**Effect of IBA levels on bud sprouting, growth and survival of Mulberry (*Morus nigra* L.) Cuttings**

**ABSTRACT**

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| --- |
| **Aim-** Standardizing the concentration of IBA and type of cutting to ensure better sprouting, growth and higher survival.Experimental design- Factorial Randomized Block Design (FRBD)**Location** - The experiment was conducted at Fruit Research Station Imaliya, Department of Horticulture, JNKVV, Jabalpur (M.P.) **Methodology-** Mulberry (*Morus nigra* L.) is a fast growing deciduous plantwhich is commercially propagated from hardwood cutting due to advantages like rapid multiplication and preservation of required plant traits. Hence, this experiment was conducted to find out the feasibility of different types of cutting under influence of various IBA levels on growth and success of cuttings. The experiment was conducted in 3 x 4 Factorial Randomized Block Design (FRBD) consisting of 12 treatments with 3 replications. Factor – A had three levels of cuttings (hardwood, semi hardwood, softwood cuttings and factor – B had four levels of IBA (0, 2000, 3000 and 4000 ppm).**Result**- Among factor- A, hardwood (A1) showed significantly better results and soft wood (A3) showed the lowest performance. Among factor- B, IBA @ 3000 ppm showed significantly better results in respect to all parameters. The increased level of IBA (4000 ppm) showed the lowest performance regarding days to start sprouting only. Among rest all parameter lowest performance was recorded under IBA @ 0 ppm. The treatment combination T3 (hardwood cutting + IBA @ 3000 ppm) showed the minimum days (5.00) to start sprouting at 30 days after planting, maximum number of shoots per cutting (2.77, 4.40, 5.60), number of leaves per cutting (5.93, 8.45, 11.98) at 60, 90, 120 days after planting respectively. Maximum longest root length (27.54cm) and survival rate (83.33%) at 120 days after planting was also observed under treatment T3 (hardwood cutting + IBA @ 3000 ppm).**Conclusion-** Among different cuttings hardwood performed best and among different levels of IBA, IBA @ 3000 ppm showed best results. While among treatment combinations, hardwood cutting treated with IBA @ 3000 ppm performed best with respect to sprouting, growth and survival of cuttings. **Significance of work**.-Hardwood cuttings are commonly used for Mulberry propagation and the Soft wood and Semi hard wood portion of stem become useless during preparation of cutting. In order to reduce plant waste and observe additional positive effects, we are employing softwood and semi hardwood cuttings of mulberry. IBA is widely used vegetative propagation through cuttings because of its quicker ability to produce roots, chemical stability low mortality in plants.  |

***Keywords****: IBA levels, Mulberry (Morus nigra L.) cuttings (Hardwood, semi hardwood, soft wood), propagation*

**INTRODUCTION**

Mulberry (*Morus nigra* L.) is a fast growing deciduous plant which is native to temperate Asia. The cultivated varieties of mulberry are diploid with chromosomes number 28 and belong to family moracaeae. The genus Morus comprises 68 species with more than 100 known cultivars distributed all over Asia, especially 24 species in China and 19 species in Japan (Sanjappa, 1989). Among different species of genus *Morus*, *Morus alba* (White Mulberry), *Morus nigra* (Black Mulberry) and *Morus rubra* (Red Mulberry) have a wide range of distribution throughout the world (Datta, 2000).Most of the Indian varieties of mulberry belong to *M. indica.* Mulbery is a good source of medicine for dysentery, constipation, hypoglycemia and avulsed teeth (Lee *et al*. 2011). Fresh mulberry consists of 88% water, 1.7% fiber, 1.4% protein, 0.4% fat and 8.1% sugar.

Propagation of Mulberry through stem cuttings is the easiest, cheapest and quickest method of propagation as compared to other methods (Rao and Khan, 1963). Mulberry is commercially propagated from hardwood cutting due to distinct advantages, such as rapid multiplication of parent material and preservation of required plant characters. Hardwood cuttings were typically used in much of the research that we found, but in order to reduce plant waste and observe additional positive effects, we are employing Softwood and semi hardwood cuttings of mulberry. The effective multiplication of cuttings requires hormonal activity which facilitates growth and survival. Numerous researchers have stated that the ideal hormone concentration should be applied to encourage roots on cuttings.

Among the various growth hormones, IBA is widely used vegetative propagation through cuttings because of its quicker ability to produce roots, chemical stability low mortality in plants (Soni, 1970). Application of auxin to cuttings causes physiological changes during the adventitious root formation which helps in mobilization of carbohydrates from leaves and upper stem and accelerates their transport to the rooting zone.

This study was carried out to determine the effect of different concentrations of IBA with different types of Mulberry cuttings on rooting and shooting potential. To standardizing the concentration of IBA and type of cutting ensures higher success rate on sprouting, growth and survival.

**MATERIAL METHOD**

The investigation was established using an asymmetric factorial RBD design with three replications. The experiment comprised three types of cutting- hardwood, Semi hardwood, softwood (Factor - A) and four levels of IBA - 0 ppm, 2000 ppm, 3000 ppm, 4000 ppm (Factor -B). Planting material was taken from a 9–10 year old mother plant. Hardwood cuttings were made from dormant branches. Semi-hardwood cuttings came from a branch that was both mature and immature in terms of physiological development, whereas softwood cuttings take from immature new shoots.

Solution of IBA was made up of 0, 2000, 3000 and 4000 ppm. Quick dip method of treatment used to treat the basal region of the different types of stem cuttings with the appropriate IBA concentrations (0 ppm, 2000 ppm, 3000 ppm and 4000 ppm) according to the treatment and was planted in polythene bags containing media soil 75% with Vermicompost 25%.

**Table 1: Treatment details**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **Treatment combinations** | **Symbols** |
| **T1** | Hard Wood Cutting + IBA 0 PPM | A1B1 |
| **T2** | Hard Wood Cutting + IBA 2000 PPM | A1B2 |
| **T3** | Hard Wood Cutting + IBA 3000 PPM | A1B3 |
| **T4** | Hard Wood Cutting + IBA 4000 PPM | A1B4 |
| **T5** | Semi Hard Wood Cutting + IBA 0 PPM | A2B1 |
| **T6** | Semi Hard Wood Cutting + IBA 2000 PPM | A2B2 |
| **T7** | Semi Hard Wood Cutting + IBA 3000 PPM | A2B3 |
| **T8** | Semi Hard Wood Cutting + IBA 4000 PPM | A2B4 |
| **T9** | Soft Wood Cutting + IBA 0 PPM | A3B1 |
| **T10** | Soft Wood Cutting + IBA 2000 PPM | A3B2 |
| **T11** | Soft Wood Cutting + IBA 3000 PPM | A3B3 |
| **T12** | Soft Wood Cutting + IBA 4000 PPM | A3B4 |

The observations were taken at different days intervals. Days to start sprouting were calculated by the difference taken between days of sprouting start and days of planting cuttings. The number of shoots emerging out from five cuttings under each treatment was recorded at 60, 90 and 120 days after planting. Number of leaves counts at 60, 90, and 120 days after planting. Total number of rooted cuttings surviving under each treatment in each replication was recorded and the survival percentage of cuttings calculated.

**RESULT AND DISCUSSION**

Data regarding days to sprouting is shown in Table 2. All treatments recorded significant results in Sprouting percentage. Among different IBA levels, minimum days to sprouting (6.78) were observed in IBA @ 3000 ppm. Among cuttings, minimum days to sprouting (5.83) were observed in hardwood cuttings. Among treatment combinations treatment T3 (Hardwood cutting + IBA @ 3000 ppm) showed minimum days to sprouting (5.00). However, the maximum days to sprouting (10.33) was observed in T12 (Softwood cutting + IBA @ 4000 ppm). These findings might be due to hardwood cuttings having a higher concentration of stored food materials primarily consisting of carbohydrates, especially starches with mature tissues then semi hard and soft wood cuttings. These starches serve as energy reserves that support the initial growth of roots and shoots during the early stages of rooting and establishment. Auxin concentration in the cell increased the cell division which results in quick callus formation in the cutting. It facilitates the sprouting process and shortens the time needed to initiate the sprout. The results are in close association with Patil et al. (2000), Kumar *et al*. (2023). The IBA level up to certain concentration facilitates the growth but the concentration quite higher than those found in plant tissues have the potential to hinder the establishment and growth of roots (Hartmann *et al*., 2011).

Data regarding sprouting per cent is shown in Table 2. All treatments recorded significant results in sprouting percentage. Among different IBA levels, maximum sprouting percentage (75.56) was observed in IBA @ 3000 ppm. Among cuttings, maximum sprouting percentage (82.50) was observed in hardwood cuttings. Among treatment combinations, treatment T3 (Hardwood cutting + IBA @ 3000 ppm) showed maximum sprouting percentage (93.33%). However, the minimum sprouting percentage (40%) was observed in T9 (Softwood cutting + IBA @ 0 ppm). This finding might be due to hardwood cuttings taken from mature, dormant stems and they have a higher concentration of stored food materials primarily consisting of carbohydrates as energy reserves cause early completion of physiological processes that support the initial growth of cuttings during the early stages of establishment. The results are in close association with Kaur *et al*. (2018), Kumar *et al*. (2023) and Malakar et al. (2019).

Data pertaining to the number of shoots per cutting is shown in Table 3. All treatments performed significant results in the number of shoots. Among different IBA levels, maximum number of shoots (2.36, 3.39, and 4.31) was obtained at 60, 90 and 120 days after planting respectively in IBA @ 3000 ppm. Among cuttings, the maximum number of shoots (2.31, 3.70, and 4.64) was observed at 60, 90 and 120 days after planting respectively in hardwood cuttings. Among treatment combinations, treatment T3 (Hardwood cutting + IBA @ 3000 ppm) showed maximum number of shoots (2.77, 4.40 and 5.60) at 60, 90 and 120 days after planting respectively. However, the minimum numbers of shoots (1.35, 1.77 and 2.08) at 60, 90 and 120 days after planting respectively in T9 (Softwood cutting + IBA @ 0 ppm). This finding might be due to the increased shoot number and may be the result of an increased leaf count and a robust root system that improved the plants ability to absorb water and minerals from the soil, increasing the production and assimilation of carbohydrates and promoting vegetative development causes more shoots. Hardwood cutting develops more shoots because of its higher carbohydrate reserves, more dry matter and more accumulation which resulted in the earliest completion of physiological processes. The results are in close association with Kaur *et al*. (2018), Pooja *et al*. (2022) and Hartmann *et al*. (2002).

Data regarding the number of leaves is shown in Table 4. All treatments recorded significant results in the number of leaves. Among different IBA levels, the maximum number of leaves (4.37, 6.31, and 9.49) was recorded at 60, 90 and 120 days after planting respectively in IBA @ 3000 ppm. Among cuttings, the maximum number of leaves (4.82, 7.03, and 10.18) was observed at 60, 90 and 120 days after planting in hardwood cuttings. Among treatment combinations, treatment T3 (Hardwood cutting + IBA @ 3000 ppm) recorded the maximum number of leaves (5.93, 8.45 and 11.98) at 60, 90 and 120 days after planting respectively. However, the minimum number of leaves (1.88, 2.92 and 5.21) was obtained at 60, 90 and 120 days after planting respectively in T9 (Softwood cutting + IBA @ 0 ppm). This finding might be due to IBA leads to cell elongation and hydrolysis of carbohydrates causes more vegetative growth leads to increased photosynthetic activity promotes rapid growth of leaves and shoots. The results are in close association with Singh et al. (2015), Kaur *et al*. (2018), Kumar *et al*. (2023), Rao et al. (2020) and Hawramee *et al*. (2019).

Data related to the longest root is shown in Table 5. All treatments performed significant results in the longest root. Among different types of cutting, hardwood cutting recorded the maximum root length (24.92 cm). Among different IBA levels, IBA @ 3000 ppm recorded maximum root length (23.72 cm) . Among treatment combinations, treatment T3 (Hardwood cutting + IBA @ 3000 ppm) observed maximum root length (27.54 cm). However, the minimum root length (11.33 cm) was obtained in treatment T9 (Soft wood + IBA @ 0 ppm). This result might be due to IBA promoting cell multiplication and elongation, which may have assisted in root induction. Its positive response with hardwood cuttings speeds up the beginning of new roots and the subsequent growth of more roots (Tanwar *et al*. 2020). The action of auxin activity, which may have spurred the hydrolysis and transfer of sugars and nitrogenous substances towards the base of cuttings and led to rapid cell division and cell elongation under favourable conditions, may be the cause of the longest root ever recorded. The findings are also in close association with Singh et al. (2003), Gnawali et al. (2022) and Reddy et al. (2008).

Data regarding survival percentage is shown in Table 5. All treatments recorded significant results in Survival percentage. Among different IBA levels, maximum survival percentage (63.33%) was observed in IBA @ 3000 ppm. Among cuttings, maximum survival percentage (70%) was observed in hardwood cuttings. Among treatment combinations, treatment T4 (Hardwood cutting + IBA @ 4000 ppm) showed maximum survival percentage (83.33%). However, the minimum survival percentage (30%) was observed in T9 (Softwood cutting + IBA @ 0 ppm). This result might be due to auxin enhances cell elongation and division, hydrolysis and transfer of carbohydrates near the base of cuttings facilitates the more rooting (Hartmann *et al*., 2002). IBA favours the increased shoot number and shoot length may be the result of an increased leaf count and a robust root system that improved the plants ability to absorb water and minerals from the soil promoting growth which enhances survivability of cuttings. The results are in close association with Singh et al. (2015), Ghosh et al et al. (2017) and Patel et al. (2020).

**Table 2. Effect of IBA on different cuttings on days to sprouting and sprouting percentage (%)**

|  |  |  |
| --- | --- | --- |
|  | **Days to sprouting (days)** | **Sprouting percentage (%)** |
| **Factor -A (Cuttings)** |  |  |
| **Hard wood cutting** | 5.83 | 82.5 |
| **Semi Hard wood cutting** | 6.83 | 68.33 |
| **Soft wood cutting** | 9.33 | 45.83 |
| **S.E m (±)** | 0.159 | 1.32 |
| **CD at 5%** | 0.466 | 3.88 |
| **Factor -B (IBA levels)** |  |  |
| **IBA @ 0 PPM** | 7.56 | 55.56 |
| **IBA @ 2000 PPM** | 7.33 | 66.67 |
| **IBA @ 3000 PPM** | 6.78 | 75.56 |
| **IBA @ 4000 PPM** | 7.67 | 64.44 |
| **S.E m (±)** | 0.183 | 1.53 |
| **CD at 5%** | 0.538 | 4.48 |
| **Treatment Combination** |  |  |
| **T1** | 6.67 | 66.67 |
| **T2** | 5.67 | 86.67 |
| **T3** | 5.00 | 93.33 |
| **T4** | 6.00 | 83.33 |
| **T5** | 7.33 | 60 |
| **T6** | 7.00 | 70 |
| **T7** | 6.33 | 80 |
| **T8** | 6.67 | 63.33 |
| **T9** | 8.67 | 40 |
| **T10** | 9.33 | 43.33 |
| **T11** | 9.00 | 53.33 |
| **T12** | 10.33 | 46.67 |
| **S.E m (±)** | 0.31 | 2.64 |
| **CD at 5%** | 0.93 | 7.75 |

**Table 3. Effect of IBA on different cuttings on number of shoots**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **60 DAP** | **90 DAP** | **120 DAP** |
| **Factor -A (Cuttings)** |  |  |  |
| **Hard wood cutting** | 2.31 | 3.7 | 4.64 |
| **Semi hard wood cutting** | 1.99 | 2.84 | 3.7 |
| **Soft wood cutting** | 1.72 | 2.16 | 2.69 |
| **S.E m (±)** | 0.06 | 0.07 | 0.09 |
| **CD at 5%** | 0.17 | 0.2 | 0.28 |
| **Factor -B (IBA levels)** |  |  |  |
| **IBA @ 0 PPM** | 1.6 | 2.36 | 3.06 |
| **IBA @ 2000 PPM** | 2.05 | 2.99 | 3.75 |
| **IBA @ 3000 PPM** | 2.36 | 3.39 | 4.31 |
| **IBA @ 4000 PPM** | 2.01 | 2.85 | 3.58 |
| **S.E m (±)** | 0.07 | 0.08 | 0.11 |
| **CD at 5%** | 0.19 | 0.23 | 0.32 |
| **Treatment Combination** |  |  |  |
| **T1** | 1.81 | 3.11 | 3.81 |
| **T2** | 2.52 | 3.88 | 4.89 |
| **T3** | 2.77 | 4.4 | 5.6 |
| **T4** | 2.14 | 3.4 | 4.26 |
| **T5** | 1.64 | 2.2 | 3.31 |
| **T6** | 2.11 | 3.09 | 3.89 |
| **T7** | 2.2 | 3.26 | 4.11 |
| **T8** | 2 | 2.81 | 3.48 |
| **T9** | 1.35 | 1.77 | 2.08 |
| **T10** | 1.52 | 2.01 | 2.46 |
| **T11** | 2.1 | 2.5 | 3.21 |
| **T12** | 1.89 | 2.35 | 3.48 |
| **S.E m (±)** | 0.11 | 0.14 | 0.19 |
| **CD at 5%** | 0.33 | 0.4 | 0.56 |

**Table 4. Effect of IBA on different cuttings on number of leaves**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **60 DAP** | **90 DAP** | **120 DAP** |
| **Factor -A (Cuttings)** |  |  |  |
| **Hard wood cutting** | 4.82 | 7.03 | 10.18 |
| **Semi hard wood cutting** | 3.52 | 5.63 | 8.39 |
| **Soft wood cutting** | 2.55 | 3.58 | 5.98 |
| **S.E m (±)** | 0.11 | 0.14 | 0.19 |
| **CD at 5%** | 0.31 | 0.4 | 0.57 |
| **Factor -B (IBA levels)** |  |  |  |
| **IBA @ 0 PPM** | 2.72 | 4.58 | 6.74 |
| **IBA @ 2000 PPM** | 3.88 | 5.58 | 8.44 |
| **IBA @ 3000 PPM** | 4.37 | 6.31 | 9.49 |
| **IBA @ 4000 PPM** | 3.55 | 5.17 | 8.07 |
| **S.E m (±)** | 0.11 | 0.16 | 0.22 |
| **CD at 5%** | 0.31 | 0.47 | 0.66 |
| **Treatment Combination** |  |  |  |
| **T1** | 3.2 | 5.73 | 7.87 |
| **T2** | 5.5 | 7.58 | 10.93 |
| **T3** | 5.93 | 8.45 | 11.98 |
| **T4** | 4.64 | 6.36 | 9.95 |
| **T5** | 3.09 | 5.09 | 7.15 |
| **T6** | 3.85 | 5.93 | 8.81 |
| **T7** | 4.05 | 6.25 | 9.58 |
| **T8** | 3.1 | 5.23 | 8.03 |
| **T9** | 1.88 | 2.92 | 5.21 |
| **T10** | 2.28 | 3.24 | 5.59 |
| **T11** | 3.12 | 4.24 | 6.9 |
| **T12** | 2.91 | 3.91 | 6.22 |
| **S.E m (±)** | 0.21 | 0.27 | 0.39 |
| **CD at 5%** | 0.62 | 0.81 | 1.14 |

**Table 5. Effect of IBA on different cuttings on root length (cm) and survival percentage (%)**

|  |  |  |
| --- | --- | --- |
|  | **longest root length (cm)** | **Survival percentage (%)** |
| **Factor -A (Cuttings)** |  |  |
| **Hard wood cutting** | 24.92 | 70 |
| **Semi Hard wood cutting** | 22.95 | 55.83 |
| **Soft wood cutting** | 14.73 | 35.38 |
| **S.E m (±)** | 0.41 | 1.39 |
| **CD at 5%** | 1.19 | 4.08 |
| **Factor -B (IBA levels)** |  |  |
| **IBA @ 0 PPM** | 17.64 | 46.67 |
| **IBA @ 2000 PPM** | 20.81 | 53.33 |
| **IBA @ 3000 PPM** | 23.72 | 63.33 |
| **IBA @ 4000 PPM** | 21.29 | 52.22 |
| **S.E m (±)** | 0.47 | 1.61 |
| **CD at 5%** | 1.38 | 4.71 |
| **Treatment Combination** |  |  |
| **T1** | 21.91 | 60 |
| **T2** | 26.21 | 70 |
| **T3** | 27.54 | 83.33 |
| **T4** | 24.01 | 66.67 |
| **T5** | 19.67 | 50 |
| **T6** | 23.47 | 56.67 |
| **T7** | 25.45 | 63.33 |
| **T8** | 23.19 | 53.33 |
| **T9** | 11.33 | 30 |
| **T10** | 12.74 | 33.33 |
| **T11** | 18.16 | 43.33 |
| **T12** | 16.67 | 36.67 |
| **S.E m (±)** | 0.81 | 2.78 |
| **CD at 5%** | 2.38 | 8.16 |

**Conclusion**

On the basis of result, it is concluded that among different cuttings hardwood performed best and among different levels of IBA, IBA @ 3000 ppm showed best results. While among treatment combination, hardwood cutting treated with IBA @ 3000 ppm performed best with respect to sprouting, growth and survival of cuttings. The hardwood cutting treated with IBA @ 2000 ppm was found next best treatment combination for propagation of seedless lemon.

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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