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Growth Performance of Black Pepper (*P. nigrum*) Cuttings in Different Rooting Media and Growth Regulators

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Abstract: Black pepper (*Piper nigrum*) is recognized as "Black Gold" and "King of Spices" because of its widespread use in culinary preparation, food flavoring, and condiment seasoning. It has worldwide fragrance and medical use. The purpose of the conducted research was to investigate the growth performance of *P. nigrum* cuttings in various rooting media and growth regulators concentrations in a low-cost non-mist propagation chamber at the Agroforestry Field Laboratory, Department of Agroforestry and Environmental Science, Sylhet Agricultural University, Sylhet during the period starting from August 2019 to June' 2020. The experiment consisted of two factors: different rooting media and different concentrations of growth regulator, IBA (Indole 3-Butyric Acid). Under the first factor, there were four treatments, namely M_1= biochar, M_2= vermicompost, M_3= well-decomposed cow dung, and M_4= field soil as control. Under the second factor, there were four treatments, namely R_1= 0.2%, R_2= 0.4% and R_3= 0.8%, and R_4= 0.0% of IBA. The whole experiment was designed in a factorial RCBD (Randomized Complete Block Design) with three replications. Among the different media, M_1 treatment (biochar) exhibited superior performance concerning vine length and the number of nodes per vine. On the other hand, R_2 treatment (0.4%) concentration of IBA showed better performance regarding the number of roots and vine length. The research found that the growth performance of *P. nigrum* cuttings is accelerated by integrating rooting media and growth regulators. Consequently, the demand for planting materials could be met.

Keywords: Black pepper cuttings; Biochar; Vermicompost; IBA.

INTRODUCTION

The Black Pepper (*Piper nigrum* L., Piperaceae family) is a recurrent vine extensively cultivated in humid areas of the world for its berries that are used in our daily life for cooking or in a wide range of trades, *viz.*, food processing, medicine, and even perfumery. Today, the black pepper is the biosphere's most exported spice. It has expanded universal reflection because of its capacity in spice manufacturing. Black pepper, often known as "Black Gold" and the "King of Spices," is one of the most significant spices humans have ever used (Talucder et al., 2019 and 2020; Sivaraman et al., 1999). It is native to South and Southeast Asia. The primary producers are China, India, Brazil, Indonesia, Malaysia, and Vietnam. The global progress rate for spice demand is around 3.2 percent (Bromand, 2017). Bangladesh has a strong domestic demand for black pepper and imports black pepper from outside to meet the demand (BBS, 2018). Spice consumption per capita is anticipated to double by 2050 (Haque et al., 2017). According to AIS (2016), there are 374 thousand hectares of organized spice and crop cultivation, which accounts for just 3 percent of all arable land. In contrast, there is only about 5 ha of arable land suitable for growing black pepper in the districts of Sylhet, Bogura, and Habigonj, which yield only 6 metric tons of black pepper annually. Black pepper crop area and production status are unavailable in the BBS 2017. More than 122,000 metric tons of black pepper, turmeric, cinnamon, ginger, and cardamom are imported by Bangladesh, primarily from SAARC member India whereas Sri Lanka supports minute quantities (Haque et al., 2017). However, the country's estimated 16.7 million homesteads occupy roughly 0.3 million hectares of land, a number that is steadily rising as the population rises, presenting a significant opportunity to grow black pepper within an agroforestry framework. Additionally, the Sylhet region's climate and soil conditions are favorable for the commencing and developing black pepper. An insufficient supply of quality planting materials, low productivity, poor processing methods, an underdeveloped marketing channel, high dependence on rainfall, and a lack of technical knowledge on black pepper gardening were major challenges reported by Talucder (2019). Therefore, effective techniques of black pepper multiplication must be developed.

A thorough examination of the crop's agronomic aspects, including planting material production, supports, spacing, pruning, training, irrigation, weeding, mulching, harvesting, organic amendment, and cropping systems, is lacking, although different aspects of black paper cultivation and production been documented in various countries (Sivaraman, 1999). Both vegetative and seed reproduction is possible in black pepper. It takes a lot of time and effort to propagate seeds because of their high sterility and low viability in the post-fertilization stages. They produce only a small number of offspring (Ravindran, 2000). Additionally, plants produced in this way from various vines must display variations in their growth patterns and output (Khan et al., 2021; Philip et al., 1992). As a result, commercial production is boosted by the adoption of vegetative propagation techniques. Although black pepper can be propagated through layering, rooted cutting, cuttings, grafting, and budding for industrial cultivation (Thangaselvabal et al., 2008). The black pepper plant has two types of branches. An orthotropic branch is monopodial that grows straight up and has adventitious roots clinging to the support at each node. The plagiotropic branch, also known as the lateral branch or lateral, has a fruit spike and inflorescence at the node (Chen and Tawan, 2020; Ravindran, 2000). In addition, unintended runner shoots or stolen are also produced by pepper which has long been used as seedlings in Sri Lanka, India, Indonesia, Vietnam, and many other nations that grow pepper. Bangladesh has only studied three Jaintia black pepper development strategies: the soil mound method, the bamboo split method, and the serpentine method (Bhuyan et al., 2015).

There is no research has been reported regarding the outcome of different organic rooting mass media and growth regulators on black pepper cuttings in Bangladesh. There is a pressing need to document the outcome of rooting media and growth supervisors on the black pepper cuttings for the extension of black pepper gardens throughout Bangladesh. Hence, the study aimed at evaluating the performance of vegetative propagation techniques for black pepper in various rooting media and different concentrations of growth regulators. The production technology can broaden the scope of large-scale production as it was evident that farmers involved in pepper production contributed to securing food requirements and increasing household income (Girma, 2017).

MATERIALS AND METHODS

Study area: The study is initiated at the existing field laboratory of the Department of Agroforestry and Environmental Science, SAU, Sylhet (Figure 1). Germplasm of *P. nigrum* was collected from Citrus Research Centre, Jaintiapur, Sylhet. Data were collected from March 2020 to June 2020.

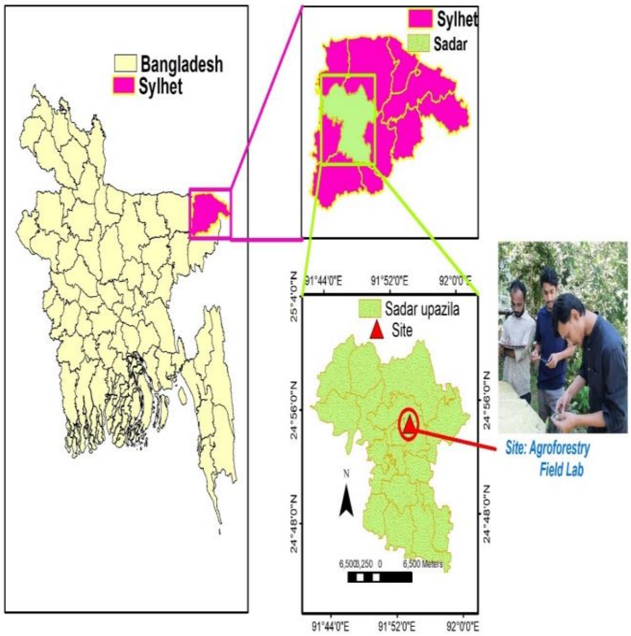

Figure 1. Study Area (Sylhet, Bangladesh)

Design of the study: The study was supported in a factorial RCBD (Randomized Complete Block Design) following three times the replication of each treatment.

Materials preparation: Cuttings of black pepper stem (vine cutting) were used as planting material. Biochar was prepared from sawdust using prototype biochar klin developed by the department of agroforestry and environmental science, Sylhet Agricultural University, Sylhet following standard protocol. On the other hand, vermicompost was collected from the same university's soil science department.

Intercultural operations: Irrigation was provided as required, or sufficient moisture was kept by providing irrigation during the research period. Weeding was done manually using hand picking technique throughout the research period. Weeding was done at 15 days intervals.

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Intercultural operations like mulching, stalking, etc., were provided. Mulching was done after 15 days of the plantation.

Treatments, concentration, and application time: The experiment was carried out in a low-cost non-mist propagator at the existing nursery laboratory, department of agroforestry and environmental science, SAU. The experiment consisted of two factors: different rooting media and different concentrations of growth regulator, IBA (Indole 3-Butyric Acid). There were four first treatments and a second factor (Table 1).

Table 1. Treatments and components of this study

Treatments of the Study	Interval
First Factors	
M_1: biochar	As basal dose
M_2: vermicompost	
M_3: well decomposed cow dung	
M_4: field soil as control	
Second Factors	
R_1: 0.2% of IBA	At the initial time of treatment
R_2: 0.4% of IBA	
R_3: 0.8% of IBA	
R_4: 0.0% of IBA	

Data collection: Data were collected on the parameters such as vine length (cm), node number vine^{-1}, root number node^{-1} and branches number per vine^{-1} at the end of the research.

Statistical Analysis: The data collected were double-checked, coded, transferred from the interview schedule to a master sheet, summarized, categorized, and entered into a database with Microsoft Excel 2019. Those data were analyzed by using R software which was used to perform all statistical analyses.

RESULTS

Effect of rooting media

Vine length (cm): The vine length of black pepper in rooting media significantly differed at a 5% level (Table 2). The highest vine length observed was 160.67 cm in M_1 treatment (biochar), followed by 156.17 and 153.54 cm in M_2 (vermicompost), and M_3 (cowdung) treatments, respectively, and the lowest vine length was observed at 147.08 in the M_4 treatment (field soil).

Nodes number*:* The nodes' number of black peppers in rooting media significantly differed at a 0.05 significance level (Table 2). The maximum node number was observed 20.08 also in M_1 treatment (biochar), followed by 19.08 and 16.67 in M_2 (vermicompost), and M_3 (cowdung), respectively, and the lowest number of nodes was observed at 9.25 in the M_4 as control media.

The root number: The root number in rooting media significantly differed at a 5% level (Table 2). The highest root number was observed 3.83 in M_3 (cow dung) followed by 3.67, 3.50 in M_2 (vermicompost), and M_4 (control), respectively, and the lowest root number was observed 3.25 in M_1 (biochar media) (Table 2).

The number of branches*:* The study detected a non-significant outcome of rooting mass media on the branches number of black pepper (Table 2). The highest branch number was observed 1.25 in M_4 (control media) and the lowest 1.17 in M_1 (biochar), M_2 (vermicompost), and M_3 (cow dung media) treatments.

Table 2. The effect of rooting media on the vegetative growth of black pepper cuttings

Treat-ments	Vine length (cm)	Number of nodes/ vines	Number of roots/ nodes	Number of branches
M_1	160.67a	20.08a	3.25b	1.17a
M_2	156.17b	19.08a	3.67ab	1.17a
M_3	153.54c	16.67b	3.83a	1.17a
M_4	147.08d	9.25c	3.50ab	1.25a
$LSD_{0.05\%}$	01.48	1.56	0.54	0.34
CV (%)	01.15	11.51	18.27	34.24

Effect of IBA

Vine length (cm): The vine length of black pepper in IBA media significantly differed at a 5% level (Table 3). In IBA media, the highest vine length was observed 157.87 cm in the R_2 treatment (0.4% of IBA), followed by 155.63, 154.33 cm in R_1 (0.2%), and R_3 (0.8%), respectively, and the lowest vine length observed 149.63 in R_4 (0.0%) as control IBA media.

Nodes number: In nodes number of black peppers did not significantly differ in different concentrations of IBA media (Table 3). In the case of nodes number, the maximal number of nodes was observed 16.67 in R_3 (0.8%), followed by 16.33, 16.08 in R_1 (0.2%), and R_2 (0.4%), respectively, and the lowest number of nodes observed 16.00 in R_4 (0.0% IBA media) as control.

The number of roots: The root number of black peppers in IBA media significantly differed at a 0.05 level (Table 3). The root number was observed 5.42 in R_2 (0.4%) which was highest followed by 3.08, 2.92 in R_3 (0.8%), and M_4 (0.0%), respectively, and the lowest root number was observed 2.83 in R_1 (0.2% of IBA media) treatment.

The number of branches: The root number of black peppers in IBA media is insignificant (Table 3). The highest branch number was 1.25 in $R_1$0.2% of IBA media), and the lowest branch number (1.17) was observed in R_2 (0.4%), R_3 (0.8%), and R_4 (0.0% of IBA media) treatments.

Interaction between rooting media and IBA

Vine length (cm): The vine length of black pepper in rooting media: IBA significantly differed at a 5% level (Table 4). The highest vine length observed was 165.17 cm in biochar: 0.4% IBA and followed by 160.33, 161.67, 160.00, 157.00, 156.83, 155.83, 155.50, 154.83, 152.00, 150.50, 149.33, 146.33 cm in biochar: 0.2% IBA, biochar: 0.8% IBA, vermicompost: 0.4% IBA, well-decomposed

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cowdung: 0.4% IBA, vermicompost: 0.2% IBA, vermicompost: 0.8% IBA, biochar: 0.0% IBA, well decomposed cowdung:0.2% IBA, field soil as control: 0.2% IBA, field soil as control: 0.4% IBA, field soil as control: 0.8% IBA, respectively and lowest vine length observed 142.17 cm in the field as control: 0.0% IBA media.

Table 3. The effect of different concentrations of IBA on the vegetative growth of black pepper cuttings

Treatments	Vine length (cm)	Number of nodes/ vines	Number of roots/ nodes	Number of branches
R_1	155.63b	16.33a	2.83b	1.25a
R_2	157.87a	16.08a	5.42a	1.17a
R_3	154.33b	16.67a	3.08b	1.17a
R_4	149.63c	16.00a	2.92b	1.17a
$LSD_{0.05}$	01.48	1.56	0.54	0.34
CV (%)	01.15	11.51	18.27	34.24

Table 4. The combined effect of different rooting media and different concentrations of IBA on the vegetative growth of black pepper cuttings

Treatments	Vine length (cm)	Number of nodes/vines	Number of roots/nodes	Number of branches
$M_1 R_1$	160.33b	20.33ab	2.33b	1.00a
$M_1 R_2$	165.17a	19.33abcd	5.00a	1.33a
$M_1 R_3$	161.67b	20.67a	3.00b	1.00a
$M_1 R_4$	155.50cd	20.00abc	2.67b	1.33a
$M_2 R_1$	156.83c	18.67abcd	3.00b	1.33a
$M_2 R_2$	160.00b	19.67abc	5.67a	1.00a
$M_2 R_3$	155.83cd	20.67a	3.00b	1.33a
$M_2 R_4$	152.00ef	17.33bcd	3.00b	1.00a
$M_3 R_1$	154.83cde	17.00cd	3.33b	1.00a
$M_3 R_2$	157.00c	16.33d	5.67a	1.33a
$M_3 R_3$	153.50de	17.00cd	3.00b	1.33a
$M_3 R_4$	148.83gh	16.33d	3.33b	1.00a
$M_4 R_1$	150.50fg	9.33e	2.67b	1.67a
$M_4 R_2$	149.33fg	9.00e	5.33a	1.00a
$M_4 R_3$	146.33h	8.33e	3.00b	1.00a
$M_4 R_4$	142.17i	10.33e	3.00b	1.33a
$LSD_{0.05}$	2.96	3.12	1.09	0.68
CV (%)	1.15	11.51	18.27	34.24

Note: Here, first factor, M_1= biochar, M_2=vermicompost, M_3=well decomposed cow dung and M_4= field soil as control and second factor, R_1=0.2%, R_2=0.4% and R_3= 0.8% and R_4= 0.0%

Nodes number: The number of nodes of black pepper in rooting media: IBA significantly differed at a 5% level (Table 4). The highest number of nodes observed was 20.67 in biochar: 0.08% IBA and vermicompost: 0.08% IBA media and followed by 20.33, 20.00, 19.67, 19.33, 18.67, 17.33, 17.00, 16.33, 10.33, 9.33, 9.00 in biochar: 0.2% IBA, biochar: 0.4% IBA, vermicompost: 0.4% IBA, biochar: 0.4% IBA, vermicompost: 0.2% IBA, vermicompost: 0.0% IBA, well-decomposed cow dung: 0.2% and 0.8% IBA, well-decomposed cow dung: 0.4% IBA, vermicompost: 0.4% and 0.0% IBA, field soil as control:0.0% IBA, field soil as control:0.2% IBA, field soil as control: 0.4% IBA, respectively and lowest number of nodes observed 8.33 IBA in the field as control:0.8% IBA media.

Roots number: The number of roots of black pepper in rooting media: IBA significantly differed at a 5% level (Table 4). The highest number of nodes observed was 5.67 in vermicompost: 0.4%IBA and well-decomposed cow dung: 0.4%IBA followed by 5.33, 5.00, 3.33 field soil as control: 0.4% IBA, biochar: 0.4%IBA, well-decomposed cow dung: 0.0% IBA, respectively; 3.00 found in biochar: 0.8%IBA, vermicompost: 0.2% IBA, vermicompost:0.8% IBA, vermicompost:0.0% IBA, well-decomposed cow dung: 0.8% IBA, field soil as control: 0.8% IBA, field soil as control: 0.0% IBA, 2.67 found in biochar: 0.0% IBA and field soil as control: 0.2% IBA and lowest number of roots observed 2.33 in the field as biochar:0.2% IBA media.

Branches number: The combined effect of rooting media and different concentrations of IBA was not significant on the number of branches (Table 4). The highest number of branches was observed at 1.67 in field soil as a control in combination with 0.2% IBA, followed by 1.33 in biochar and 0.4% IBA, biochar and 0.0% IBA, vermicompost and 0.2% IBA, vermicompost and 0.8% IBA, well-decomposed cow dung and 0.4% IBA, well-decomposed cow dung and 0.8% IBA and field soil as control and 0.0% IBA and lowest number of branches observed 1.00 in the field as biochar and 0.2% IBA, biochar and 0.8% IBA, vermicompost and 0.4% IBA, vermicompost and 0.0% IBA, well-decomposed cow dung and 0.2% IBA, well-decomposed cow dung and 0.0% IBA, field soil as control and 0.4% IBA and field soil as control and 0.8% in IBA media.

DISCUSSION

Cutting is a general propagation technique for black pepper (*P. nigrum*). Cuttings taken from terminal or runner branches are planted directly in the field, resulting in the poor establishment. As a result, it is required to put in a nursery to establish an adequate rooting system. The highest vine length and the number of nodes were observed 160.67 cm and 20.08, respectively, in biochar, where the highest root number was observed 3.83 in cow dung, and the highest branch number was observed 1.25 in control media. In respect of growth regulator concentration, the highest vine length and root number were observed 157.87 cm and 5.42, respectively, in 0.4% of IBA, where the maximum node number was observed 16.67 in 0.8%, and the highest branches number was observed 1.25 treated

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with 0.2% IBA solution. In the interaction between rooting media and IBA growth regulator, the highest vine length was observed 165.17 cm in biochar: 0.4% IBA, the maximum nodes number was observed 20.67 in biochar: 0.08% IBA, the highest node number was observed 5.67 in vermicompost: 0.4% IBA, the highest number of branches observed 1.67 in field soil as control: 0.2% IBA. Among the different media, biochar exhibited superior performance concerning vine length and the number of nodes per vine. On the other hand, 0.4% concentration of IBA showed better performance regarding the number of roots and vine length.

The purpose of biochar production is to enhance the productivity of soil, sortation of carbon or filter soil water which is percolating (Bird et al., 2011). When organic material is thermally degraded at a relatively lower temperature (below 700°C) with a small amount of oxygen (O_2), biochar is created (Bird, 2015). It was argued that biochar can improve plant growth by altering the physicochemical characteristics of soils, which raises microbial activity in general (Blackwell et al., 2015; Hunt et al., 2010). When preparing the soil, adding charcoal or similar material with tiny pores where microorganisms can live might increase the efficacy of beneficial or effective bacteria (Thies et al., 2015). Agegnehu et al. (2016) showed that adding a small quantity of biochar to field soils or bedding plant container medium in greenhouses significantly improves plant growth and yields regardless of the nutrient availability (Agegnehu et al., 2016). For instance, tomato floras cultivated in a range of attentions of commercial soil mediums supplemented with biochar showed improvements (Vaccari et al., 2015), as shown through research evidence. Petunias, marigolds, bell peppers, and tomatoes showed improved germination and growth when equivalent charcoal-activated carbon supplements were added to bedding plant container material (Dunlop et al., 2015). Thankamani et al. (1996) compared vermicompost as a propagation medium for *P. nigrum* to a bagging mixture of soil, farmyard manure and sand (Thankamani et al., 1996). Vermicompost-grown *P. nigrum* cuttings were noticeably higher and contained higher leaves than those produced in bagging soil. Research evidence also revealed that root development is stimulated by applying growth regulators like IBA by dipping cuttings in a solution (Pillay et al., 1982). Under the Andaman circumstances, runner shoot two-node cuttings treated with 1000 ppm IBA-produced black pepper (Shridhar and Singh, 1990). This indicates that vine cutting of black pepper can yield better performance under the influence of growth regulators 0.4% concentration of IBA and rooting media (biochar) and substantially act as better planting material. Thus, better performance of black pepper can ensure food security. Because black pepper can eliminate food security risks through its antibacterial mechanism, which has potential significance in terms of nourishment security (Zou et al., 2015). Consequently, the livelihood of farmers could be improved.

CONCLUSION AND RECOMMENDATIONS

Black pepper is the world's greatest traded spice. It has gained global consideration because of its volume in the spice industry and medicinal importance. The appraised growth rate for spice mandate worldwide is about 3.2%. It also has high domestic demand in Bangladesh. But there is very little research on the evaluation of vegetative propagation techniques. The study has outlined a significant remark regarding the black pepper’s growth performance. Among the different media, biochar exhibited superior performance to vine length and number of nodes per vine. On the other hand, 0.4% concentration of IBA showed better performance regarding the number of roots and vine length.

Thus, the study recommends the exploration of various rooting media and experiments with other growth regulators as well as survivability in the field. Besides, farmers should be encouraged to adopt the production of black pepper using vine cutting with improved production technology rather than traditional production techniques. In this case, policy implication should be done with appropriate implementations. Further research should be done regarding this ground.

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Conflict of Interest: The authors declare there is no conflict of interest.

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