + Vermicompost	15.39	4.62	82.00
I ₁ M ₃	IBA 2000 ppm + Poultry manure	16.57	3.54	74.00
I ₂ M ₀	IBA 4000 ppm + Soil	20.87	3.89	67.00
I ₂ M ₁	IBA 4000 ppm + Farm yard manure	20.52	4.08	75.00
I ₂ M ₂	IBA 4000 ppm + Vermicompost	18.65	4.20	79.00
I ₂ M ₃	IBA 4000 ppm + Poultry manure	19.24	3.85	77.00
	SE(m)±	0.20	0.16	0.28
	C.D. at 5%	0.60	N/A	0.83

Note: N/A = not applicable because the IBA × growing-medium interaction was non-significant.

3.2 Shoot growth

3.2.1 Shoot length: Shoot length differed significantly among IBA concentrations at 30, 60 and 90 DAP (Table 2). I₁ (2000 ppm IBA) recorded the highest shoot length at all three stages, with values of 1.30, 5.22 and 10.25 cm at 30, 60 and 90 DAP, respectively. The control recorded the lowest shoot lengths of 0.29, 0.65 and 1.51 cm, respectively. I₂ recorded intermediate values of 1.07, 3.94 and 8.02 cm. The growing medium also significantly affected shoot length. Vermicompost (M₂) recorded the highest shoot length at 30, 60 and 90 DAP, with values of 0.98, 4.39 and 8.38 cm, respectively. Poultry manure recorded 0.88, 3.28 and 6.91 cm, while soil recorded the lowest values of

0.78, 2.63 and 5.51 cm. The IBA × growing-medium interaction was significant at all three observation stages. I₁M₂ recorded the highest shoot length at 30, 60 and 90 DAP, with values of 1.44, 6.20 and 12.43 cm, respectively. The lowest values were recorded under I₀M₀, with 0.14, 0.31 and 1.08 cm, respectively.

The improved shoot development under IBA may be associated with enhanced establishment and subsequent growth of the treated cuttings. Vermicompost may have provided a more favourable physical and nutritional environment for root development and shoot growth. Similar effects of rooting media on vegetative development of Piper cuttings have been reported [6, 8].

3.2.2 Shoot diameter

Shoot diameter at 90 DAP was significantly influenced by IBA concentration and growing medium (Table 2). I₂ (4000 ppm IBA) recorded the highest shoot diameter (3.88 mm), followed by I₁ (3.69 mm), whereas I₀ recorded the lowest value (2.27 mm). Among growing media, M₂ recorded the highest shoot diameter (3.90 mm), followed by M₁ (3.30 mm) and M₃ (3.03 mm), while M₀ recorded the lowest value (2.91 mm). The IBA × growing-medium interaction was significant. I₁M₂ recorded the highest shoot diameter (4.31 mm), followed by I₂M₂ (4.18 mm) and I₂M₁ (4.05 mm). The lowest shoot diameter was recorded under I₀M₀

(1.57 mm). The greater shoot diameter under IBA treatments may be associated with improved establishment and vegetative development of the cuttings. The favourable response to vermicompost may reflect its ability to provide suitable physical and nutritional conditions for plant growth.

Similar findings were reported by Sharath and Bhoomika^[17], who observed superior shoot and root development of black pepper cuttings in vermicompost-based growing media; the medium containing soil, perlite and vermicompost (2:1:2) also recorded favourable sprouting and rooting performance.

Table 2: Effect of IBA concentration and growing media on shoot length and shoot diameter of black pepper cuttings under shade-net conditions cutting

Treatments	Treatments details	Length of shoot (cm)			Diameter of shoots (mm)
	IBA	30 DAP	60 DAP	90 DAP	90 DAP
I ₀	Control	0.29	0.65	1.51	2.27
I ₁	IBA 2000 ppm	1.30	5.22	10.25	3.69
I ₂	IBA 4000 ppm	1.07	3.94	8.02	3.88
	SE(m)±	0.01	0.06	0.12	0.04
	C.D. at 5%	0.03	0.17	0.36	0.12
	Growing Media				
M ₀	Control (Soil)	0.78	2.63	5.51	2.91
M ₁	Farm yard manures	0.90	3.18	6.25	3.30
M ₂	Vermicompost	0.98	4.39	8.38	3.90
M ₃	Poultry manures	0.88	3.28	6.91	3.03
	SE(m)±	0.01	0.07	0.14	0.05
	C.D. at 5%	0.29	0.65	1.51	0.14
Interaction effect between IBA and growing media (I x M)					
I ₀ M ₀	Control	0. 0.14	0.31	1.08	1.57
I ₀ M ₁	Farm yard manure	0. 0.32	0.60	1.59	2.01
I ₀ M ₂	Vermicompost	0. 0.39	0.97	1.74	3.20
I ₀ M ₃	Poultry manure	0. 0.31	0.74	1.64	2.32
I ₁ M ₀	IBA 2000 ppm + Soil	1. 1.20	4.01	8.26	3.28
I ₁ M ₁	IBA 2000 ppm + Farm yard manure	1. 1.31	5.70	10.96	3.83
I ₁ M ₂	IBA 2000 ppm + Vermicompost	1. 1.44	6.20	12.43	4.31
I ₁ M ₃	IBA 2000 ppm + Poultry manure	1. 1.25	4.96	9.90	3.35
I ₂ M ₀	IBA 4000 ppm + Soil	1. 1.02	2.38	5.07	3.88
I ₂ M ₁	IBA 4000 ppm + Farm yard manure	1. 1.08	3.25	6.86	4.05
I ₂ M ₂	IBA 4000 ppm + Vermicompost	1. 1.10	6.00	10.30	4.18
I ₂ M ₃	IBA 4000 ppm + Poultry manure	1. 1.07	4.13	9.19	3.43
	SE(m)±	0. 0.02	0.12	0.25	0.08
	C.D. at 5%	0. 0.07	0.35	0.73	0.25

4. Conclusion

The present study demonstrated that IBA concentration and growing media significantly influenced the sprouting and shoot growth of black pepper (*Piper nigrum* L.) cuttings under shade-net conditions. Among the IBA treatments, 2000 ppm IBA (I₁) promoted earlier sprouting and greater shoot elongation, while 4000 ppm IBA (I₂) recorded the highest shoot diameter. Among the growing media, vermicompost (M₂) consistently promoted earlier sprouting, higher sprouting percentage and better shoot growth. The interaction between IBA and growing media showed that I₁M₂ (2000 ppm IBA + vermicompost) recorded the earliest sprouting (15.39 days), highest number of sprouts (4.62), sprouting percentage (82.00%), shoot length at 30, 60 and 90 DAP (1.44, 6.20 and 12.43 cm, respectively) and shoot diameter (4.31 mm). Therefore, under the conditions of the present study, the combination of 2000 ppm IBA with vermicompost showed a favourable response for the propagation and early establishment of black pepper cuttings under shade-net conditions.

5. Conflict of Interest: The authors declare that they have no conflicts of interest. Author Contributions: K.C.:

conceptualization, investigation, data collection and original draft preparation; S.D.K.: supervision and methodology; N.N.: supervision and scientific review; S.S.D.: soil and media-related methodology; R.S.: experimental and scientific inputs; T.K.S., L.M. and R.S.: investigation, data collection and manuscript review. All authors read and approved the final manuscript. This should be checked with the actual contribution of each author before submission.

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