**Response of Different Types of Cuttings of Seedless Lemon to Indole Butyric Acid Levels on propagation, germination and growth**

**Abstract**

The present study was aimed to adjudge the growth and success of different stem cuttings of lemon to different IBA levels. Plant Growth substances provided exogenously have been shown to assist in stimulating good and early root development in cuttings. Most likely, indole-3-butyric acid is the greatest substance for widespread usage since it works well in and is safe for plants to use at a variety of concentrations to rooting and success. The experiment was conducted at Fruit Research Station Imaliya, Department of Horticulture, JNKVV, Jabalpur (M.P.), India 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). *Citrus limon* (L.) can be propagated successfully through stem cutting. Hence, this experiment was conducted to find out the effectivity of IBA levels on the growth and success of cuttings. Among factor- Hardwood (A1) showed significantly better results and soft wood (A3) showed low performance. Among factor- B IBA @ 3000 ppm showed significantly better results and IBA @ 0 ppm showed the lowest performance. However, treatment combination T4 (Hardwood cutting + IBA @ 4000 ppm) showed the maximum sprouting percentage (96.67 %), shoot length (4.90 cm, 5.77 cm, 6.07 cm, 7.13 cm), number of leaves (11.20, 14.63, 18.17, 21.87) at 30, 60, 90 and 120 days respectively with maximum per cent success (90.00 %, 86.67 %, 83.33 %) at 60, 90, 120 days respectively, number of adventitious roots (17.30), longest root (19.34 cm). While lowest performance on growth and success was obtained in T12 (Soft wood cutting + IBA @ 4000 ppm).

**Key words:** Seedless lemon , IBA levels, Cuttings, vegetative propagation**.**

**Introduction**

Vegetative propagation of plants by stem cuttings is the most commonly used method for

producing herbaceous and woody plant in many parts of the world. A cutting is a piece of the

part of plants used to propagate which regenerate their missing part is called cutting. Stem

cutting can be classified as follows: hardwood cuttings, semi hardwood cuttings, softwood

cutting and herbaceous cuttings. Stem cuttings have been used for the vegetative propagation

of several fruit trees including citrus (Singh et al., 2018; Gnawali et al., 2025). Lemons (*Citrus limon* (L.)Burm. f. are a major crop among the citrus species. It is employed for both non-culinary and culinary purposes all over the world. It belongs to the family Rutaceae and has Indian origins (Spiegel-Roy and Goldschmidt, 1996). Vitamins C, B, and A, as well as minerals K, Ca, Fe, Mg, Na, S, and P, are abundant in lemons. Due to its market-sold candy and flavour-infused drinks, it has significant socioeconomic significance. (Liu and Colleagues, 2012). In citrus production, India ranks fourth in the world but stands first in acid lime and lemon production. India produces 10.76 million metric tonnes of citrus fruit annually from 1.40 m ha area. (ICAR – CCRI, 2021). Seedless lemons are unable to reproduce sexually. Asexual propagation is vital to produce citrus plants having desirable characteristics as mother plants and provide true to type plant, fruits of uniform size and quality, tree commences early bearing. Lemons can be multiplied most quickly, cheaply, and easily *via* cuttings. (Hartmamm and Kester, 2011).

Plant Growth substances provided exogenously have been shown to assist in stimulating good and early root development in cuttings. Auxin is used to encourage the growth of roots in woody plant cuttings. In lemon and lime cultivars, IBA (indole 3-butyric acid) is the most effective root-promoting agent (Khursheed and Abdul, 2003). Most likely, indole-3-butyric acid is the greatest substance for widespread usage since it works well in and is safe for plants to use at a variety of concentrations to rooting and success (Hartmann and Kester, 1990). The optimum IBA concentration facilitates growth but if it greater than the amount present in plant tissue showed a toxic effect (Blythe *et al.,* 2007). The present study was conducted to adjudge the growth and success of different stem cuttings of lemon to different IBA levels.

**Materials and method**

The experiment was laid out in Asymmetrical 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).

Cutting was selected from 9-10 years old mother plant. Hardwood cuttings were made from dormant branches. Semi-hardwood cuttings were obtained from a branch that was both mature and immature in terms of physiological development, whereas softwood cuttings were obtained from immature new shoots. A total 360 cuttings were made about 12-15 cm length. The IBA solution was made up of 0, 2000, 3000 and 4000 ppm. The basal region of the stem cuttings was treated with the appropriate IBA concentrations (0 ppm, 2000 ppm, 3000 ppm and 4000 ppm) according to the treatment and was immediately planted in polythene bags containing media soil 75% and Vermicompost 25%.

The sprouting percentage was recorded by computing the total number of sprouted cuttings out of total number of planted cuttings in treatment. Shoot length was recorded at 30, 60, 90 and 120 DAP by using a measuring scale from its basal portion to the tip of the shoots and mean was calculated. Number of leaves was recorded at 30, 60, 90, 120 days after planting in every treatment and the average is calculated. Percent success was recorded by counting number of rooted cuttings out of total number of planted cuttings in a treatment. Number of adventitious roots was counted after removing the roots from plant and the longest root length was also recorded by using a measuring scale.

**Result and Discussion**

Data regarding sprouting per cent is shown in Table 1. All treatments recorded significant results in Sprouting percentage. Among different IBA levels, maximum sprouting percentage (78.89 %) was observed in IBA @ 3000 ppm. Among cuttings, maximum sprouting percentage (89.17 %) was observed in hardwood cuttings. Among treatment combinations treatment T4 (Hardwood cutting + IBA @ 4000 ppm) showed maximum sprouting percentage (96.69 %). However minimum sprouting percentage 50.0 % was observed in T12 (Soft wood + IBA @ 4000 ppm). This might be due to high accumulation of callus formation in cuttings with optimum dose of auxin resulting highest percentage of sprouted cuttings. This finding is supported by Pio *et al*. (2002); Pandey *et al*. (2003); Bassan *et al*. (2010); Kumar *et al.* (2015) and Malakar *et al.* (2019). Hardwood cutting had more dry matter and more accumulation which resulted earliest completion of physiological process which result early sprouting.

Data pertaining to shoot length is shown in Table 2. All treatments were performed significant results in shoot length. Among different IBA levels, maximum shoot length (3.92 cm, 4.91 cm, 5.06 cm, 6.11 cm) was obtained at 30, 60, 90 and 120 days after planting respectively in IBA @ 3000 ppm. Among cuttings, maximum shoot length (4.67 cm, 5.43 cm, 5.78 cm, 6.87 cm) was observed at 30, 60, 90 and 120 days after planting respectively in hardwood cuttings. Among treatment combinations treatment T4 (Hardwood cutting + IBA @ 4000 ppm) showed maximum shoot length (4.90 cm, 5.77 cm, 6.07 cm, 7.13 cm) at 30, 60, 90 and 120 days after planting respectively. However, minimum shoot length (2.33 cm, 2.83 cm, 3.03 cm, 3.73 cm) at 30, 60, 90 and 120 days after planting respectively in T12 (Soft wood cutting + IBA @ was obtained 4000 ppm). It might be due to the activation of auxin in the vegetative part by using IBA. Such findings were reported by Murkute *et al*. (2015); Kumar and Singh (2020). Hardwood cutting develops more shoot length because of its higher carbohydrate reserves. Similar findings were supported by Hartmann and Kester (1990).

Data pertaining to per cent success is shown in Table 3. All treatments were performed significant results in per cent success. Among different IBA levels, maximum per cent success (65.56 %, 60.00%, 55.56%) was recorded at 60, 90, 120 days respectively in IBA @ 3000 ppm. Among cuttings, the maximum per cent success (79.19 %, 75.00%, 70.83 %) was observed at 60, 90, 120 days respectively in hardwood cuttings. Among treatment combinations treatment T4 (Hardwood cutting + IBA @ 4000 ppm) showed maximum per cent success (90.0 %, 86.67 %, 83.33 %) at 60, 90, 120 days respectively. However a minimum number of per cent success (36.67 %, 30.00 %, 26.67 %) was observed at 60, 90, 120 days respectively in T12 (Soft wood + IBA @ 4000 ppm). It might be due to basal cutting from the branch was best rooted and gave the highest rooting and survival compared to medium and terminal cuttings. Similar findings were reported by Elsheikh (1999). Growth regulators have ability to encourage the growth of adventitious root systems and lengthen and increase the number of roots per cutting by absorbing water and minerals from the soil. This is going to assist the cuttings to survive (Reddy *et al*., 2008).

Data regarding number of leaves is shown in Table 4. All treatments recorded significant results in number of leaves. Among different IBA levels a maximum number of leaves (9.81, 13.00, 16.21, 19.41) was recorded at 30, 60, 90 and 120 days after planting respectively in IBA @ 3000 ppm. Among cuttings, a maximum number of leaves (10.46, 13.70, 17.05, 20.56) was observed at 30, 60, 90 and 120 days after planting in hardwood cuttings. Among treatment combinations treatment T4 (Hardwood cutting + IBA @ 4000 ppm) recorded the maximum number of leaves (11.20, 14.63, 18.17, 21.87) at 30, 60, 90 and 120 days after planting respectively. However, minimum number of leaves (7.23, 10.03, 12.63, 15.00) was obtained at 30, 60, 90 and 120 days after planting respectively in T12 (Soft wood + IBA @ 4000 ppm). This might be due to the activation of shoot growth leading to increase number of nodes that lead a greater number of leaves. Auxin was influential in initiating profuse rooting, which expedited the absorption of mineral and water, thus favoured leaf production. Such findings supported by Rajangam *et al*. (2022). Hardwood cutting had more dry matter and more accumulation which resulted earliest completion of the physiological process which result early sprouting, a greater number of leaves and shoots in cutting. (Fourier, 1984) reported hardwood cutting made up of matured, dormant firm wood after leaves abscised. It had more carbohydrate, nitrogen and other factors then semi hardwood and softwood cuttings.

Data pertaining to number of adventitious roots is shown in Table 5. All treatments were responded with significant results in number of adventitious roots, Among the different IBA levels, IBA @ 3000 ppm obtained the maximum (12.48) number of adventitious roots. Among different types of cuttings, hardwood cutting obtained maximum (15.08) number of adventitious roots. Among treatment combinations maximum (17.30) number of secondary roots were recorded in treatment T4 (Hardwood cutting + IBA @ 4000 ppm). While minimum (6.83) number of adventitious roots were obtained in treatment T12 (Soft wood cutting + IBA @ 4000 ppm). This might be due to the Application of IBA caused hydrolysis and translocation of carbohydrates and nitrogenous substances at the base of cutting resulted in cell division and cell elongation, its application also enhances histological features like formation of callus and tissue and vascular tissue differentiation resulted maximum rooting. Similar findings supported by Panday *et al*. (2003), Satpal *et al*. (2014), Mitra and Bose (1954) and Sabbah (1991). These findings might be due to hardwood cutting have higher amount of sugar, total carbohydrate and peroxidase enzyme activity, as well as low nitrogen are provided ideal condition for rooting. Similar findings supported by Bhardwaj and Mishra (2005).

Data related to longest root is shown in Table 5. All treatments were performed significant results in longest root. Among different types of cutting, hardwood cutting recorded maximum (17.94 cm) longest root. Among different IBA levels, IBA @ 3000 ppm recorded maximum (13.43 cm) longest root. Among treatment combinations treatment T4 (Hardwood cutting + IBA @ 4000 ppm) observed maximum (19.34 cm) longest root length. While the minimum (5.49 cm) root length was obtained in treatment T12 (Softwood cutting + IBA @ 4000 ppm). This might be due to the increase maximum number of branches per shoot whose tips produce more auxin which results in root elongation, and the effect of metabolites translocation and carbohydrates metabolism. Similar research supported by Bhatt and Tomar (2010). Basal cutting (hard wood cutting) from the branch were best rooted and gave highest rooting and survival compared to medium and terminal cuttings. Similar findings reported by Elsheikh (1999). Hardwood cutting show best root and shoot development also reported by Mlakar *et al*. (2019).

Lowest performance found in soft wood cuttings might be due to Auxin concentrations quite higher than those found in plant tissues have the potential to hinder the establishment and growth of roots. A like conclusion was reached by Hartmann *et al.* (2011) and Blythe *et al.* (2007).

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| **Table 1 Response of cuttings to IBA on sprouting per cent (%)** | |
|  | **Sprouting per cent (%)** |
| **Factor -A (Cuttings)** |  |
| **Hard wood cutting** | 89.17 |
| **Semi Hard wood cutting** | 72.50 |
| **Soft wood cutting** | 59.17 |
| **S.E m (±)** | 2.326 |
| **CD at 5%** | 6.821 |
| **Factor -B (IBA levels)** |  |
| **IBA @ 0 PPM** | 67.78 |
| **IBA @ 2000 PPM** | 77.78 |
| **IBA @ 3000 PPM** | 78.89 |
| **IBA @ 4000 PPM** | 70.00 |
| **S.E m (±)** | 2.685 |
| **CD at 5%** | 7.876 |
| **Treatment Combination** |  |
| **T1** | 80.00 |
| **T2** | 86.67 |
| **T3** | 93.33 |
| **T4** | 96.67 |
| **T5** | 66.67 |
| **T6** | 76.67 |
| **T7** | 83.33 |
| **T8** | 63.33 |
| **T9** | 56.67 |
| **T10** | 70.00 |
| **T11** | 60.00 |
| **T12** | 50.00 |
| **S.E m (±)** | 4.651 |
| **CD at 5%** | 13.641 |

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| **Table 2 Response of cuttings to IBA on shoot length (cm)** | | | | |
|  | **30 DAP** | **60 DAP** | **90 DAP** | **120 DAP** |
| **Factor -A (Cuttings)** |  |  |  |  |
| **Hard wood cutting** | 4.67 | 5.43 | 5.52 | 6.87 |
| **Semi Hard wood cutting** | 3.98 | 5.06 | 5.25 | 6.12 |
| **Soft wood cutting** | 2.66 | 3.51 | 3.67 | 4.57 |
| **S.E m (±)** | 0.078 | 0.08 | 0.081 | 0.12 |
| **CD at 5%** | 0.229 | 0.236 | 0.239 | 0.351 |
| **Factor -B (IBA levels)** |  |  |  |  |
| **IBA @ 0 PPM** | 3.62 | 4.5 | 4.74 | 5.56 |
| **IBA @ 2000 PPM** | 3.9 | 4.82 | 5.02 | 6.03 |
| **IBA @ 3000 PPM** | 3.92 | 4.91 | 5.06 | 6.11 |
| **IBA @ 4000 PPM** | 3.64 | 4.56 | 4.77 | 5.7 |
| **S.E m (±)** | 0.09 | 0.093 | 0.094 | 0.138 |
| **CD at 5%** | 0.264 | 0.272 | 0.276 | 0.406 |
| **Treatment Combination** |  |  |  |  |
| **T1** | 4.33 | 5.23 | 5.5 | 6.53 |
| **T2** | 4.63 | 5.37 | 5.6 | 6.73 |
| **T3** | 4.8 | 5.7 | 5.93 | 7.07 |
| **T4** | 4.9 | 5.77 | 6.07 | 7.13 |
| **T5** | 3.93 | 4.7 | 4.93 | 5.87 |
| **T6** | 4 | 5.13 | 5.4 | 6 |
| **T7** | 4.3 | 5.36 | 5.47 | 6.37 |
| **T8** | 3.7 | 5.07 | 5.2 | 6.23 |
| **T9** | 2.6 | 3.57 | 3.8 | 4.27 |
| **T10** | 3.07 | 3.97 | 4.07 | 5.37 |
| **T11** | 2.65 | 3.67 | 3.77 | 4.9 |
| **T12** | 2.33 | 2.83 | 3.03 | 3.73 |
| **S.E m (±)** | 0.156 | 0.161 | 0.163 | 0.24 |
| **CD at 5%** | 0.458 | 0.472 | 0.478 | 0.703 |

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| **Table 3 Response of cuttings to IBA on per cent success (%)** | | | |
|  | **60 DAP** | **90 DAP** | **120 DAP** |
| **Factor -A (Cuttings)** |  |  |  |
| **Hard wood cutting** | 79.17 | 75.00 | 70.83 |
| **Semi Hard wood cutting** | 56.67 | 48.33 | 45.00 |
| **Soft wood cutting** | 47.50 | 39.17 | 35.83 |
| **S.E m (±)** | 2.112 | 2.449 | 2.508 |
| **CD at 5%** | 6.195 | 7.183 | 7.357 |
| **Factor -B (IBA levels)** |  |  |  |
| **IBA @ 0 PPM** | 54.44 | 44.44 | 41.11 |
| **IBA @ 2000 PPM** | 64.44 | 57.78 | 54.44 |
| **IBA @ 3000 PPM** | 65.56 | 60.00 | 55.56 |
| **IBA @ 4000 PPM** | 60.00 | 54.44 | 51.11 |
| **S.E m (±)** | 2.439 | 2.828 | 2.896 |
| **CD at 5%** | 7.153 | 8.294 | 8.495 |
| **Treatment Combination** |  |  |  |
| **T1** | 70.00 | 63.33 | 60.00 |
| **T2** | 73.33 | 70.00 | 66.67 |
| **T3** | 83.33 | 80.00 | 73.33 |
| **T4** | 90.00 | 86.67 | 83.33 |
| **T5** | 50.00 | 33.33 | 30.00 |
| **T6** | 56.67 | 53.33 | 50.00 |
| **T7** | 66.67 | 60.00 | 56.67 |
| **T8** | 53.33 | 46.67 | 43.33 |
| **T9** | 43.33 | 36.67 | 33.33 |
| **T10** | 63.33 | 50.00 | 46.67 |
| **T11** | 46.67 | 40.00 | 36.67 |
| **T12** | 36.67 | 30.00 | 26.67 |
| **S.E m (±)** | 4.224 | 4.898 | 5.017 |
| **CD at 5%** | 12.390 | 14.365 | 14.714 |

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| **Table 4 Response of cuttings to IBA on number of leaves** | | | | |
|  | **30 DAP** | **60 DAP** | **90 DAP** | **120 DAP** |
| **Factor -A (Cuttings)** |  |  |  |  |
| **Hard wood cutting** | 10.46 | 13.70 | 17.05 | 20.56 |
| **Semi Hard wood cutting** | 9.16 | 12.54 | 15.74 | 18.72 |
| **Soft wood cutting** | 8.51 | 11.53 | 14.43 | 17.08 |
| **S.E m (±)** | 0.177 | 0.200 | 0.239 | 0.304 |
| **CD at 5%** | 0.518 | 0.586 | 0.700 | 0.891 |
| **Factor -B (IBA levels)** |  |  |  |  |
| **IBA @ 0 PPM** | 8.73 | 12.20 | 15.16 | 18.04 |
| **IBA @ 2000 PPM** | 9.77 | 12.87 | 16.19 | 19.32 |
| **IBA @ 3000 PPM** | 9.81 | 13.00 | 16.21 | 19.41 |
| **IBA @ 4000 PPM** | 9.19 | 12.29 | 15.41 | 18.36 |
| **S.E m (±)** | 0.204 | 0.231 | 0.276 | 0.351 |
| **CD at 5%** | 0.598 | 0.676 | 0.809 | 1.029 |
| **Treatment Combination** |  |  |  |  |
| **T1** | 9.47 | 12.33 | 15.30 | 18.77 |
| **T2** | 10.2 | 13.27 | 16.67 | 19.87 |
| **T3** | 10.97 | 14.57 | 18.07 | 21.73 |
| **T4** | 11.2 | 14.63 | 18.17 | 21.87 |
| **T5** | 7.87 | 12.00 | 15.10 | 17.73 |
| **T6** | 9.53 | 12.73 | 16.00 | 19.17 |
| **T7** | 10.1 | 13.23 | 16.43 | 19.77 |
| **T8** | 9.13 | 12.20 | 15.43 | 18.20 |
| **T9** | 8.87 | 12.27 | 15.07 | 17.63 |
| **T10** | 9.57 | 12.60 | 15.90 | 18.93 |
| **T11** | 8.37 | 11.20 | 14.13 | 16.73 |
| **T12** | 7.23 | 10.03 | 12.63 | 15.00 |
| **S.E m (±)** | 0.353 | 0.399 | 0.477 | 0.607 |
| **CD at 5%** | 1.035 | 1.171 | 1.400 | 1.782 |

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| **Table 5 Response of cuttings to IBA on number of adventitious roots and longest root at 120 days** | | |
|  | **Number of adventitious roots** | **Longest root (cm)** |
| **Factor -A (Cuttings)** |  |  |
| **Hard wood cutting** | 15.08 | 17.94 |
| **Semi Hard wood cutting** | 10.60 | 11.69 |
| **Soft wood cutting** | 8.68 | 7.93 |
| **S.E m (±)** | 0.291 | 0.279 |
| **CD at 5%** | 0.852 | 0.818 |
| **Factor -B (IBA levels)** |  |  |
| **IBA @ 0 PPM** | 10.29 | 11.62 |
| **IBA @ 2000 PPM** | 11.56 | 12.73 |
| **IBA @ 3000 PPM** | 12.48 | 13.43 |
| **IBA @ 4000 PPM** | 11.49 | 12.28 |
| **S.E m (±)** | 0.336 | 0.322 |
| **CD at 5%** | 0.984 | 0.944 |
| **Treatment Combination** |  |  |
| **T1** | 12.27 | 17.19 |
| **T2** | 13.53 | 17.35 |
| **T3** | 17.23 | 17.89 |
| **T4** | 17.30 | 19.34 |
| **T5** | 10.20 | 9.10 |
| **T6** | 11.13 | 11.43 |
| **T7** | 10.73 | 14.18 |
| **T8** | 10.33 | 12.03 |
| **T9** | 8.40 | 8.58 |
| **T10** | 10.00 | 9.40 |
| **T11** | 9.47 | 8.23 |
| **T12** | 6.83 | 5.49 |
| **S.E m (±)** | 0.581 | 0.558 |
| **CD at 5%** | 1.704 | 1.636 |

**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 @ 4000 ppm performed best with respect to sprouting, growth and success. The hardwood cutting treated with IBA @ 3000 ppm was found next best treatment combination for multiplication of seedless le mon.

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