



Rooting Hormone and Substrate Effects on Mini-Cloned Mulberry (*Morus indica*)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Manipulation of propagation is a common practice in many commercial plant to obtain healthy and resistance plant for good yield. Many propagation techniques such as cutting, grafting, layering were evolved focusing on low budget production of high quality planting materials. An experiment was conducted to focus on standardizing a sound protocol for mini clonal propagation of *M. indica* variety V1. Among different concentrations of growth hormones evaluated, apical cuttings treated with IBA at 3000 ppm recorded significantly higher sprouting per cent (82.39%), rooting per cent (63.27%), survival per cent (68.80%), root length (22.22 cm), shoot length (22.05 cm), number of roots (14.40) and number of leaves (18.30) followed by NAA at 4000 ppm. Besides that, various

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rooting medium used, Soil: Coir pith: FYM (1:1:1) registered superior in survival per cent (14.26%), sprouting per cent (67.50%), rooting per cent (38.77%) and number of roots (12.45) whereas Soil: Sand: Vermicompost (1:1:1) registered maximum performance in shoot length (16.98 cm), root length (16.42 cm) and number of leaves (14.18). Hence it was clearly evident that IBA at 3000 ppm treated plants raised under Soil: Coir pith: FYM medium suitable for mass multiplication of *M. indica*.

Keywords: Mulberry; mini clone; rooting hormone; rooting media.

ABBREVIATIONS

DAP : Days After Planting;
FYM : farmyard Manure;
IBA : Indole-3-butyric acid;
MT : Metric Tone;
NAA : Naphthalene acetic acid;
V1 : Victory 1;
WP : Wettable Powder.

1. INTRODUCTION

Mulberry (*Morus*) belongs to the family Moraceae. Morphologically mulberry is a fast growing, deciduous woody perennial tree, with deep rooting system. There are about 68 species reported in genus *Morus* and majority of them occur in Asia, especially in China (24 species) and Japan [1]. Continental America is also rich in *Morus* species and poorly reported from Africa, Europe and Middle East, and absent in Australia [2]. On the other hand in India, there are many species of *Morus* are present like *M. alba*, *M. indica*, *M. serrata* and *M. laevigata* are grow wild in the Himalayas. Several varieties have been introduced belonging to *M. multicaulis*, *M. nigra*, *M. sinensis* and *M. phillippinensis*. Most of the mulberry varieties cultivated in India belongs to *M. indica* types. In the world out of 68 mulberry species have been reported [3] only 16 species performs well in terms of leaf, fruit and timber production [4]. In India mulberry has been cultivated throughout the year especially in southern states namely Karnataka, Andhra Pradesh, Tamil Nadu and Telangana.

Mulberry has potential economic importance in developing countries in Asia, where sericulture is an important industry. The silkworm, *Bombyx mori* L., solely feeds on the leaf of mulberry therefore sustainability of sericulture heavily depends on the production of high-quality mulberry leaf. Mulberry is preferred due to its leaf yield, delicious fruit yield and some species have medicinal and ornamental properties and others are used due to their environmental adaptability [5]. Mulberry is one of the most economically important tree crops whereas Man's interest in

mulberry cultivation originated with the growth of civilization and his fascination for quality fabric that led him search for silk.

Mulberry is generally propagated by sexual and asexual method. Sexual propagation is done through seeds and asexual propagation includes cutting, grafting and layering. Different methods of vegetative propagation are widely followed in different countries according to the environmental conditions and soil nature [6]. Though propagation through stem cutting is easy, it has some restrictions viz., low rooting potential, less number of harvests per plant and long juvenile period. Additional problem involved in developing saplings in nursery is the maintenance and management cost for 3-6 months [7]. There are several factors which can affect the rooting potential of stem cuttings include the nature of species, cultivar needs, source, condition of stock plant and pest and disease attack. Besides these growing conditions such as media, mist, bottom heat, use of hormones, fertilizer and supplemental lighting are also significantly influenced [8]. In order to overcome these limitations, it is planned to establish an alternate method which mulberry can be propagated rapidly in a cost-effective way.

Mini clonal technology is a technique which helps in the production of large number of plants in short time with limited space. Mini clone cuttings showed enhanced rooting potential, rooting speed, and quality root system with reduced cost when compared to stem cuttings. Additionally, this system offer propagules with increased uniformity and reduced topophysis effect [9]. There are many tree species has been successfully propagated by mini cutting technique viz., *Melia dubia*, *Casuarina sp.*, *Eucalyptus sp.*, *Tectona grandis* and *Dalbergia sissoo* reported by Parthiban et al. [10]. When compare to the traditional stem-cutting method of propagation, mini-cuttings have many advantages leading to operational, technical, economic, environmental and quality benefits.

The labour cost is reduced, due to elimination of labour intensive operations. Many agronomic practices like soil preparation, irrigation, fertilizer application, weeding, pest and disease management, cuttings transport etc. can be done with less manpower in smaller indoor areas at very lower costs, where the amount of chemicals used is also drastically reduced [11].

Thus various studies have been carried out in growth of mulberry using stem cuttings but only scanty of information is available on propagation of mini cuttings. With this backdrop, an attempt has been made to develop Mini clonal technology in mulberry cultivation with the following objectives, to determine the rooting hormone for clonal propagation of *M. indica* and optimize the suitable rooting medium for clonal propagation of *M. indica*.

2. MATERIALS AND METHODS

2.1 Selection of Mother Plant

Mulberry variety V1 is one among the popular varieties of India. It is developed by Central Sericultural Research and Training Institute in Mysore. Its leaves are large, thick, smooth, glossy dark green and ovate and claimed to be resistant against leaf spot and moderately resistant to leaf rust disease. It has high photosynthetic efficiency with an yield potential of 60 MT/ha/yr. It depends on the type of soil, climate and availability of water. Though it is ruling variety most of farmers much prefer V1 as foliage for silkworm. Owing to these advantages, it was decided to use V1 as mother source to harvest propagules for mini clonal propagation [12].

2.2 Preparation of Stem Cuttings

Semi hard wood cuttings were excised from selected V1 mulberry variety. The cuttings were further trimmed to a length of approximately 15 cm with minimum three to four active buds. A slanting cut was given at the basal part of all cuttings and they were treated with 0.2 per cent Carbendazim 50% WP for 10 minutes. Treated cuttings were planted in nursery bed and each bed was accommodated with 90 cuttings [13].

2.3 Nursery Bed Preparation

Before commencement of experiment, the field was ploughed to make the soil fine and suitable for establishing mother garden. Two beds of 2m

× 1m size were prepared and each bed was enriched with 1kg of FYM, 500g of *Trichoderma viride* and 500g of *Pseudomonas fluorescense* [14].

2.4 Preparation of Mini Cuttings

Apical shoot cuttings were collected from mother plant and mini-cuttings were harvested using sterile pruning scissors during early morning hours from the shoots. All leaves in the shoot, except two leaves near the apical point were removed before using it for different hormonal treatments. A 45° angle slanting cut was made at the base of all the apical cuttings. After preparation, cuttings were given a prophylactic treatment against fungal disease using aqueous solution of 0.2 per cent Carbendazim 50 % WP for 20 minutes, subsequently washed with distilled water. After fungicidal treatment mini cuttings were subjected to various auxin treatments such as IBA and NAA [15]. Further, the apical shoot cuttings were also dipped in 0.2 per cent Dichlorovos solution 76 % EC to control the leaf webber for 2 minutes.

2.5 Rooting Hormone and its Concentration for Growth of Mini Cuttings

Auxin is one of the major endogenous hormones known to be intimately involved in the process of adventitious rooting [16]. The prepared apical shoot cuttings were treated with various rooting hormones such as Indole Butyric Acid and Naphthalene Acetic Acid powder for 15 minutes. Different concentration of rooting hormones viz., 1000, 2000, 3000, 4000 and 5000 ppm were used. The preparation of rooting hormone requires IBA and NAA powder, Boric acid crystal, Bavistin powder and talc powder. For 1000, 2000, 3000, 4000, 5000 ppm of selected concentration needs 0.1g, 0.2g, 0.3g, 0.4g, 0.5g of hormone using 100g of talc based formation. Selected Mini-cuttings were dipped in the rooting hormone and planted in polybags and raised under polytunnel. Observations on growth attributes viz., shoot length, root length, number of leaves and numbers of roots were taken at 90 DAP.

2.6 Optimize the Rooting Medium for Mini Clonal Propagation

After auxin treatment the apical shoot cuttings were planted in polybags containing different rooting medium. The 1/3 basal cut portion was

inserted in different rooting media using sticking technique [17]. In order to make complete wetting on entire cut surface, holes were made in each bag to avoid the damage of cambium and to prevent the removal of rooting hormone. Later the cuttings were planted in rooting medium are kept inside the low cost poly tunnels under shade net. Irrigation was done once in a week in order to maintain desired humidity of 80 to 90 per cent. The temperature in the poly tunnel was maintained at $33 \pm 1^\circ\text{C}$. The studies were conducted in Factorial Completely Randomized Design (FCRD) with four replications, with 15 cuttings per replication. Most of the cuttings started rooting on 15 days after planting. The detailed accounts of treatments were given below.

Chart 1. The treatment details

| Treatment | Rooting hormone | Concentration |
|----------------|--------------------------|-------------------------------------|
| T ₁ | IBA | 0, 1000, 2000, 3000, 4000, 5000 ppm |
| T ₂ | NAA | 0, 1000, 2000, 3000, 4000, 5000 ppm |
| | Rooting Media Mixture | Ratio |
| M1 | Soil | - |
| M2 | Soil+ Sand+ FYM | 1:1:1 |
| M3 | Soil+ Coir pith | 1:1 |
| M4 | Soil+ Sand+ Vermicompost | 1:1:1 |
| M5 | Soil+ Coir pith+ FYM | 1:1:1 |

2.7 Observations Recorded

Sprouting percentage

$$\text{Sprouting percentage} = \frac{\text{Number of cuttings sprouted}}{\text{Number of cuttings planted}} \times 100$$

Rooting per cent

$$\text{Rooting percentage} = \frac{\text{Number of rooted cuttings}}{\text{Number of cuttings planted}} \times 100$$

Survival percentage

$$\text{Survival percentage} = \frac{\text{Number of cuttings survived}}{\text{Number of cuttings planted}} \times 100$$

Root length:

The rooted cuttings were washed in water to remove the medium without disturbing the root system. The root length of each plant was initially measured from the terminal end of the shoot to the tip of the root using standard scale and expressed in cm.

Number of roots per cutting:

Number of roots was calculated by counting lateral roots present in a mini shoot.

Shoot length:

The shoot length was measured from the point of shoot initiation to tip of the shoot and expressed in cm.

Number of leaves per cutting:

Total number of leaves produced by mini cuttings was counted numerically.

2.8 Statistical Design

All data were subjected to statistical analysis to assess the possible relationship between different parameters and analysis of variance was employed in nursery by adopting Factorial Completely Randomized Design. The stage wise data were analyzed separately using AGRES software.

3. RESULTS AND DISCUSSION

Auxin is one of the major endogenous hormones involved in the process of adventitious rooting [16] and the physiological stages of rooting are associated with changes in auxin concentration [18]. Adventitious root formation in stem cuttings is a crucial physiological process for clonal propagation of many plant species. In the present study IBA @ 3000 ppm reigned best in growth traits viz., sprouting percentage (82.39%), survival percentage (68.80%), rooting percentage (63.27%), number of leaves (18.30), number of roots (14.40), root length (22.22 cm) and shoot length (22.05 cm) (Fig. 1). Usually exogenous application of auxins viz., IBA and NAA are recommended for promoting adventitious roots in stem cutting propagation of many shrubs [19] and tress [11]. Current study revealed that among two different rooting hormones (IBA and NAA) used, IBA concentration recorded better survival

percentage. IBA @ 3000 ppm noted to be the highest survival per cent (68.80%) followed by NAA @ 4000 ppm (57.72%) (Fig. 3). These results are agreed with Rahdari et al. [1] in *Aralia* semi-wood cuttings. High survival per cent is considered due to care requirement in propagation unit.

Koyuncu and Senel [20] found the highest survival per cent (80.00%) in black mulberry. In addition to that, IBA @ 3000 ppm registered the maximum survival per cent (74.33%) in *Psidium guajava* cuttings reported by Rani et al. [21]. The increased survival per cent is due to increase in number and length of root due to effective intake of nutrients and water [22]. Similar studies were reported by Abdullah et al. [23] and Sukhjit [24] in hardwood cuttings of guava and peach. In the present investigation IBA @ 3000 ppm showed the highest sprouting of 82.39 per cent followed by NAA @ 4000 ppm was 68.44 per cent and IBA @ 2000 ppm was 66.35 per cent. Similar to present findings of Singh *et al.* [25] mulberry cuttings treated with IBA @ 2000 ppm are obtained maximum number of sprouted cuttings (9.67) followed by NAA @ 2000 ppm (5.67). This might be due to better root growth, absorption and translocation of nutrients to plant parts [26]. In addition to that, Husen [27]; Husen [28] reported similar findings in *Tectona grandis*.

In general hormone application promotes and increases the root formation. In the present study different concentrations of IBA and NAA were used, IBA at 3000 ppm recorded the highest rooting per cent compared to other treatments. Rooting in IBA @ 3000 ppm was 74.00 per cent followed by NAA @ 4000 ppm was 39.00 per cent (Table 1, Fig. 2). Kalyoncu *et al.* [29] observed the highest rooting per cent [100%] was obtained from the application of IBA at 3000 ppm in black mulberry cuttings. This findings were also supported by Koyuncu and Senel [20] who reported that black mulberry cuttings treated with 5 g/lit IBA in bunch planting method suited for its better rooting. The increase in auxin concentrations led to increase in rooting per cent in oleander plant up to 3000 ppm IBA and subsequent increase in IBA leads to decrease in rooting reported by Habibi et al. [30]. A higher dose of auxin (200 ug per cutting) shows inhibition in rooting of certain clones of *Triphlochiton scleroxylon* cuttings [31].

Similarly, when auxin concentration increases beyond 3000 ppm rooting was found to be decreased. On contrary to this study auxin

application increased the rooting per cent in tree species [24, 32] in *Bougainvillea glabra*; [33] in *Citrus lemon* cv. Cuttings; [34] in teak mini cuttings). The study reported that maximum number of roots recorded in IBA treated plants compared to NAA. IBA @ 3000 ppm registered maximum number of roots (14.40) at 90 DAP followed by NAA @ 4000 ppm (12.45) (Table 2). These results are in accordance to findings of Rani et al. (2018) who reported that apical cuttings treated with IBA (3000 ppm) produced more number of roots in *Psidium guajava* and this could be due to accumulation of essential internal substances and facilitates downward movement of nutrients to roots.

The present investigation is in consonance with Ullah et al. [35] who stated that induction of more roots in cuttings due to stimulation of cambium activity by hormonal application in many species. The variation in dose response to the number of roots might also be attributed to the varietal and climatic differences in the location [36]. Among all treatments IBA recorded maximum root length. At 90 DAP the maximum root length registered in IBA at 3000 ppm was 22.22 cm followed by NAA at 4000 ppm (20.62 cm). Similar observations were made by Singh [37] in mulberry reported that maximum root length was influenced by hormonal application. According to Ghatnatti [38] maximum root length was possible to the action of auxin activity due to hydrolysis and translocations of carbohydrates towards base of cuttings are lead to cell division and elongation. This result falls in line with Baroudi *et al.* [39] who reported that softwood cuttings of mulberry (*M. alba*) treated with IBA (2000 ppm) produced good root length, more number of roots and rooting per cent. The present findings are also similar to the observations of Galavi *et al.* [40] in *Vitis vinifera* and Kumar [41] in *Melia dubia*.

In the present investigation, at 90 DAP, IBA at 3000 ppm recorded the maximum number of leaves (18.30) followed by NAA at 4000 ppm (12.05) (Table 3). This result are in line with findings of Pallavi *et al.* [36] who recorded the increase in number of leaves, more number of roots, plant height and more number of branches at 2000 ppm of IBA in mulberry cuttings. Similarly the positive influence of IBA on number of leaves might be due to activation of shoot growth led to an increased number of active nodes and similar conclusions were also given by Wahab et al. [42] in *Psidium guajava* L. cuttings, Siddiqui and Hussain [43] in *Ficus Hawaii* cuttings, Alam et al.

[44] in Kiwi cuttings which supports the current study.

The maximum shoot length of 22.05 recorded in IBA at 3000 ppm at 90 DAP followed by NAA at 4000 ppm (21.51 cm). This increase in shoot length may be due to geotropism effect. These

results are in agreement with Kiruthika [14] who found that *M. sinensis* mini cuttings treated with IBA at 5000 ppm showed the maximum shoot length (22.65 cm) at 90 DAP. In addition to that similar findings were also reported in *D. sissoo* [45]; *Tectona grandis* [46] and other plant species.

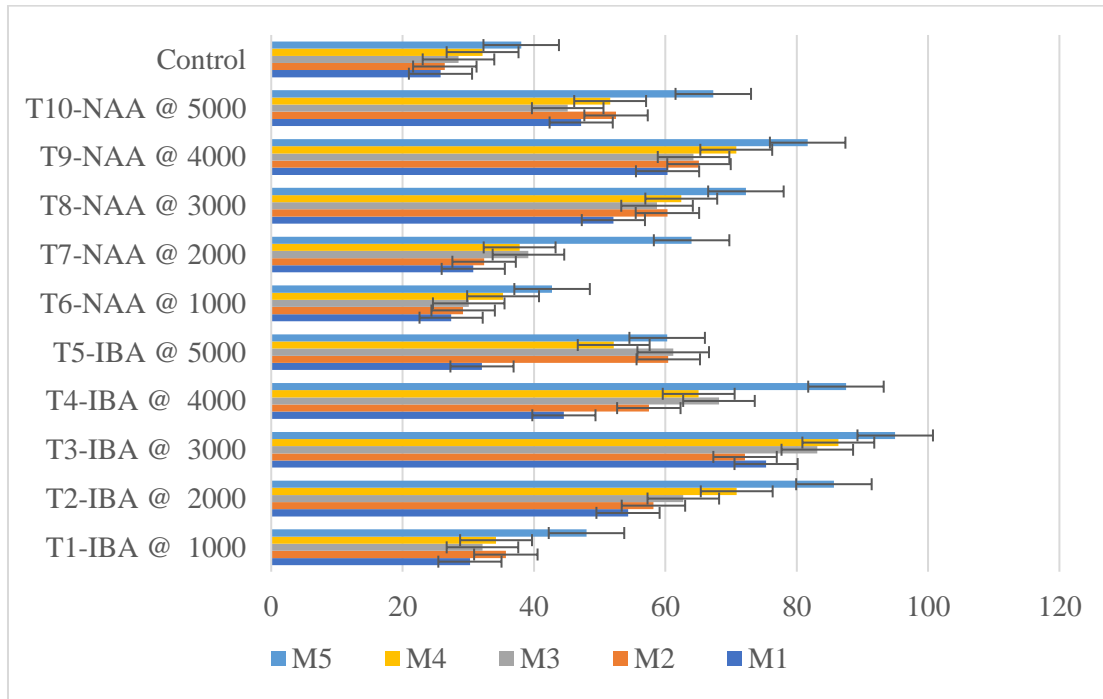


Fig. 1. Interaction of rooting hormone and rooting medium on sprouting per cent of *M. indica*
 M1- Soil M2- Soil: Sand: FYM (1:1:1) M3- Soil: Coir pith (1:1) M4- Soil: Sand: Vermicompost (1:1:1) M5- Soil: Coir pith: FYM (1:1:1)

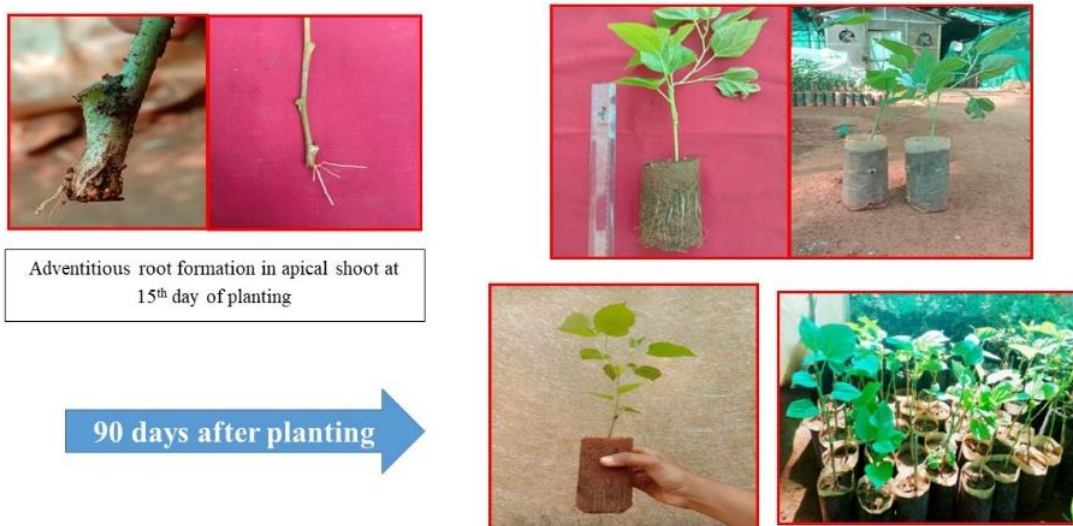


Fig. 2. Root formation in mini clone cuttings in mulberry

Table 1. Effect of rooting hormone and rooting medium on rooting per cent of *M. indica*

| Treatments | Shoot Length | | | | | | Number of roots | | | | | |
|-------------|--------------|--------------|--------------|--------------|--------------|--------------|-----------------|--------------|-------------|--------------|--------------|--------------|
| | M1 | M2 | M3 | M4 | M5 | Mean | M1 | M2 | M3 | M4 | M5 | Mean |
| IBA @ 1000 | 11.63 | 12.72 | 10.70 | 14.05 | 13.11 | 12.44 | 8.25 | 9.00 | 8.00 | 10.00 | 11.50 | 9.35 |
| IBA @ 2000 | 15.03 | 16.00 | 14.23 | 18.37 | 16.22 | 15.97 | 11.00 | 12.25 | 10.50 | 13.50 | 14.25 | 12.30 |
| IBA @ 3000 | 19.77 | 20.08 | 18.60 | 26.11 | 25.70 | 22.05 | 13.25 | 14.50 | 12.50 | 15.25 | 16.50 | 14.40 |
| IBA @ 4000 | 13.82 | 14.73 | 12.20 | 16.81 | 15.81 | 14.67 | 10.50 | 12.00 | 9.25 | 13.00 | 13.25 | 11.60 |
| IBA @ 5000 | 12.51 | 13.22 | 11.21 | 15.90 | 14.58 | 13.48 | 9.75 | 11.25 | 9.00 | 11.75 | 12.50 | 10.85 |
| NAA@ 1000 | 10.54 | 11.56 | 10.00 | 12.11 | 11.98 | 11.23 | 8.25 | 8.50 | 7.75 | 9.00 | 9.50 | 8.50 |
| NAA@ 2000 | 11.22 | 12.10 | 10.03 | 13.30 | 12.56 | 11.84 | 8.50 | 8.75 | 8.00 | 9.25 | 10.00 | 8.90 |
| NAA@ 3000 | 15.23 | 15.01 | 14.32 | 16.82 | 16.07 | 15.49 | 9.75 | 10.25 | 9.25 | 11.00 | 12.00 | 10.45 |
| NAA@ 4000 | 20.06 | 21.33 | 19.38 | 24.06 | 22.71 | 21.50 | 12.25 | 12.00 | 10.00 | 13.50 | 14.50 | 12.45 |
| NAA@ 5000 | 14.78 | 15.16 | 13.33 | 15.91 | 15.22 | 14.88 | 12.00 | 11.50 | 9.00 | 12.50 | 13.00 | 11.60 |
| Control | 11.22 | 11.86 | 10.60 | 13.35 | 12.94 | 11.99 | 8.00 | 8.75 | 7.75 | 9.25 | 10.00 | 8.75 |
| Mean | 14.16 | 14.88 | 13.14 | 16.98 | 16.08 | 15.05 | 10.13 | 10.80 | 9.18 | 11.63 | 12.45 | 10.84 |
| | | T | = 0.089 | | T | = 0.176* | | T | = 0.070 | | T | = 0.138* |
| | SE(d) | M | = 0.060 | CD | M | = 0.118* | SE(d) | M | = 0.047 | CD | M | = 0.093* |
| | | T×M | = 0.199 | | T×M | = 0.393* | | T×M | = 0.157 | | T×M | = 0.310* |

*Significant @ 5% level, Each value is the mean of four replications M1- Soil M2- Soil: Sand: FYM (1:1:1) M3- Soil: Coir pith (1:1) M4- Soil: Sand: Vermicompost (1:1:1) M5- Soil: Coir pith: FYM (1:1:1)

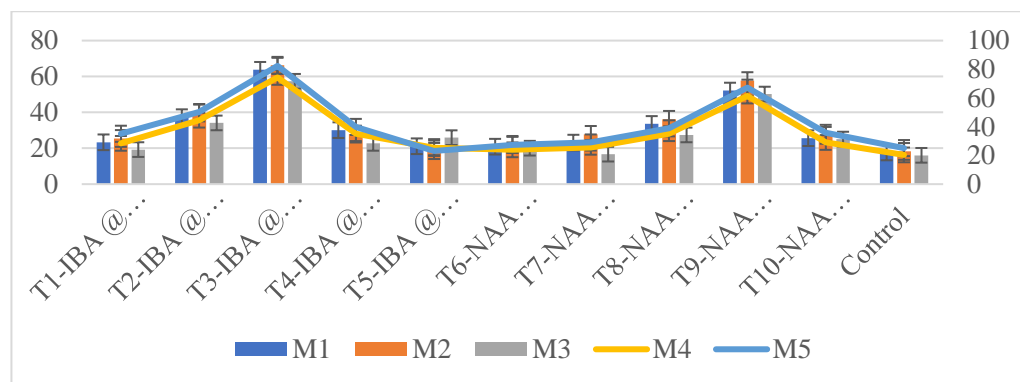


Fig. 3. Interaction of rooting hormone and rooting medium on survival per cent of *M. indica*

Table 2. Effect of rooting hormone and rooting medium on Shoot length and number of roots of *M. indica*

| Treatments | Shoot Length | | | | | | Number of roots | | | | | |
|-------------|--------------|--------------|--------------|--------------|--------------|--------------|-----------------|--------------|-------------|--------------|--------------|--------------|
| | M1 | M2 | M3 | M4 | M5 | Mean | M1 | M2 | M3 | M4 | M5 | Mean |
| IBA @ 1000 | 11.63 | 12.72 | 10.70 | 14.05 | 13.11 | 12.44 | 8.25 | 9.00 | 8.00 | 10.00 | 11.50 | 9.35 |
| IBA @ 2000 | 15.03 | 16.00 | 14.23 | 18.37 | 16.22 | 15.97 | 11.00 | 12.25 | 10.50 | 13.50 | 14.25 | 12.30 |
| IBA @ 3000 | 19.77 | 20.08 | 18.60 | 26.11 | 25.70 | 22.05 | 13.25 | 14.50 | 12.50 | 15.25 | 16.50 | 14.40 |
| IBA @ 4000 | 13.82 | 14.73 | 12.20 | 16.81 | 15.81 | 14.67 | 10.50 | 12.00 | 9.25 | 13.00 | 13.25 | 11.60 |
| IBA @ 5000 | 12.51 | 13.22 | 11.21 | 15.90 | 14.58 | 13.48 | 9.75 | 11.25 | 9.00 | 11.75 | 12.50 | 10.85 |
| NAA@ 1000 | 10.54 | 11.56 | 10.00 | 12.11 | 11.98 | 11.23 | 8.25 | 8.50 | 7.75 | 9.00 | 9.50 | 8.50 |
| NAA@ 2000 | 11.22 | 12.10 | 10.03 | 13.30 | 12.56 | 11.84 | 8.50 | 8.75 | 8.00 | 9.25 | 10.00 | 8.90 |
| NAA@ 3000 | 15.23 | 15.01 | 14.32 | 16.82 | 16.07 | 15.49 | 9.75 | 10.25 | 9.25 | 11.00 | 12.00 | 10.45 |
| NAA@ 4000 | 20.06 | 21.33 | 19.38 | 24.06 | 22.71 | 21.50 | 12.25 | 12.00 | 10.00 | 13.50 | 14.50 | 12.45 |
| NAA@ 5000 | 14.78 | 15.16 | 13.33 | 15.91 | 15.22 | 14.88 | 12.00 | 11.50 | 9.00 | 12.50 | 13.00 | 11.60 |
| Control | 11.22 | 11.86 | 10.60 | 13.35 | 12.94 | 11.99 | 8.00 | 8.75 | 7.75 | 9.25 | 10.00 | 8.75 |
| Mean | 14.16 | 14.88 | 13.14 | 16.98 | 16.08 | 15.05 | 10.13 | 10.80 | 9.18 | 11.63 | 12.45 | 10.84 |
| | SE(d) | T | = 0.089 | CD | T | = 0.176* | SE(d) | T | = 0.070 | CD | T | = 0.138* |
| | M | = 0.060 | | M | = 0.118* | | M | = 0.047 | | M | = 0.093* | |
| | T×M | = 0.199 | | T×M | = 0.393* | | T×M | = 0.157 | | T×M | = 0.310* | |

*Significant @ 5% level, Each value is the mean of four replications, M1- Soil M2-Soil: Sand: FYM M3-Soil: Coir pith M4- Soil: Sand: Vermicompost M5- Soil: FYM: Coir pith

Table 3. Interaction of rooting hormone and rooting medium on Root length and number of leaves of *M. indica*

| Treatments | Root length | | | | | | Number of leaves | | | | | |
|-------------|--------------|--------------|--------------|--------------|--------------|--------------|------------------|-------------|-------------|--------------|--------------|--------------|
| | M1 | M2 | M3 | M4 | M5 | Mean | M1 | M2 | M3 | M4 | M5 | Mean |
| IBA @ 1000 | 12.76 | 13.04 | 11.70 | 15.93 | 14.13 | 13.51 | 5.50 | 6.50 | 5.00 | 8.25 | 7.75 | 6.60 |
| IBA @ 2000 | 14.03 | 14.79 | 13.40 | 17.75 | 15.27 | 15.05 | 12.00 | 12.75 | 10.50 | 14.75 | 13.50 | 12.70 |
| IBA @ 3000 | 20.37 | 22.91 | 18.76 | 26.03 | 23.03 | 22.22 | 15.75 | 18.50 | 14.75 | 22.50 | 20.00 | 18.30 |
| IBA @ 4000 | 13.33 | 14.27 | 12.11 | 16.71 | 15.13 | 14.31 | 11.50 | 12.00 | 10.00 | 13.25 | 12.75 | 11.90 |
| IBA @ 5000 | 11.70 | 12.89 | 10.99 | 12.33 | 12.76 | 12.13 | 5.25 | 6.00 | 5.00 | 7.50 | 6.75 | 6.10 |
| NAA@ 1000 | 8.10 | 10.22 | 7.91 | 11.74 | 11.02 | 9.79 | 7.00 | 7.50 | 6.50 | 9.00 | 8.25 | 7.65 |
| NAA@ 2000 | 8.22 | 10.78 | 8.04 | 12.83 | 11.94 | 10.36 | 7.50 | 8.00 | 7.00 | 9.25 | 8.50 | 8.05 |
| NAA@ 3000 | 12.67 | 13.33 | 10.76 | 16.43 | 14.60 | 13.55 | 9.00 | 9.50 | 8.50 | 13.50 | 10.25 | 10.15 |
| NAA@ 4000 | 19.38 | 20.07 | 18.20 | 23.01 | 22.43 | 20.62 | 11.50 | 12.00 | 10.75 | 17.50 | 14.75 | 13.30 |
| NAA@ 5000 | 11.13 | 13.02 | 10.11 | 15.17 | 14.33 | 12.75 | 8.50 | 9.00 | 8.00 | 12.00 | 10.00 | 9.50 |
| Control | 8.55 | 9.65 | 7.24 | 12.78 | 11.33 | 9.91 | 6.50 | 7.00 | 6.00 | 8.50 | 8.00 | 7.20 |
| Mean | 12.74 | 14.08 | 11.74 | 16.42 | 15.08 | 14.02 | 9.09 | 9.88 | 8.36 | 14.18 | 12.77 | 10.05 |
| | | T | = 0.085 | | T | = 0.168* | | T | = 0.062 | | T | = 0.122* |
| | SE(d) | M | = 0.057 | CD | M | = 0.113* | SE(d) | M | = 0.041 | CD | M | = 0.082* |
| | | T×M | = 0.190 | | T×M | = 0.375* | | T×M | = 0.138 | | T×M | = 0.273* |

4. CONCLUSION

In the present study ideal size of 7 to 8 cm mini apical cuttings of mulberry (variety-V1) were subjected to hormonal treatment for root induction. Two growth regulators viz., NAA and IBA at different concentrations (1000, 2000, 3000, 4000 and 5000 ppm) were used. Hormone treated mini cuttings were subjected to five different rooting medium viz., Soil, Soil: sand: FYM (1:1:1), Soil: coir pith (1:1), Soil: sand: vermicompost (1:1:1) and Soil: coir pith: FYM (1:1:1). Out of two growth regulators, cuttings treated with IBA 3000 ppm registered superiority in overall performance viz., survival percentage (68.80 %), sprouting percentage (82.39 %), rooting percentage (63.27 %), shoot length (22.05 cm), root length (22.22 cm), number of roots (14.40) and number of leaves (18.30) followed by NAA at 4000 ppm. In a holistic perspective, the study recommends that propagation of *M. indica* mini cuttings treated with IBA at 3000 ppm for better growth performance.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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