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REVIEW ARTICLE

Mulberry cutting propagation: A Review

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ABSTRACT
Mulberry (Morus sp.) is a crucial component of the sericulture industry as it serves as a primary food source for silkworms. Various methods, such as seeds, cuttings, budding, and grafting, can be employed for its propagation. Among these methods, cutting propagation offers significant advantages due to its high success rate and rapid establishment. In the establishment of mulberry, the use of plant growth regulators (PGRs) such as IBA and NAA, along with other chemicals, has proven to be particularly effective in preventing root sprouting in cuttings. Some cultivars of mulberry, despite their attractiveness, pose challenges in terms of rooting or have a low potential for root formation. In such cases, tissue culture techniques, specifically micropropagation, can be employed to multiply these difficult varieties. Micropropagation involves the creation of plants in vitro by providing suitable growth hormones and fulfilling their growth requirements, allowing for multiplication and regeneration under controlled conditions. By utilizing tissue culture techniques, it becomes possible to multiply challenging types of mulberry. Researchers and various literature sources have reported the effectiveness of using PGRs and PGRs in combination with other chemicals in the successful propagation of mulberry through cutting.
Keywords: Silkworm, Mulberry, Propagation

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INTRODUCTION

Morus alba, a member of the Moraceae family, is indigenous to temperate Asia. More than 100 recognised cultivars of the 68 species that make up the genus Morus are found across Asia, including 24 species discovered in China and 19 species discovered in Japan [5]. Three species of the genus are extensively dispersed worldwide: *Morus alba* (White Mulberry), *Morus nigra* (Black Mulberry), and *Morus rubra* (Red Mulberry). It is a perennial fruit tree that grows quickly and thrives in tropical, subtropical, and temperate areas [27]. While mulberries are cultivated everywhere, they are more widely spread in Karnataka, notably in Mysore, which is ideal for sericulture. The raising of silkworms for the creation of silk is a significant application of mulberry leaves. Additionally, it is utilised to make wood products including chairs, tables, sporting goods, and agricultural tools. Additionally, bark is utilised to create high-quality paper [13]. Mulberry fruits have certain medicinal properties, such as laxative and fever-refrigerant properties, as well as for sore throat, dyspepsia, and melancholia [28]. Leaves are regarded as diaphoretic and emollient, and a decoction of them is used as a gargle for throat inflammation. Roots and bark are purgative, anthelmintic, and astringent [27].

In comparison to other ways, stem cutting propagation of Mulberry is the simplest, most affordable, and fastest approach. The only propagation technique that yields plants that are true to type is vegetative propagation. Plants may be reproduced in vitro by vegetative propagation [9]. It significantly speeds up the propagation cycle while reducing genetic segregation caused by irregular seed output. Except for grafting, adventitious root (AR) formation is the most important phase in effective vegetative propagation. Improved uniformity and rapid availability to better clones are two advantages of vegetative reproduction for plantation operations [17]. Mulberry is commercially cultivated from hard wood cuttings due to unique features such as quick parent material multiplication and maintenance of the required plant properties. The production of ARs in mulberry cuttings demonstrates that soluble proteins, soluble sugars, antioxidant enzymes, and rooting-related enzymes undergo dramatic modifications during the rooting process [18].

Fruits from mulberries have some medicinal properties. To treat throat irritation, a decoction of leaves is used as a gargle. Leaves are said to be diaphoretic and emollient [10]. Roots and bark are purgative, anthelmintic, and astringent. Plant growth regulators are organic chemicals that are generated in minute quantities in specific plant sections and delivered to the location where they are needed, changing physiological responses. The production of mulberry leaves, which increases the supply of cocoons, is greatly influenced by plant growth regulator [8].

The best results came from IBA treatments employing the auxin hormone group. IBA has been found to be crucial for both softwood and hardwood cutting [7]. In the nursery industry, indole-3-butyric acid (IBA) and 1-naphthaleneacetic acid (NAA) are the most utilised root-promoting chemicals due to their nontoxicity at a variety of concentrations [25]. Under a concentration of IBA of 2000 ppm, the greatest proportion of rooted cuttings, length of roots, number of sprouted cuttings, and measurements of the longest root sprouts were all noted [27]. The greatest rooting percentage was seen at IBA concentrations of 2000 and 3000 ppm [14].

Effect of IBA on Mulberry stems cuttings

15 cm cuttings of the mulberry (*Morus alba* L.). Prior to planting the cuttings in the different rooting medium (Sand+ FYM, Vermicompost, and Cocopeat), the basal ends of the cuttings were immediately dipped in diluted solutions containing 1000ppm, 2000ppm, and 0ppm of IBA. The cuttings were immediately planted in root trainers after the treatment, 7.5 cm deep in the rooting medium. Vermicompost rooting medium with an IBA concentration of 2000 ppm shown to be the most effective after three months in the multiplication of Mulberry hard wood cuttings [4]. The effects of varied IBA concentrations (0, 3000, 4000, and 5000 ppm) and soaking in water for 24 hours on black mulberry (*Morus nigra* L.) hardwood cutting propagation. The interaction effects of the two parameters revealed that cuttings treated with 4000 ppm IBA and immersed in water for 24 hours produced the most rooting (40%) and the highest other root and shoot traits were achieved in the same interaction as well [23]. Indole-3-butyric acid (IBA) in fast clonal proliferation of mulberry for larger biomass, large scale production and biochemical changes that appeared during roots. In a mist chamber, non-treated (control) and treated (1000, 2000, and 3000 IBA mg $^{L-1}$) soft stem cuttings were cultivated. Cuttings that had been treated with 3000 mg IBA $^{L-1}$ at 50 days had more roots, had more of them, and had longer roots than untreated cuttings [12].

Cuttings of *Morus alba* were taken from actively developing and were given different dosages of indole 3-butyric acid (100, 150, 200, 250, and 300 ppm) as treatments, with control maintained by immersing cuttings in distilled water. It was found that IBA @ 100 ppm is the best plant growth regulator to use for vegetative *Morus alba* proliferation now [23]. Mulberry hardwood cuttings were immersed in different concentrations of Indole-3-Butyric Acid solution. The results showed that planting cuttings on March 1st resulted in the highest percentage of rooted seedling (20.83%), followed by February 8th (16.33%) and March 22nd (12.5%). Cuttings treated with varying concentrations of IBA, success rate 58.33, 66.67, 50.00, and 20.83% for 2000, 1500, 1000, and 0ppm, respectively. The highest rates of rooting success (66.67%) were obtained from cuttings harvested on March 1st and soaked in 1500ppm of IBA solution [11]. Stem cuttings were treated to varying IBA concentrations (1000ppm, 2000ppm and 0ppm) and planting media (Sand+FYM, Vermicompost, and Cocopeat). Under 2000ppm IBA concentration, survival percentage (71.11%), rooting percentage (70.00), number of primary roots (10.77), and length of longest root (10.22 cm) were obtained. Under vermicompost planting media shows most effective [28]. Indole-3-butyric acid concentrations of 1000, 2000, and 3000 ppm on V-1 mulberry cuttings the effect of different IBA concentrations on mulberry cuttings with different bud sprout counts. We can advise using two budded cuttings treated with 3000 ppm of IBA rather than three budded cuttings, since the number of leaves (10.60) and length of the shoot (26.63 cm) were highest in two budded cuttings treated with 3000 ppm of IBA [22].

Effect of IBA and NAA on Mulberry Stem cuttings

Morus alba stem cuttings were treated in of 1000, 1500, and 2000 mg L^{-1}. Solutions of Indole-3-butyric acid and Naphthalene acetic acid using dipping method and these cuttings were rooted in a 1:1 combination of sandy soil and farmyard manure in plastic root trainers inside a mist house. IBA 2000 L-1 mg had the longest roots and cuttings on average, generated the most total sprouted cuttings, and possessed the greatest percentage of rooted cuttings [27]. A 'Himalayan' mulberry stem cutting's root and shoot were examined after being exposed to four distinct dosages of indole-3-butyric acid (IBA) and naphthalene acetic acid (NAA) at concentrations of 500, 1000, 2000, and 3000 ppm, respectively. After 40 days of cuttings, 3000 ppm of IBA had the highest survival rate, 18.8 roots, 10.82 centimetres of root length, 13.11 centimetres of axillary shoot length, 5.79 leaves, 5.1 centimetres of leaf width, and 6.84 centimetres of leaf length. IBA 3000 ppm is suitable for "Himalayan" mulberry stem cutting propagation as a result [29]. The effect of four concentrations of naphthaleneacetic acid, indole-3-butyric acid and zinc sulphate (0, 100, 200,

and 400 mg L^{-1}) provided individually or together on the mulberry cuttings' germination and development (0, 100, 200, and 400 mg L^{-1}). Using the quick-dip technique, M. alba cuttings were submerged for 5 seconds in each solution, then dried, and after 60 days, were planted in plastic pots in a greenhouse. NAA (at 200 mg L^{-1}), IBA (200 and 400 mg L^{-1}), and Zn sulphate (200 and 400 mg L^{-1}), used alone or in combination, can be a useful and dependable approach for mulberry growth [30].

Effect of IBA on Mulberry cutting propagation with respect to planting time and Planting method

Planting dates (December 25th, January 10th, and January 25th), three growth circumstances (Open space, some shade, and a mist chamber), and a 500-ppm concentration of Indole-3-butyric acid were all included in the treatments. Mulberry hardwood stem cuttings were 15 cm long with 4–6 nodes and were collected from plants that were 5–6 years old. The mist chamber growth environment and the January 10th planting date exhibits the finest mulberry cutting performance and [13]. Four local mulberry varieties Beyrudi, Hatuni, Sami, and Yabani were evaluated for rooting. Cuttings of 20 to 25 cm long were taken during the dormant season from one-year-old shoots (January 15 in the first year and February 20 in the second year). IBA solution at varied concentrations applied to the cutting for 10 seconds. 93–118 days after cutting, average root length (cm), rooting percentage, and the number of roots per cutting were measured. The best rooting results were achieved with cuttings that were treated with 5000 ppm IBA. The highest rooting, 31.7%, was obtained in 'Beyrudi' with 5000 mg L^{-1} IBA [20]. Testing was done on how IBA and cinnamic acid treatments affected the ability of cuttings from black mulberry trees growing in Tokat to take root. Cuttings taken in July, September, November, and January were exposed to 6000 ppm Indole Butyric Acid (IBA), 6000 ppm IBA+100 ppm Cinnamic Acid (CA), or 100 ppm Cinnamic Acid (CA) with no treatment. For 60 days, the cuttings were kept in perlite-filled, bottom-heated rooting beds. The maximum rooting ratio (48.3%) and average root number (3.1) were seen in cuttings collected in November and January with 6000 ppm IBA + 100 ppm CA treatment [15].

Micropropagation of Mulberry

In-vitro cultivation was done using axillary buds. Shoot initiation was enhanced on Murashige and Skoog (MS) medium supplemented with different dosages of 6-bezyl amino purine with 1mg/l kinetin on shoot multiplication. A greater rate of shoot initiation (90%) was seen on MS medium with 2 mg/l 6-bezyl amino purine. The average number of shoots increased when started shoots were subcultured on MS medium with 2 mg/l 6-bezyl amino purine and 1 mg/l kinetinA larger average number of elongated shoots (19) were noticed on MS medium with 1 mg/l 6-bezyl amino purine and 1 mg/l kinetin. The highest rate of root formation (70%) was seen when elongated shoots were subcultured on MS medium with 2 mg/l indole-3-butyric acid. Plantlets with an 80% survival rate were put in peat moss pots for acclimatisation in the greenhouse [2]. The nodal explants of the PPR-1 mulberry variety were inoculated into various quantities and combinations of cytokinins supplemented media, and the maximum axillary bud proliferation was obtained on combinational rather than individually provided hormonal media. After 20 days of growth on combinational media including 6 benzylaminopurine (BAP) (1.5 mg/L) and kinetin (2.0 mg/L), the maximum axillary shoot length (7.2 0.61 cm) and number of leaves per explant (8.1 0.85) were achieved. Using a 1:1 mix of vermicompost and soil, the hardened plantlets were then gradually acclimated to field conditions. In natural environments, PPR-1 plantlets generated in vitro have a survival rate of about 70% [24]. Apical buds of the mulberry (Morus indica L.) were grown on LSBM supplemented with varying concentrations of BAP and TIBA. Possibility of micro propagation in vitro the optimal medium for shot initiation (94% response) and multiplication (10.6) was found to be LSBM fortified with 8.88 M BAP together with 2 M TIBA. The significant variation in the number of shoots and roots produced across and between treatments. Well-developed axenic plants with comparable genetic makeup were successfully grown in the field with a 90% survival rate using a progressive hardening process [16]. On MS medium supplemented with BAP and Kn, primary cultures of Morus alba L. displayed high rates of sprouting (80%) from nodal- and (70%) from shoot tip explants, as well as shoot differentiation. When cultivated on MS with supplementation of BAP (2 mg/l) and NAA (0.2 mg/l), shoot tips and nodal explants proliferated quickly in vitro. For multiple shot formations, this combination has been shown to be the most successful. Multiplication occur when both types of explants were cultured on MS and supplemented with BAP (2 mg/l) + NAA (0.2 mg/l) + Aspargine (25 mg/l) + Glutamate (1 mg/l). Around 80% of the shoots that were grown on MS medium with NAA (1.0 mg/l) developed roots [1]. On Murashige and Skoog (MS) media with various phytohormone concentrations/combinations, explants from field-grown plants were grown. In MS media containing BAP (1.0 mg/l), TDZ (0.1 mg/l), and NAA (0.25 mg/l), many shoots were produced from nodal segments. Adventitious buds multiplied and flourished on secondary media containing MS with BAP (1.0 mg/l), NAA (0.25 mg/l), and Gibberellic acid (GA3, 0.5 mg/l). On MS, well-rooted plantlets were hardened after being treated with indole-3-butyric acid (IBA, 0.5 mg/l) with or without charcoal (1%, w/v) to encourage rooting. In vitro produced plantlets survived 98% of the time in greenhouse conditions. The

method developed would be very beneficial for both mulberry transgenic applications as well as mulberry bulk multiplication [26].

Effect of Sound frequencies on adventitious rooting induction of Mulberry cutting

The impact of various sound frequencies on mulberry cuttings helps to adventitious rooting (Morus sp.). In the first experiment, spring and fall cuttings were subjected to sound frequencies of 300 Hz, 1000 Hz, or 0 Hz. In the second experiment, spermidine and a frequency of 1000 Hz were both administered. Cuttings taken in the autumn that are subjected to a sound frequency of 1000 Hz may have an improved sensitivity to adventitious rooting [19].

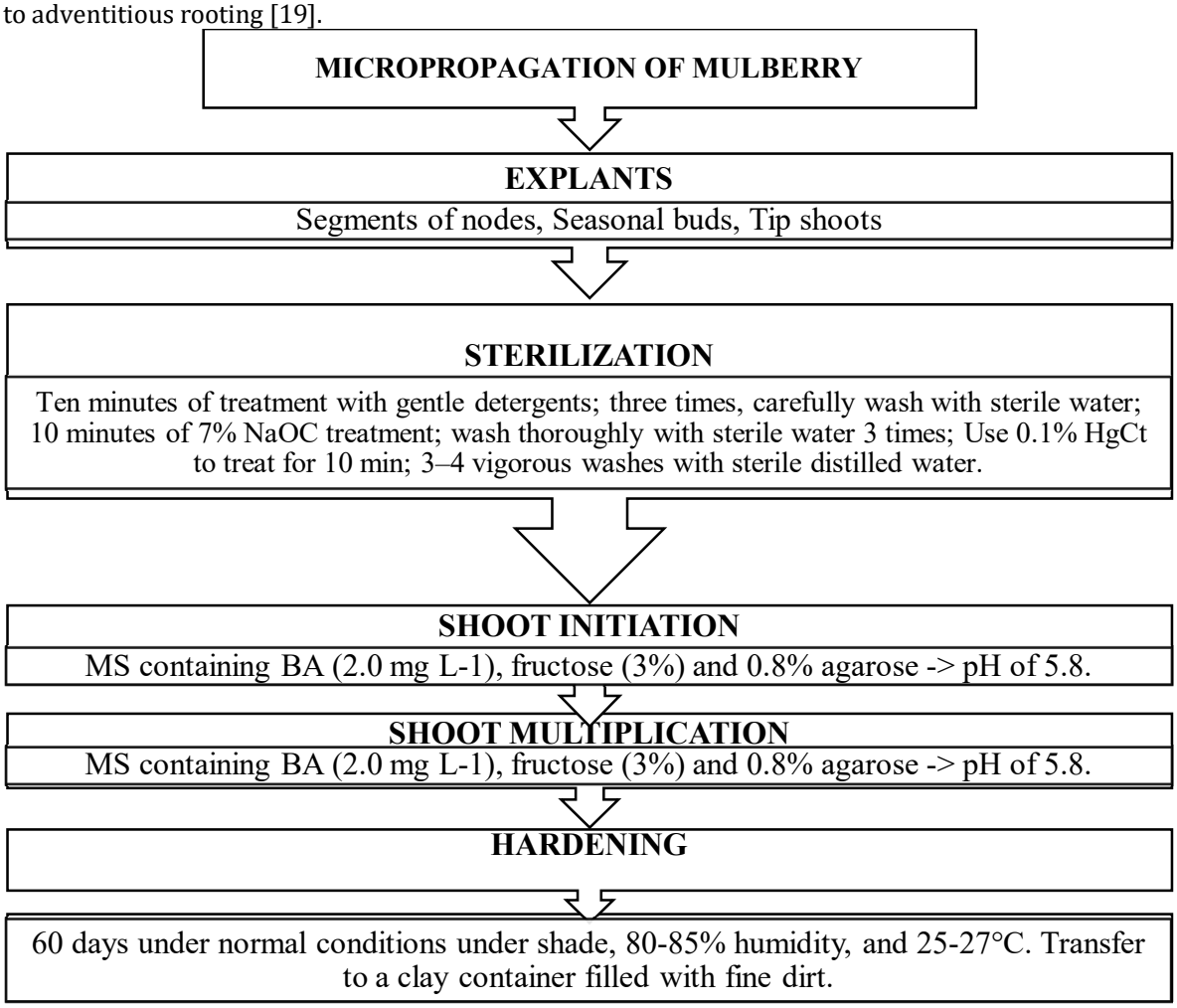

Fig 1: Mulberry explant propagation (Micropropagation) [31]

CONCLUSION

Application of IBA and NAA was more beneficial for overall parameters of *Morus alba* stem cuttings. It has showed that Mulberry cutting treated with IBA and NAA is most effective for rooting and shooting of Mulberry cutting propagation. Dipping of Mulberry cutting for a sometime period is with respect to concentration of IBA and NAA, the effective rooting shooting depends on which concentration the cutting is dipped for a time and shows a most effective rooting, shooting and other parameters of mulberry cutting, when it is treated with PGR's and rooting media during propagation of Mulberry cutting. We also know that mulberry cutting can also propagation in lab by MS media also showed a very good results for commercial propagation of Mulberry cutting.

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