**Effect of Rooting Media and IBA Treatments on Root and Shoot Development and Their Influence on Hardening Mortality in Pomegranate (*Punica granatum* L.) cv. Bhagwa**

**Abstract**

The current study sought to assess the impact of various rooting media and IBA concentrations on the root and shoot development of hardwood cuttings in pomegranate (*Punica granatum* L.) cv. Bhagwa. The experiment was carried out at the Centre of Excellence for Fruits, Siddipet, Telangana, during Rabi 2024–25. It used a FCRD with three rooting media (sand + vermiculite, sand + vermicompost and sand + vermiculite + vermicompost) and four IBA concentrations (0, 1000, 1500 and 2000 ppm). There were significant differences between the treatments. The combination of sand and vermiculite with 2000 ppm IBA (M2G4) produced the highest number of shoots (5.67), the maximum shoot lengths (32.33 cm), the highest rooting percentage (86.25%), and the maximum root lengths (29.67 cm). It also had the minimum mortality rate (50.95%) during hardening. Vermiculite helped with aeration and holding water, while IBA helped with the growth of roots and shoots. using sand and vermiculite as rooting media along with 2000 ppm IBA is recommended for optimal propagation of pomegranate cuttings, ensuring better survival, rooting efficiency, and plant vigor.

**Key words:** Aeration, FCRD, IBA concentration, Rooting media, Rooting Percentage, Water retention.

# Introduction

The pomegranate (*Punica granatum* L.), a member of the genus Punica and family Punicaceae, is an ancient fruit crop. Because of its tasty fruits, pomegranates are grown in tropical and sub-tropical regions of the world. Iran is thought to be the birthplace of the pomegranate. Because of its ability to withstand a variety of soil and climate conditions, it is considered an arid and semi-arid zone crop in India.

Pomegranate fruits can be eaten raw or processed into syrup, jelly, and bottled juice. Because of their therapeutic and nutritional qualities, they are highly prized in India. With a 68% edible portion, 78% moisture, 1.6%

protein, 14.5% carbohydrate, 10 mg calcium,

70 mg phosphorus, 0.3 mg iron, and 16 mg vitamin C per 100g, pomegranates are a very nutrient-dense fruit (Kumar *et al.* 2018). The roots, rind, and seeds are used in medicine, especially for diarrhea, while the fruits are frequently used for drinks, salads, and desserts.

Pomegranate fruit is more profitable and remunerative in the market due to its significant pharmacological qualities, such as antimicrobial, antiviral, and antimutagenic effects, as well as its excellent keeping quality, fine table, and therapeutic values (Negi *et al.* 2003 and Seeram *et al.* 2005).

Both sexual and asexual methods are used to spread pomegranates. In many regions of India, seed propagation is common because

it is simple, but because cross-pollination causes significant variation in tree vigor, fruit quality, and precocity. In order to reduce the high degree of variability, the vegetative method of propagation is recommended instead of seed propagation. Vegetative propagation is the most efficient method for producing true-to-type pomegranate plants. Despite its effectiveness, air layering is costly, slow, and affects the mother plant. Hardwood cuttings offer a quicker and more affordable alternative to seed-grown plants, which take three years or longer to produce fruit.

The Clonal selection of Ganesh x Guleshah red is called Bhagwa. developed under the auspices of the All India Coordinated Research Project on Arid Zone Fruits (AICRP- AZF) by MPKV, Rahuri (2003-04). Dark green leaves and spiky branches characterize the spreading, evergreen Bhagwa pomegranate shrub. It yields male, hermaphrodite, and intermediate dark saffron flowers in all three bahars. Its glossy, attractive fruits store well for 15 to 20 days and have soft seeds, thick saffron rind, and dark red arils. Bhagwa yields 30–40 kg/plant, or 25–30 t/ha, when planted in high density. Medium to large fruits (avg. 405.97 g) are produced by this late-maturing plant (180–190 days). Sweet (15.38% acidity, 0.37 oBrix). the arils are highly sought after and sell for two to three times the price of the Ganesh variety.

Rooting media have a major impact on root development and plant survival. The perfect medium should be lightweight, porous, free of pests and diseases, and able to hold onto moisture while still allowing for good drainage. Materials like sand, vermicompost, FYM, perlite, and vermiculite improve porosity, CEC, and water retention (Shrivastava *et al*., 1998). IBA is the most effective growth regulator at promoting healthy root development, even though IAA and NAA also show species-specific effects (Ghosh *et al*., 1988; Sarma and Sarma, 1991). Because pomegranate cuttings are hard to root, rooting and survival can be significantly increased by using IBA and optimizing the media.

# Materials and Method

The present study was conducted during rabi, 2024-25 at Centre of Excellence for Fruits, Mulugu, Siddipet, Telangana, under the supervision of School of Agricultural Sciences, Malla Reddy University, Hyderadad, Telangana. The experiment was laid out in Factorial Completely Randomized Design with two factors *viz.,* Rooting media (3 levels) and IBA treatments (4 levels), making twelve treatment combinations which were replicated trice. Hardwood cuttings were planted in portrays consisting of rooting media *viz.,* sand, vermiculite and vermicompost after treating with IBA at 0 ppm, 1000 ppm, 1500 ppm and 2000 ppm in powder form. The observations on various parameters at 30, 60 and 90 DAP were recorded as presented below.

1. **Results and Discussion**
   1. **Shoot Parameters**
      1. **Number of shoots per cutting**

Significant differences were observed in the number of shoots per cutting at 30, 60, and 90 DAP due to the effects of rooting media, IBA treatments and their interaction was were presented in Table 1. The average number of shoots increased from 1.68 at 30 DAP to 2.81 at 90 DAP. At 90 DAP, the highest shoot number (3.42) was recorded in sand + vermiculite (M2), followed by sand + vermiculite

+ vermicompost (M3) with 2.84, while the lowest (2.17) was in sand + vermicompost (M1). Among IBA treatments, 2000 ppm (G4) resulted in the highest number of shoots (4.22), while control (G1) had the least (1.56). A significant interaction was found between media and IBA; the maximum number of shoots (5.67) occurred in M2G4, followed by M3G4 (3.67) and M2G3 (3.56). The minimum (1.56) was in M1G1. These findings are consistent with Rajkumar *et al*. (2017), who stressed vermiculite's function in shoot development and Bender (2007), who highlighted vermiculite's ability to hold nutrients. Additionally, IBA-treated cuttings showed increased shoot production, according to Kumar *et al*. (2015). In line with research by Purohit and Shekharappa (1985) and Bhat *et al.* (2004) in pomegranates, auxins such as IBA

probably encouraged shoot formation through cell division and elongation.

# Length of longest shoot per cutting

The length of longest shoot per cutting varied significantly by the rooting media and IBA and their interactions at 60 and 90 DAP in pomegranate was presented in Table 2. There was an increase in the mean length of longest shoot per cutting from 11.78 cm (30 DAP) to

19.99 cm (90 DAP).

The cuttings planted in (M2) sand and vermiculite medium were observed to record significantly more length of longest shoot per cutting at 90 DAP (22.63 cm) followed by the cuttings planted in (M3) sand, vermiculite and vermicompost (18.75 cm) which was on par with (M1) sand and vermicompost (18.59 cm).

Among the IBA treatments the length of longest shoot per cutting was found to be maximum (28.44 cm) in cuttings treated with (G4) IBA at 2000 ppm followed by (G3) IBA at 1500 ppm (23.67 cm), while the minimum length of longest shoot per cutting (10.28 cm) was observed in (G1) IBA at 0 ppm.

Significant interaction existed between rooting media and IBA for length of longest shoot per cutting. simultaneously longest shoot per cutting with highest length of 32.33 cm was observed in (M2G4) sand and vermiculite with IBA at 2000 ppm, followed by 27.67 cm was observed in (M3G4) sand, vermiculite and vermicompost with IBA at 2000 ppm and the least length of 7.67 cm was observed in (M1G1) sand and vermicompost with IBA at 0 ppm.

Current research indicates that the longest shoots were produced by cuttings cultivated in a mixture of sand and vermiculite. This might be the case because vermiculite gives the root a sufficient supply of oxygen, water, and nutrients to function properly, which helps the root absorb more moisture and nutrients and produces the longest shoot. Auxin may have increased the number of leaves and length of the longest shoot by promoting shoot growth and causing stems and leaves to elongate through cell division. The present findings align with those of Bhat *et al*. (2004) in pomegranates, Batista *et al*. (2011) in

pomegranates, Parvez *et al*. (2007) in peaches, and Khayyat *et al*. (2007) in pothos.

# Percentage of mortality during hardening process

There were significant differences in percentage mortality of rooted cuttings during the hardening process among the rooting media and different IBA treatments at 90 DAP are presented in Table 3.

The cuttings planted in (M3) sand, vermicompost and vermiculite medium recorded lowest percentage mortality of rooted cuttings (28.9 %), followed by cuttings planted in sand and vermiculite medium (30.78%), highest percentage mortality of rooted cuttings was observed by those planted in sand and vermicompost (35.68%).

Among the IBA treatments, (G4) IBA at 2000 ppm recorded the lowest percentage mortality of rooted cuttings (18.02%) which was followed by (30.21%) those cuttings treated with IBA at 1500 ppm and the highest percentage mortality of rooted cuttings (44.89%) observed in IBA at 0 ppm. There existed a non-significant interaction between rooting media and IBA treatments for percentage of mortality during hardening process of rooted cuttings. The results are line with Mayer *et al*. (2015).

# Root parameters

* + 1. **Percentage of rooted cuttings (%)**

There were significant differences in respect of percentage of rooted cuttings among the rooting media and different IBA treatments at 30 days after planting was presented in Table 4.

The cuttings planted in a mixture of sand and vermiculite (M2) medium recorded the highest rooting percentage (87.92%), followed by cuttings planted in sand, vermiculite and vermicompost (M3) medium (78.34%) and the lowest percentage of rooted cutting in cuttings planted in sand and vermicompost (M1) medium (75.00%).

Among the IBA treatments, IBA powder dip at 2000 ppm (G4) recorded the highest rooting percentage (88.89%), which was

followed by (82.22%) those cuttings treated with 1500 ppm (G3) and the least rooting percentage was recorded in the control (G1) (71.11%). There existed a non-significant interaction between rooting media and IBA treatments for percentage of rooted cuttings.

Sand + vermiculite may work well because of its increased water-holding capacity and the gradual release of nutrients from the vermiculite medium (Ansari, 2013). In order to maximize auxin levels and raise the cuttings' rooting percentage, cuttings treated with increasing concentrations of IBA may be paired with endogenous auxins already present in the cuttings (Melgarejo *et al*., 2000). Similar findings were obtained by Rajkumar *et al*. (2017), Gautam *et al*. (2010) in guava, Tanwar *et al*. (2020) in pomegranate, and Ristow *et al*. (2012) in blueberry.

# Number of primary and secondary roots

Significant influence of rooting media, IBA treatments as well as their interactions was observed on number of primary and secondary roots per cutting in pomegranate at 90 DAP was presented in Table 5.

At 90 DAP, the cuttings planted in a mixture of sand and vermiculite (M2) recorded highest count of primary and secondary roots (6.59 and 36.33) followed by cutting planted in sand, vermiculite and vermicompost (M3) (5.25 and 29.67) and the least count was observed in sand and vermicompost (M1) (4.00 and 26.50). Among the IBA treatments IBA at 2000 ppm was found higher number of primary and secondary roots (9.11 and 42.11) which was on par with IBA at 1500 ppm (4.89 and 34.00) and the least number of primary and secondary roots was found in IBA at 0 ppm (2.67 and 17.89)

The interaction effect between rooting media and IBA treatments was found significant for number of primary and secondary roots per cutting. Maximum number of primary and secondary roots (11.00 and 48.00) was found in cuttings planted in (M2G4) sand and vermiculite with IBA 2000 ppm which was on par with cuttings treated with (M3G4) sand, vermiculite and vermicompost with IBA 2000

ppm (9.00 and 43.00) and the least number of count (2.33 and 13.67) was found in sand and vermicompost with 0 ppm.

The best results were obtained from cuttings grown in a mixture of sand and vermiculite, which may be due to the physical characteristics of vermiculite, such as its capacity to retain water and aerate, as well as the high concentration of IBA, which encourages the development of a large number of primary and secondary roots and an effective root system. IBA's effect on cell wall flexibility, which encourages callus formation, root growth, and faster cell division, may be the reason why cuttings treated with 2000 ppm of IBA had the greatest number of primary and secondary roots. Similar results were noted in pomegranates by Purohit and Shekharappa (1985), Bankar and Parsad (1993), and Upadhyay and Badyal (2007).

# Length of longest root per cutting

Significant influence of rooting media, IBA treatments as well as their interactions was observed on length of longest root per cutting in pomegranate at 60 DAP and at 90 DAP were presented in Table 6. The mean length of longest root per cutting increased from 4.49 cm at 60 DAP to 22.01 cm at 90 DAP.

At 90 DAP, the cuttings planted in (M3) sand and vermiculite medium were found to show the maximum length of longest root (23.50 cm), followed by (M3) sand, vermiculite and vermicompost (21.42 cm) and the minimum length of longest root (21.12 cm) was observed in (M1) sand and vermicompost media. Among IBA treatments, (G4) IBA at 2000 ppm was founded to record the highest value (27.67 cm) of length of longest root per cutting, followed by (G3) IBA at 1500 ppm (24.17 cm), while the minimum length of longest root per cutting was recorded by (G1) control (15.61 cm).

The interaction effect between rooting media and IBA treatments was found significant for the length of longest root per cutting. The longest roots per cutting (29.67 cm) were found in cuttings planted in sand and vermiculite with IBA at 2000 ppm (M2G4) which was on par with (27.50 cm) cuttings planted in (M3G4) sand, vermiculite and vermicompost with IBA at 2000

ppm while the minimum length was observed in (M1G1) sand and vermicompost with IBA 0 ppm.

These results are in line with those of Rathore *et al*. (1984) in guavas, Abhinav *et al*. (2016) in grapes, and Hakim *et al*. (2018) in pomegranates. Because IBA promotes cell division and elongation, which lengthens roots due to increased vegetative growth and the accumulation of carbohydrates and increases root mass due to a greater number of roots, the successful rooting of IBA-treated cuttings may have contributed to the increase in root length. Growing media with higher fertilizer and water- holding capacities result in larger roots because they always provide enough nutrition and water. Favourable climate conditions, such as high humidity and temperatures, however, improved root development and, as a result, increased cambium activity for proliferation.

# Conclusion

The study clearly demonstrated that both rooting media and IBA treatments significantly influenced shoot and root parameters in pomegranate cuttings. Among the media, sand and vermiculite (M2) consistently showed superior results, followed by sand, vermiculite, and vermicompost (M3). IBA at 2000 ppm (G4) was most effective across all parameters, including number and length of shoots, rooting percentage, root number, and

root length. The best combination was M2G4, which resulted in the highest number of shoots (5.67), maximum shoot length (32.33 cm), greatest number of primary and secondary roots (11.00 and 48.00), and longest root (29.67 cm). Mortality was lowest in M2 and G4, indicating their suitability for better survival during hardening. The positive impact of vermiculite is attributed to its aeration, water retention, and nutrient-holding capacity, while IBA enhanced cell division and elongation, improving overall root and shoot development. The findings align with earlier studies in various crops, confirming the effectiveness of sand + vermiculite media and higher IBA concentrations. Thus, using sand and vermiculite as rooting media along with 2000 ppm IBA is recommended for optimal propagation of pomegranate cuttings, ensuring better survival, rooting efficiency, and plant vigor.

**Disclaimer (Artificial intelligence)**

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Details of the AI usage are given below:

1.

2.

3.

**Table 1** Effect of rooting media and IBA treatment on number of shoots per cutting of hardwood cuttings in pomegranate cv. Bhagwa.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **No. of shoots per cutting** | | | | | | | | | | | | | | | |
| **Rooting Media (M)** | **AT 30 DAP** | | | | **Mean** | **AT 60 DAP** | | | | **Mean** | **AT 90 DAP** | | | | **Mean** |
| **IBA Treatment (G)** | | | | **IBA Treatment (G)** | | | | **IBA Treatment (G)** | | | |
| **0**  **PPM (G1)** | **1000**  **PPM (G2)** | **1500**  **PPM (G3)** | **2000**  **PPM (G4)** | **0**  **PPM (G1)** | **1000**  **PPM (G2)** | **1500**  **PPM (G3)** | **2000**  **PPM (G4)** | **0**  **PPM (G1)** | **1000**  **PPM (G2)** | **1500**  **PPM (G3)** | **2000**  **PPM (G4)** |
| **Sand+ Vermicompost (M1)** | 1.00 | 1.87 | 1.33 | 1.20 | **1.35** | 1.00 | 1.33 | 1.67 | 2.67 | **1.67** | 1.33 | 1.67 | 2.33 | 3.33 | **2.17** |
| **Sand+ Vermiculite (M2)** | 1.73 | 1.73 | 1.87 | 2.20 | **1.88** | 1.33 | 2.00 | 2.67 | 3.33 | **2.33** | 1.67 | 2.67 | 3.67 | 5.67 | **3.42** |
| **Sand+ Vermiculite + Vermicompost (M3)** | 1.53 | 1.87 | 1.67 | 2.13 | **1.80** | 1.00 | 1.67 | 2.00 | 2.33 | **1.75** | 1.67 | 2.67 | 3.33 | 3.67 | **2.84** |
| **Mean** | **1.42** | **1.82** | **1.62** | **1.84** | 1.68 | **1.11** | **1.67** | **2.11** | **2.78** | 1.92 | **1.56** | **2.34** | **3.11** | **4.22** | 2.81 |
| **Factor** | M | G | M x G | | | M | G | M x G | | | M | G | M x G | | |
| **Sem+** | 0.11 | 0.13 | 0.22 | | | 0.08 | 0.09 | 0.16 | | | 0.23 | 0.27 | 0.47 | | |
| **CD at 5%** | 0.23 | 0.27 | 0.46 | | | 0.46 | 0.19 | 0.33 | | | 0.48 | 0.56 | 0.97 | | |

**Table 2** Effect of rooting media and IBA treatment on length of longest shoot of hardwood cuttings in pomegranate cv. Bhagwa.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Length of longest shoot per cutting (cm)** | | | | | | | | | | |
| **Rooting Media (M)** | **AT 60 DAP** | | | | **Mean** | **AT 90 DAP** | | | | **Mean** |
| **IBA Treatment (G)** | | | | **IBA Treatment (G)** | | | |
| **0**  **PPM (G1)** | **1000**  **PPM (G2)** | **1500**  **PPM (G3)** | **2000**  **PPM (G4)** | **0**  **PPM (G1)** | **1000**  **PPM (G2)** | **1500**  **PPM (G3)** | **2000**  **PPM (G4)** |  |
| **Sand+ Vermicompost (M1)** | 6.00 | 11.00 | 11.83 | 13.83 | **10.67** | 7.67 | 17.67 | 23.67 | 25.33 | **18.59** |
| **Sand+ Vermiculite (M2)** | 9.17 | 10.67 | 15.00 | 19.00 | **13.46** | 12.17 | 20.67 | 25.33 | 32.33 | **22.63** |
| **Sand+ Vermiculite + Vermicompost (M3)** | 6.67 | 10.83 | 12.67 | 14.67 | **11.21** | 11.00 | 14.33 | 22.00 | 27.67 | **18.75** |
| **mean** | **7.28** | **10.83** | **13.17** | **15.83** | 11.78 | **10.28** | **17.56** | **23.67** | **28.44** | 19.99 |
| **Factor** | M | G | M x G | | | M | G | M x G | | |
| **Sem+** | 0.27 | 0.31 | 0.55 | | | 0.76 | 0.86 | 1.49 | | |
| **CD at 5%** | 0.57 | 0.65 | 1.14 | | | 1.53 | 1.77 | 3.07 | | |

**Table 3** Effect of rooting media and IBA treatment on percentage of mortality during hardening process of hardwood cuttings in pomegranate cv. Bhagwa.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Percentage of mortality during Hardening process @90 DAP** | | | | | |
| **Rooting Media (M)** | **IBA Treatment (G)** | | | | |
| **0 PPM (G1)** | **1000 PPM (G2)** | **1500 PPM (G3)** | **2000 PPM (G4)** | **Mean** |
| **Sand+ Vermicompost (M1)** | 49.79 | 37.55 | 30.95 | 24.44 | **35.68** |
| **Sand+ Vermiculite (M2)** | 44.29 | 32.68 | 30.17 | 15.98 | **30.78** |
| **Sand+ Vermiculite + Vermicompost (M3)** | 40.60 | 31.87 | 29.52 | 13.65 | **28.91** |
| **Mean** | **44.89** | **34.03** | **30.21** | **18.02** |  |
| Factor | M | G | M x G | | |
| Sem+ | 2.77 | 3.20 | 5.55 | | |

|  |  |  |  |
| --- | --- | --- | --- |
| CD at 5% | 5.73 | 6.62 | NS |

**Table 4** Effect of rooting media and IBA treatment on percentage of rooted cuttings in pomegranate cv. Bhagwa at 30 DAP.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Percentage of rooted cuttings at 30 DAP** | | | | | |
| **Rooting Media (M)** | **IBA Treatment (G)** | | | | **Mean** |
| **0 PPM (G1)** | **1000 PPM (G2)** | **1500**  **PPM (G3)** | **2000 PPM (G4)** |
| **Sand+ Vermicompost (M1)** | 66.67 | 73.33 | 76.67 | 83.33 | **75.00** |
| **Sand+ Vermiculite (M2)** | 75.00 | 88.33 | 91.67 | 96.67 | **87.92** |
| **Sand+ Vermiculite + Vermicompost (M3)** | 71.67 | 76.67 | 78.33 | 86.67 | **78.34** |
| **Mean** | **71.11** | **79.44** | **82.22** | **88.89** |  |
| **Factor** | M | G | M x G | | |
| **Sem+** | 1.40 | 1.61 | 2.80 | | |
| **CD at 5%** | 2.89 | 3.34 | NS | | |

**Table 5** Effect of rooting media and IBA treatment on number of primary and secondary roots per cutting of hardwood cuttings in pomegranate cv. Bhagwa at 90 DAP.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Number of Primary & Secondary roots** | | | | | | | | | | |
| **Rooting Media (M)** | **Primary roots** | | | | **Mean** | **Secondary roots** | | | | **Mean** |
| **IBA Treatment (G)** | | | | **IBA Treatment (G)** | | | |
| **0**  **PPM (G1)** | **1000**  **PPM (G2)** | **1500**  **PPM (G3)** | **2000**  **PPM (G4)** | **0**  **PPM (G1)** | **1000**  **PPM (G2)** | **1500**  **PPM (G3)** | **2000**  **PPM (G4)** |
| **Sand+**  **Vermicompost (M1)** | 2.33 | 3.00 | 3.33 | 7.33 | **4.00** | 13.67 | 21.00 | 35.33 | 36.00 | **26.50** |
| **Sand+ Vermiculite**  **(M2)** | 2.67 | 6.00 | 6.67 | 11.00 | **6.59** | 18.33 | 37.33 | 41.67 | 48.00 | **36.33** |
| **Sand+ Vermiculite**  **+ Vermicompost (M3)** | 3.00 | 4.33 | 4.67 | 9.00 | **5.25** | 21.67 | 29.67 | 24.33 | 43.00 | **29.67** |
| **Mean** | **2.67** | **4.44** | **4.89** | **9.11** |  | **17.89** | **29.33** | **33.78** | **42.33** |  |
| **Factor** | M | G | M x G | | | M | G | M x G | | |
| **Sem+** | 0.34 | 0.39 | 0.68 | | | 1.75 | 2.03 | 3.51 | | |
| **CD at 5%** | 0.7 | 0.81 | 1.4 | | | 3.62 | 4.19 | 7.25 | | |

**Table 6** Effect of rooting media and IBA treatment on length of longest root per cutting of hardwood cuttings in pomegranate cv. Bhagwa at 60 and 90 DAP

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Length of longest root per cutting (cm)** | | | | | | | | | | |
| **Rooting Media (M)** | **AT 60 DAP** | | | | **Mean** | **AT 90 DAP** | | | | **Mean** |
| **IBA Treatment (G)** | | | | **IBA Treatment (G)** | | | |
| **0**  **PPM (G1)** | **1000**  **PPM (G2)** | **1500**  **PPM (G3)** | **2000**  **PPM (G4)** | **0**  **PPM (G1)** | **1000**  **PPM (G2)** | **1500**  **PPM (G3)** | **2000**  **PPM (G4)** |
| **Sand+**  **Vermicompost (M1)** | 1.17 | 4.67 | 4.70 | 5.33 | **3.97** | 13.33 | 22.00 | 23.33 | 25.83 | **21.12** |
| **Sand+**  **Vermiculite (M2)** | 3.83 | 4.33 | 5.00 | 6.67 | **4.96** | 16.67 | 21.67 | 26.00 | 29.67 | **23.50** |
| **Sand+ Vermiculite + Vermicompost**  **(M3)** | 1.67 | 5.33 | 5.50 | 5.67 | **4.54** | 16.83 | 18.17 | 23.17 | 27.50 | **21.42** |
| **Mean** | **2.22** | **4.78** | **5.07** | **5.89** | 4.49 | **15.61** | **20.61** | **24.17** | **27.67** | 22.01 |
| **Factor** | M | G | M x G | | | M | G | M x G | | |
| **Sem+** | 0.10 | 0.12 | 0.21 | | | 0.57 | 0.66 | 1.14 | | |
| **CD at 5%** | 0.21 | 0.25 | 0.43 | | | 1.18 | 1.36 | 2.37 | | |



Fig 1. Effect of rooting media and IBA treatment on length of longest root per cutting of hardwood

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