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# RESPONSES OF IBA AND NAA ON SHOOT AND ROOT GROWTH OF SEMI HARD WOOD CUTTINGS OF GUGGUL [*COMMIPHORA WIGHTII* (ARN.) BHAN.]

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**ABSTRACT**

The need of today world is high output yield and enhanced production of the crop as well as incorporates new technologies *i.e.* application of plant growth regulators (PGR). Poor seed set and germination limits propagation of *Commiphora wightii* plant. To fulfill the supply-demand gap, it is essential to develop propagation and agro technique for the *Commiphora* species. The PGR usually affects the physiological processes of growth and development in plants, when applied in low concentration. Hence, the present study was carried out to standardize the techniques for mass multiplication at Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, RVSKVV, Mandsaur (M.P.) during the year of 2021-22. The experimental material was consisting of eight combinations of PGRs (IBA and NAA@ 250, 500, 750 and 1000 ppm both) with one untreated control were used in CRD Design with three replications. Treatment $T_3$-IBA 750 ppm had early sprouting, maximum sprouting, chlorophyll content, number of leaves, leaf area, leaf weight at 120 days after planting (DAP). The maximum leaf area index was recorded in treatment $T_3$-IBA 750 PPM at 90-120 DAP. Among shoot parameters, treatment $T_3$-IBA 750 ppm was registered the highest number of shoots, longest shoot, fresh weight of stem and dry weight of stem at 120 DAP. Among root parameters, treatment, $T_3$-IBA 750 ppm was recorded early rooting, maximum rooting and survival, more number of roots, longest root, fresh weight of roots and dry weight of roots at 120 DAP. The maximum gross income, net income and B:C ratio per treatment was recorded with $T_3$ IBA 750 ppm *i.e.*, Rs. 18,942.00/-, Rs. 15,390.10/- and 4.33, respectively.

***Key words :*** *Commiphora wightii* , IBA, NAA, Propagation, Shoot and root growth, B:C ratio.

## Introduction

*Commiphora wightii* (Arnott.) Bhand. commonly known as guggul in Hindi belongs to family Burseraceae. It is reported to be an important component of the flora of tropical arid ecosystem (Kumar and Shankar, 1982). It is mostly found in the arid, rocky tracts of Rajasthan, Gujarat, Karnataka, Rajputana, Bellari, Assam, Berar and Mysore states of India and Sindh and Baluchistan states of Pakistan (Thomas *et al*., 2020b). Guggul gum is ooze out form the bark as a result of wound or incision on the bark (Thomas *et al*., 2022a). Forests are the main source for collection of guggal gum (Bandi *et al*., 2012). The gum is also used in perfumery, calico- printing, fumigation, dyeing silk and cotton and as incense (Behera *et al*., 2020) and in allopathic, ayurvedic and unani systems of medicine owing to its anti-inflammatory, anti-rheumatic, hypercholesteremic, hypolipidemic and anti-fertility activity. Its slow growth, poor seed setting and lower germination rate as well as excessive demands, improper method of collection, uncontrolled forest destruction and

poor knowledge of cultivation are the major issues for highly decreasing of this plant. Therefore, it is categorized as threatened plant (Thosar and Yande, 2009). This plant has become endangered and reported in Data Deficient category of IUCN's Red Data list (Thomas *et al*., 2020a). The major constraint in cultivation and domestication of this important medicinal plant is lack of availability of quality planting material due to delay in germination. Hence, there is need for alternative sources of planting materials. Vegetative propagation through stem cutting is most common and successful method (Thosar and Yande, 2009). Auxins play an essential role in coordination of plant growth and behavioral processes in the life cycle. Role of some auxins IAA, IBA and NAA has been examined for their stimulatory effects on adventitious root formation in stem cuttings as well as on subsequent growth and survival of cuttings.

## Materials and Methods

The experiment was carried out during the year 2021-22 at Net shade house, Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, Rajmata Vijayaraje Krishi Vishwa Vidhyalaya, Gwalior (M.P.). Site of the experiment was located in the Malwa plateau in the western part of Madhya Pradesh and belongs to sub-tropical and semi-arid climatic conditions. The experiment was laid out in Complete Randomized Design with three replications. The experimental material consisting of eight combinations of growth hormones (IBA and NAA @ 250, 500, 750 and 1000 ppm both) with one untreated control were used. The semi hardwood cuttings of guggul were procured from herbal garden College of horticulture, Mandsaur (Madhya Pradesh). Cuttings were uniform size (15-20 cm long) having 4-5 functional buds were obtained from one year old mature shoots well established, healthy plants, by giving a basal round cut just below the bud and another slanting cut above the bud. The cuttings were about 1.00 cm thick in diameter and 15-20 cm in length. Soil, sand and vermicompost were used for filling polybags as per treatment in ratio of 2:1:1 respectively. For preparing the 1000 ml IBA solution of 250, 500, 750 and 1000 ppm, IBA powder @ 250, 500, 750 and 1000 mg were weighed and dissolved separately in little quantity of 1 N NaOH. Thereafter, the desired volume of solutions were made up with addition of distilled water. Similarly, NAA solution was prepared. These solutions were then diluted with distilled water to make 1000 ml. pretreated cuttings were planted in the prepared poly bags containing rooting media. The cutting transplanted under net shade house and five sprouted cuttings were selected randomly from each replication of the treatments. The statistical analysis of variance for the applied design (RBD) was analyzed using Genstat software (14$^{th}$ Edition). The F-test was measured at the $P<0.05$ level of significance.

## Results and Discussion

### Leaf parameters

The data on leaf parameters of guggul are represented in Tables 1 and 2. Significantly minimum days taken to sprout cutting$^{-1}$ (16) was observed under the treatment $T_3$- IBA 750 ppm followed by $T_4$- IBA 1000 ppm (16.1) which were at par with each other but statistically superior with rest of treatments. Whereas, maximum days taken to sprout cutting$^{-1}$ (19.7) were recorded under the treatment $T_0$ -Control. Application of IBA helps in the accumulation of metabolites, cell enlargement, synthesis of new proteins and increase in nitrogen which might have resulted in early bud sprouting according to Diwakar *et al.* (2011). The significantly highest number of leaves cutting$^{-1}$ was observed in treatment $T_3$-IBA 750 ppm (32.80) followed by treatment $T_4$-IBA 1000 ppm (32.13) at 60 DAP. Similarly, treatment $T_3$-IBA 750 ppm had significantly maximum number of leaves cutting$^{-1}$ (51.67) at 90 DAP, which was at par with treatment $T_4$ -IBA1000 ppm (50.03), $T_2$ – IBA 500 ppm (49.93) and $T_7$ - NAA 750 ppm (48.90). Whereas, minimum number of leaves cutting$^{-1}$ was found in treatment $T_0$ - Control. Similarly, treatment $T_3$-IBA 750 ppm was noted the significantly maximum number of leaves cutting$^{-1}$ (56.40) at 120 DAP. Increase in leaf number may be due to vigorous rooting induced by the growth regulator enabling the cuttings to absorb more nutrients and thereby producing more leaves as reported by Stancato *et al*. (2003). The treatment $T_3$-IBA 750 ppm had accumulated significantly highest leaf area (128.65cm$^2$), which was at par with $T_4$- IBA1000 ppm (109.87cm$^2$) at 30 DAP. The lowest leaf area was recorded in the $T_0$- control (54.99 cm$^2$). Similarly, treatment $T_3$-IBA 750 ppm had registered significantly higher leaf area (258.39, 516.24 and 711.26 cm$^2$) at 60, 90 and 120 DAP, respectively. This may be possibly due to IBA, which leads to formation of root initials and thus root formation and finally into absorbance of more amount of nutrient from soil led to higher leaf area under $T_3$-IBA 750 ppm. Diwakar and Katiyar (2013) had also reported IBA to promote leaf area. The treatment $T_3$-IBA 750 ppm had significantly highest leaf area index (8.06, 16.14 and 25.57) at 30-60, 60-90 and 90-120 DAP, respectively among the treatments. Whereas, lowest leaf area index (14.37) was found in treatment $T_0$-control. These findings are similar with the results of Sure *et al.* (2018) in guggul cuttings. These results might be due to positive rate of

**Table 1 :** Effect of plant growth regulators on days to sprout, number of leaves cutting$^{-1}$ and leaf area of guggul.

| Treatments | Days taken to sprout | Number of leaves cutting$^{-1}$ | | | | Leaf area (cm$^2$) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 30 DAP | 60 DAP | 90 DAP | 120 DAP | 30 DAP | 60 DAP | 90 DAP | 120 DAP |
| $T_0$ – Control | 19.7 | 16.73 | 18.73 | 35.67 | 40.67 | 54.99 | 115.09 | 282.47 | 407.41 |
| $T_1$ – IBA 250 ppm | 18.4 | 19.53 | 22.93 | 47.07 | 51.60 | 77.51 | 151.17 | 422.63 | 575.59 |
| $T_2$ – IBA 500 ppm | 16.7 | 23.27 | 29.00 | 49.93 | 54.60 | 96.53 | 208.83 | 456.04 | 643.81 |
| $T_3$ – IBA 750 ppm | 16 | 24.07 | 32.80 | 51.67 | 56.40 | 128.65 | 258.39 | 516.24 | 711.26 |
| $T_4$ – IBA 1000 ppm | 16.1 | 23.93 | 32.13 | 50.03 | 55.23 | 109.87 | 232.85 | 458.11 | 667.06 |
| $T_5$ – NAA 250 ppm | 19.1 | 17.33 | 20.53 | 43.73 | 48.77 | 60.42 | 118.32 | 336.78 | 486.61 |
| $T_6$ – NAA 500 ppm | 19.4 | 19.53 | 21.87 | 44.87 | 52.90 | 78.87 | 126.67 | 412.94 | 585.69 |
| $T_7$ – NAA 750 ppm | 16.8 | 22.20 | 27.87 | 48.90 | 54.33 | 92.68 | 193.02 | 441.42 | 610.98 |
| $T_8$ – NAA 1000 ppm | 19.3 | 19.73 | 23.67 | 47.80 | 49.97 | 76.08 | 149.16 | 386.53 | 540.05 |
| S.Em. ± | 0.30 | 1.35 | 1.43 | 1.12 | 1.10 | 8.44 | 12.93 | 12.01 | 24.98 |
| C.D. at 5% | 0.89 | 4.00 | 4.25 | 3.32 | 3.27 | 25.06 | 38.42 | 35.69 | 74.23 |

**Table 2 :** Effect of plant growth regulators leaf area index, fresh weight of leaves, sprouting percent and chlorophyll content of guggul.

| Treatments | Leaf area index | | | Fresh weight of leaves (g cutting$^{-1}$) | | | | SPAD value |
|---|---|---|---|---|---|---|---|---|
| | 30-60 DAP | 60-90 DAP | 90-120 DAP | 30 DAP | 60 DAP | 90 DAP | 120 DAP | 90 DAP |
| $T_0$ – Control | 3.54 | 8.28 | 14.37 | 0.31 | 0.97 | 1.80 | 2.21 | 35.91 |
| $T_1$ – IBA 250 ppm | 4.76 | 11.95 | 20.80 | 0.40 | 1.20 | 2.23 | 3.97 | 39.05 |
| $T_2$ – IBA 500 ppm | 6.36 | 13.85 | 22.91 | 0.81 | 2.03 | 3.37 | 4.76 | 39.42 |
| $T_3$ – IBA 750 ppm | 8.06 | 16.14 | 25.57 | 1.07 | 2.77 | 5.23 | 5.29 | 40.47 |
| $T_4$ – IBA 1000 ppm | 7.14 | 14.40 | 23.44 | 0.97 | 2.53 | 4.57 | 5.04 | 40.17 |
| $T_5$ – NAA 250 ppm | 3.72 | 9.48 | 17.15 | 0.37 | 1.40 | 1.83 | 3.57 | 36.05 |
| $T_6$ – NAA 500 ppm | 4.28 | 11.24 | 20.80 | 0.38 | 1.67 | 2.83 | 4.24 | 36.45 |
| $T_7$ – NAA 750 ppm | 5.95 | 13.22 | 21.93 | 0.75 | 1.90 | 3.11 | 4.50 | 39.41 |
| $T_8$ – NAA 1000 ppm | 4.69 | 11.16 | 19.30 | 0.43 | 1.4 | 2.43 | 3.89 | 38.31 |
| S.Em. ± | 0.37 | 0.30 | 0.56 | 0.07 | 0.13 | 0.17 | 0.31 | 0.65 |
| C.D. at 5% | 1.10 | 0.90 | 1.67 | 0.21 | 0.40 | 0.49 | 0.91 | 1.93 |

growth hormone auxins, which would have accelerated the enzymatic activity of IBA. The treatment $T_3$ - IBA 750 ppm was perceived maximum leaf weight (1.07, 2.77, 5.23 and 5.29g cutting$^{-1}$) at 30, 60, 90 and 120 DAP, respectively. The $T_3$ -IBA 750 ppm has been found at par with treatment $T_4$ –IBA1000 ppm (5.04 g cutting$^{-1}$), $T_2$–IBA500 ppm (4.76 g cutting$^{-1}$) and $T_7$- NAA 750 ppm (4.50 g cutting$^{-1}$) at 120 DAP. However minimum leaf weight was found in treatment $T_0$ - control. Leaf area and leaf weight values are directly proportional to each other. Leaf weight increases as leaf area increases. Sprouting percentage was shown appreciable difference due to various concentrations of plant growth regulators in guggul. The treatment $T_3$- IBA 750 ppm took highest sprouting percentage (80.92) followed by $T_4$- IBA 1000 ppm (80.92), which were at par with each other as well as $T_2$- IBA 500 ppm (74.57), but significantly higher over the rest of the treatments. The lowest sprouting percentage (57.91) was recorded in the $T_0$ -control. The higher sprouting percentage with $T_3$- IBA 750 ppm might be due to better root growth, which augmented absorption and translocation of nutrients from medium to the shoots, which might have taken active part in various plant metabolic processes (Padekar, 2018). The chlorophyll content was shown appreciable difference at 90 days after planting. The treatment $T_3$- IBA 750 ppm was recorded maximum chlorophyll content (40.47), which was at par with the treatment $T_4$- IBA 1000 ppm (40.17), $T_2$- IBA 500 ppm (39.42) $T_7$- NAA 750 ppm (39.41) and $T_1$- IBA 250 ppm (39.05), but appreciably superior over the remaining treatments. The increased concentrations of auxins might have increased leaf area which enhanced the process of photosynthesis resulting in more chlorophyll content in leaves (Dhatrikarani, 2019; Oscar and Javier, 2014) in cape gooseberry.

### Shoot parameters

The data on shoot parameters are presented in Tables

**Table 3 :** Effect of plant growth regulators on number of shoots cutting$^{-1}$and length of longest shoot of guggul.

| Treatments | Sprouting % | Number of shoots cutting$^{-1}$ | | | | Length of longest shoot (cm) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 30 DAP | 60 DAP | 90 DAP | 120 DAP | 30 DAP | 60 DAP | 90 DAP | 120 DAP |
| $T_0$ – Control | 30 DAP | 2.37 | 2.97 | 3.4 | 3.60 | 2.13 | 11.13 | 26.21 | 35.17 |
| $T_1$ – IBA 250 ppm | 57.91 | 2.90 | 3.43 | 3.6 | 3.73 | 3.87 | 11.72 | 27.23 | 41.65 |
| $T_2$ – IBA 500 ppm | 69.81 | 3.10 | 3.50 | 4.5 | 4.73 | 4.47 | 15.64 | 30.37 | 44.09 |
| $T_3$ – IBA 750 ppm | 74.57 | 3.60 | 3.83 | 5.3 | 5.57 | 5.20 | 16.97 | 35.20 | 45.41 |
| $T_4$ – IBA 1000 ppm | 80.92 | 3.50 | 3.77 | 4.8 | 4.93 | 4.67 | 16.39 | 30.96 | 44.98 |
| $T_5$ – NAA 250 ppm | 80.92 | 2.50 | 3.03 | 3.5 | 3.80 | 2.73 | 11.21 | 26.81 | 35.76 |
| $T_6$ – NAA 500 ppm | 58.71 | 2.77 | 3.23 | 4.1 | 4.53 | 2.93 | 12.65 | 28.24 | 38.43 |
| $T_7$ – NAA 750 ppm | 63.47 | 3.00 | 3.50 | 4.4 | 4.63 | 4.33 | 13.69 | 30.19 | 42.73 |
| $T_8$ – NAA 1000 ppm | 72.19 | 2.50 | 3.30 | 3.7 | 4.07 | 3.13 | 13.11 | 28.25 | 39.35 |
| S.Em. ± | 67.43 | 0.14 | 0.19 | 0.23 | 0.21 | 0.28 | 0.78 | 0.62 | 1.24 |
| C.D. at 5% | 2.47 | 0.43 | 0.56 | 0.68 | 0.64 | 0.83 | 2.32 | 1.84 | 3.69 |

**Table 4 :** Effect of plant growth regulators on fresh and dry weight of stem of guggul.

| Treatments | Fresh weight of stem (g) | | | | Dry weight of stem (g) | | | |
|---|---|---|---|---|---|---|---|---|
| | 30 DAP | 60 DAP | 90 DAP | 120 DAP | 30 DAP | 60 DAP | 90 DAP | 120 DAP |
| $T_0$ – Control | 6.42 | 10.37 | 12.22 | 12.72 | 2.4 | 3.33 | 5.03 | 5.91 |
| $T_1$ – IBA 250 ppm | 9.55 | 10.85 | 13.73 | 17.73 | 3.73 | 4.57 | 7.19 | 7.84 |
| $T_2$ – IBA 500 ppm | 9.98 | 15.70 | 17.74 | 18.45 | 4.1 | 4.87 | 7.67 | 10.39 |
| $T_3$ – IBA 750 ppm | 13.88 | 17.39 | 19.57 | 20.58 | 5.25 | 7.03 | 8.84 | 11.02 |
| $T_4$ – IBA 1000 ppm | 11.68 | 15.87 | 19.28 | 20.02 | 5.17 | 5.77 | 7.87 | 10.88 |
| $T_5$ – NAA 250 ppm | 6.91 | 10.67 | 13.38 | 16.07 | 2.6 | 3.47 | 6.43 | 7.31 |
| $T_6$ – NAA 500 ppm | 8.37 | 11.77 | 13.94 | 16.44 | 2.63 | 3.67 | 6.79 | 7.97 |
| $T_7$ – NAA 750 ppm | 9.72 | 14.86 | 16.95 | 18.22 | 3.8 | 4.75 | 7.42 | 9.77 |
| $T_8$ – NAA 1000 ppm | 9.32 | 12.59 | 13.98 | 16.62 | 3.07 | 3.93 | 7.01 | 8.31 |
| S.Em. ± | 0.31 | 0.88 | 0.49 | 0.78 | 0.39 | 0.44 | 0.30 | 0.57 |
| C.D. at 5% | 0.94 | 2.61 | 1.46 | 2.31 | 1.15 | 1.30 | 0.89 | 1.70 |

3 and 4. The treatment $T_3$ –IBA 750 ppm was observed higher number of shoots (3.60, 3.83 5.3 and 5.57 cutting$^{-1}$) at 30, 60, 90 and 120 DAP, respectively and was at par with the treatment $T_4$- IBA 1000 ppm. Whereas, minimum number of shoots was found in treatment $T_0$ –control. Similarly the treatment $T_3$-IBA 750 ppm was assessed maximum length of longest shoot (5.2, 16.97, 35.20 and 45.41 cm) at 30, 60, 90 and 120 DAP, respectively. Auxins activated shoot growth which might have caused hydrolysis and translocation of carbohydrates and nitrogenous substances at the base of cuttings and resulted in accelerating cell elongation and cell division (Singh *et al.*, 2003; Patidar *et al*., 2019). The treatment $T_3$-IBA 750 ppm was accumulated highest fresh weight of stem (13.88, 17.39, 19.57 and 20.58g cutting$^{-1}$) at 30, 60, 90 and 120 DAP, respectively. The treatment $T_3$-IBA 750 ppm was accumulated highest dry weight of stem (5.25, 7.03, 8.84 and 11.02 g cutting$^{-1}$) at 30, 60, 90 and 120 DAP, respectively. $T_0$-Control recorded minimum fresh and dry weight of stem. The improvement in fresh weight and dry weight of shoot in $T_3$-IBA 750 ppm might be due to increased length, leaf area and canopy spread, which resulted in greater amount of dry matter accumulation as a consequence of high photosynthates. These results are in accordance with the findings of Sivaci and Yalcin (2006).

## Root parameters

The data on root parameters are presented in Tables 5 and 6. Days taken to root initiation were shown appreciable difference due to different concentration of plant growth regulators in guggul. The early root initiation was observed in treatment $T_3$-IBA750 ppm (18.30 days) as compared to remaining treatments. The treatment $T_0$-control recorded late rooting (24.20 days). The maximum rooting was noted in treatment $T_3$-IBA 750 PPM (86.47%), whereas minimum rooting was noted in $T_0$-control (65.85%) at 120 DAP. The maximum number of roots (8.42, 10.00, 17.95 and 23.33 cutting$^{-1}$), length of longest root (8.30, 15.28, 21.12 and 27.90 cm), fresh

**Table 5 :** Effect of plant growth regulators on number of roots cutting$^{-1}$ and length of longest root of guggul.

| Treatments | Days to root initiation | Number of roots cutting$^{-1}$ | | | | Length of longest root (cm) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 30 DAP | 60 DAP | 90 DAP | 120 DAP | 30 DAP | 60 DAP | 90 DAP | 120 DAP |
| $T_0$ – Control | 24.2 | 2.58 | 4.33 | 6.17 | 7.11 | 2.33 | 8.88 | 10.63 | 17.06 |
| $T_1$ – IBA 250 ppm | 21.2 | 5.40 | 6.49 | 8.03 | 7.50 | 4.92 | 12.78 | 15.07 | 21.12 |
| $T_2$ – IBA 500 ppm | 19.8 | 6.73 | 7.39 | 13.50 | 18.07 | 5.78 | 14.48 | 18.60 | 23.85 |
| $T_3$ – IBA 750 ppm | 18.3 | 8.42 | 10.00 | 17.95 | 23.33 | 8.30 | 15.28 | 21.12 | 27.90 |
| $T_4$ – IBA 1000 ppm | 18.9 | 7.90 | 9.79 | 14.10 | 21.83 | 5.87 | 15.00 | 19.07 | 26.56 |
| $T_5$ – NAA 250 ppm | 22.9 | 2.85 | 5.10 | 6.53 | 7.41 | 4.17 | 12.20 | 13.77 | 19.29 |
| $T_6$ – NAA 500 ppm | 21.7 | 3.43 | 5.17 | 6.53 | 7.52 | 4.67 | 12.50 | 14.57 | 20.77 |
| $T_7$ – NAA 750 ppm | 20.2 | 5.55 | 6.80 | 12.62 | 13.67 | 5.37 | 13.92 | 17.13 | 23.43 |
| $T_8$ – NAA 1000 ppm | 20.3 | 4.80 | 5.63 | 7.17 | 9.22 | 5.28 | 12.70 | 15.65 | 21.46 |
| S.Em. ± | 0.15 | 0.41 | 0.52 | 0.46 | 1.12 | 0.46 | 0.66 | 0.98 | 1.15 |
| C.D. at 5% | 0.44 | 1.23 | 1.55 | 1.36 | 3.32 | 1.38 | 1.96 | 2.91 | 3.43 |

**Table 6 :** Effect of plant growth regulators on fresh weight, dry weight and survival percent of root of stem cutting of guggul.

| Treatments | Fresh weight of root (g) | | | | Dry weight of root (g) | | | | Survival % |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAP | 60 DAP | 90 DAP | 120 DAP | 30 DAP | 60 DAP | 90 DAP | 120 DAP | 120 DAP |
| $T_0$ – Control | 0.083 | 0.50 | 1.10 | 2.04 | 0.04 | 0.21 | 0.57 | 0.76 | 65.76 |
| $T_1$ – IBA 250 ppm | 0.18 | 0.77 | 1.70 | 3.98 | 0.09 | 0.25 | 0.59 | 1.03 | 89.83 |
| $T_2$ – IBA 500 ppm | 0.32 | 1.20 | 1.97 | 4.06 | 0.16 | 0.33 | 0.80 | 1.13 | 92.28 |
| $T_3$ – IBA 750 ppm | 0.50 | 1.77 | 2.23 | 4.62 | 0.20 | 0.44 | 0.97 | 1.31 | 94.71 |
| $T_4$ – IBA 1000 ppm | 0.38 | 1.40 | 2.03 | 4.33 | 0.16 | 0.33 | 0.81 | 1.28 | 92.57 |
| $T_5$ – NAA 250 ppm | 0.12 | 0.57 | 1.13 | 2.30 | 0.06 | 0.22 | 0.58 | 0.77 | 81.59 |
| $T_6$ – NAA 500 ppm | 0.14 | 0.60 | 1.13 | 3.08 | 0.07 | 0.22 | 0.60 | 1.00 | 88.07 |
| $T_7$ – NAA 750 ppm | 0.24 | 0.97 | 1.53 | 3.99 | 0.12 | 0.25 | 0.73 | 1.06 | 89.84 |
| $T_8$ – NAA 1000 ppm | 0.19 | 0.77 | 1.43 | 3.61 | 0.08 | 0.23 | 0.73 | 1.03 | 90.75 |
| S.Em. ± | 0.02 | 0.085 | 0.221 | 0.322 | 0.007 | 0.024 | 0.174 | 0.056 | 2.11 |
| C.D. at 5% | 0.05 | 0.253 | 0.656 | 0.956 | 0.022 | 0.070 | 0.516 | 0.168 | 6.26 |

**Table 7 :** Effect of plant growth regulators on gross income, net income and B:C ratio of stem cuttings of guggul.

| Treatments | Cost (`) | Gross income (`) | Net income (`) | B:C ratio |
|---|---|---|---|---|
| $T_0$ – Control | 3487.40 | 13152.00 | 9664.60 | 2.77 |
| $T_1$ – IBA 250 ppm | 3508.90 | 17966.00 | 14457.10 | 4.12 |
| $T_2$ – IBA 500 ppm | 3530.40 | 18456.67 | 14926.27 | 4.23 |
| $T_3$ – IBA 750 ppm | 3551.90 | 18942.00 | 15390.10 | 4.33 |
| $T_4$ – IBA 1000 ppm | 3573.40 | 18514.67 | 14941.27 | 4.18 |
| $T_5$ – NAA 250 ppm | 3489.15 | 16318.00 | 12828.85 | 3.68 |
| $T_6$ – NAA 500 ppm | 3490.90 | 17614.67 | 14123.77 | 4.05 |
| $T_7$ – NAA 750 ppm | 3492.65 | 17967.33 | 14474.68 | 4.14 |
| $T_8$ – NAA 1000 ppm | 3494.40 | 18150.67 | 14656.27 | 4.19 |

weight of roots (0.50, 1.77, 2.23 and 4.62 g cutting$^{-1}$), dry weight of roots (0.20, 0.44, 0.97 and 1.31 g cutting$^{-1}$) were recorded in treatment $T_3$-IBA 750 at 30, 60, 90 and 120 DAP, respectively. Auxin induces root formation by breaking root apical dominance (Rolaniya *et al.*, 2018). The maximum rooting and longest root in treatment $T_3$-IBA 750 ppm could be due to the effect of IBA as it increases cell wall plasticity and cell division stimulates callus development and root growth which helped in increase in root length (Shekhawat and Manokari, 2016). The increase in root weight in treatment $T_3$-IBA 750 ppm may be due to more number of roots, highest root girth and length of the roots. IBA helps in mobilizing reserved food material elongation of meristematic cells and differentiation of cambial initials into root primordial (Patidar *et al.*, 2019; Thomas *et al.*, 2023). The maximum survival was noted in treatment $T_3$-IBA 750 ppm (94.71%), whereas minimum survival (65.76%) was noted in $T_0$ control at 120 days after planting. Sure *et al.* (2018) reported that, survival percentage is dependent on the weather, planting media, nutritional conditions and availability of growth hormones and it play vital role for survival of cutting.

### Economics of the treatments

The data on Economics of the treatments are presented in Table 7. The maximum gross income, net income and B:C ratio per treatment was recorded with $T_3$ IBA 750 ppm *i.e.*, Rs. 18,942.00/-, Rs. 15,390.10/- and 4.33, respectively. While the minimum gross income, net income and B:C ratio per treatment of plant was recorded under $T_0$ (control). It may due to high survival percentage in of IBA treated cuttings. Similar results were confirmed with the finding of Chouhan *et al*. (2023).

## Conclusion

On the basis of research data, it can be concluded that, out of nine treatments of various doses of plant growth regulators. The best performing treatment is IBA 750 ppm for enhancing shoot and root growth of guggul cuttings.

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### Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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