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# Effect of rooting hormones on growth performance of two important aromatic crops of Garhwal Himalaya

**Rajneesh Rawat, Amol Vasishth, Vinod Kumar and Vipan Guleria**

**Abstract**
The present study aimed to investigate the effect of different concentrations of IBA and IAA on growth parameters of *Rosmarinus officinalis* and *Pelargonium graveolens*. The cuttings were dipped in 250, 500, 750 and 1000 ppm of IBA (Indole-3-butyric acid) and IAA (Indole-3-acetic acid) solutions for 12 hrs and planted in poly bags containing mixtures of Soil, Sand and FYM in 1:2:1 proportion. The experiment was laid out in Completely Randomized Design (CRD) with three replications. Data were collected on Survival percentage, number of sprouts, number of roots, root length, fresh weight and dry weight of roots at 60 and 90 DAP. The results showed that the IBA and IAA had significant effect on the root growth of *Rosmarinus officinalis* and *Pelargonium graveolens*. IBA treated cuttings showed better growth as compared to IAA. 750 ppm and 1000 ppm concentration of IBA recorded maximum growth in rosemary and geranium cuttings, respectively.

**Keywords:** Rosmary, geranium, cuttings, rooting hormones, vegetative growth

## Introduction
Rosemary (*Rosmarinus officinalis* L.) is one of the most important medicinal and aromatic, evergreen, shrubby plant which belongs to the mint family, lamiaceae. The name rosemary comes from the Latin word "Ros" meaning dew and "marinus" meaning from the sea, which means "Dew of the sea" (Singletary, 2016) [21]. Rosemary is perennial, an ornamental-medicinally significant crop all over the world and originally native to the Mediterranean region. Rosemary has a woody texture but like other herbs, does not actually contain woody tissues. This plant can reach up to 1.5m (5ft) height, rarely 2m (6 ft 7 in) and has green needle-like leaves, 2-4 cm long and 2-5 mm broad (Ashrafi and Sarem 2012) [2]. The upper surface of the leaf is dark green whereas it is white below; leaves are resinous. Branches are rigid with fissured bark and stem square, woody and brown. Pale blue small flowers appear in cymose inflorescence and in temperate climate rosemary bloom in spring and summer, but it can also bloom in warm climate (Sasikumar 2004) [18].
Rosemary propagation is done either through seed or stem cutting. Seeds of rosemary are rarely used in propagation as they are slow to germinate, taking 3–4 weeks before emergence with a poor germination rate of 10–20%. Cutting is a well-known common and relatively cheap method used in the propagation of many ornamental plant species. It overcomes the difficulties of propagation by plant seeds (Elhaak *et al*. 2015) [6]. Propagation of plants from cuttings enables a large percentage of the cuttings to produce roots quickly. Therefore, propagation of rosemary by cuttings was tried in the present study.
*Pelargonium graveolens* L. is commonly known as rose scented Geranium as the leaves of the plant produce the fragrance of rose. It belongs to family Geraniaceae. Geranium is most important, perennial, high-value aromatic shrub that can reach a height of up to 1.5 m and has spread of 1m. The leaves may be large or small, entire or deeply toothed, green, grey, soft to the touch, and strongly rose scented. The flowers are five petalled and colour vary from whitish to pale pink vary in size from 0.5-4 cm, the plant flowering season from August to January. Its hairy stems are herbaceous when young and become woody with age (Sharopov *et al*., 2014) [19]. It is native to South Africa and extensively grown in Morocco, France, Russia, China, Congo, Egypt and India. During early 20th century, rose scented geranium was first time grown in Nilgiri and Shevroy hills of South India and later it has been cultivated in the different parts of India from tropical to temperate region with an elevation of 700 to 2200 masl and the most favorable elevation is between 1200 to 1800 masl having annual rainfall 1000 to 1500 mm. The well drained loam and sandy loam soil with sufficient amount of organic matter is ideal for the cultivation of Rose-scented geranium. (Bijalwan *et al*., 2014) [4].

Essential oil of geranium is obtained by steam or hydro-distillation of aerial parts; the main constituents of essential oil are citonellol, geraniol, isomenthone, citronellyl formate and geranyl formate. These ingredients are used in soap, shampoo, tooth paste, hair oil, perfume, cosmetic cream and in medicinal and aroma therapy industries all over the world. (Kaul *et al*., 1997) [9]. Essential oil has great demand in national and international markets. Rose-scented geranium is being cultivated in hilly tracks of north Uttarakhand and South India. It is a good source of income generation to the farmers. (Verma *et al*., 2010) [25] Rose-scented geranium can be propagated by seeds and cuttings. The geranium is commonly propagated by using herbaceous or softwood cuttings. The art of propagation of plants by vegetative means is gaining popularity in the field of aromatic plant species in order to get desired material with respect to yield and essential oil content. Vegetative propagation includes fast multiplication of plants, attainment of size, ease of propagation and efficient maintenance of genetic uniformity Vegetative propagation methods are being widely followed to raise the plants of desired characteristics to maintain their purity for commercial exploitation. It has been widely documented that auxins e.g. Indole-3 butyric acid and Indole-3 acetic acid promotes adventitious root development of stem cuttings through their ability to promote the initiation of lateral roots primordial and to enhance transport of carbohydrates to the cutting base needed for root growth. The purpose of treating cuttings with auxins is to increase the percentage of rooting, root initiation, number and uniformity of rooting.

## Materials and Methods

### Study Area

The experiment was conducted in medicinal block of College of Forestry, V.C.S.G. Uttarakhand University of Horticulture and Forestry, Ranichauri, (Tehri Garhwal), which is situated at an altitude of about 1800 masl, lying between 30o15' N latitude and 78o30' E longitude under mid hills of Uttarakhand, India. Ranichauri campus experiences humid and temperate type of climate with chilled winter. The mean annual maximum and minimum temperature varies from 30.3oC to 13.5oC.

### Experimental details:

- Crops: Rosemary and Geranium.
- Design of Experiment: Completely Randomized Design
- Number of Treatments: 9
- Number of Replications: 3
- Container: Polythene bags
- Growing Media: Sand + Soil + FYM (1:2:1)
- Total Number of cuttings: 2x9x3x10 = 540
- Place: Poly house
- Dipping time: 12 hrs

| Symbol used | Name of Treatment | Concentrations |
|---|---|---|
| T1 | IBA | 250 ppm |
| T2 | IBA | 500 ppm |
| T3 | IBA | 750 ppm |
| T4 | IBA | 1000 ppm |
| T5 | IAA | 250 ppm |
| T6 | IAA | 500 ppm |
| T7 | IAA | 750 ppm |
| T8 | IAA | 1000 ppm |
| T9 | Control | |

### Collection of planting materials

Stem cuttings of *Rosmarinus officinalis* L. and *Pelargonium graveolens* L. were collected from Medicinal and Aromatic plants nursery of College of Forestry Ranichauri - Tehri Garhwal (UK).

### Preparation of cuttings

The cuttings were made of 10 -12 cm length. The leaves of each cuttings cleaned from base up to 5 cm in height. Stems cuttings with 4-5 buds of each species was selected.

### Preparation of IBA solution

Desired quantities of IBA were mixed with few flakes of NaOH and then require volume will be made by adding distilled water to make the proper concentration of IBA.

### Preparation of IAA solution

Desired quantity of IAA was mixed with few flakes of Na OH and then distilled water will be added to make the final volume of required concentration of IAA.

### Treatment of cuttings with growth regulators and planting

The basal portion of cuttings was dipped in the respective growth regulator solution for 12 hours and then planted in polythene bag. In control, cuttings were directly planted without any growth regulator treatment. The cuttings were planted 6- 8 cm deep in the polythene bags. The soil mixture around the cutting was slightly pressed to hold the cutting firmly but not compacted, to ensure adequate aeration of the rooting zone. The observations on survival percentage, number of sprouts, root length, number of roots, fresh weight and dry weight of roots were recorded at 30, 60 and 90 DAP.

### Observations recorded

#### I. Survival percentage

Survival percentage of rooted cuttings was calculated for each treatment separately at 90 days after planting by using following formulae:

$$\text{Survival percentage of cuttings} = \frac{T-Mp}{T} \times 100$$

Where,
T = Total number of rooted cuttings
Mp = Dried cuttings

#### II. Number of sprouts per cutting

The total numbers of sprouts in all five randomly selected cuttings were counted at 30, 60 and 90 days after planting and then average was calculated.

#### III. Number of roots per cutting

The number of roots per cutting was counted for each treatment from randomly selected five rooted cuttings and observations were recorded at 30, 60 and 90 days after planting and then average was calculated.

#### IV. Root length (cm)

The root length of cuttings was recorded for each treatment from randomly selected five rooted cuttings at 30, 60 and 90 days after the date of planting and then average was calculated.

**V. Fresh weight of roots per cutting (mg)**
The fresh weight of rooted cutting recorded for each treatment randomly five rooted cuttings were selected and detached then fresh weight was taken with the help of electronic balance.

**VI. Dry weight of roots per cutting (mg)**
Roots were dried in oven at 70±2 0C for 24 hours and then dry weight of five roots was recorded.

**Results and Discussions**
**1. *Rosmarinus officinalis***
**A. Survival percentage**
The result revealed that the survival percentages of rooted cuttings were significantly affected by the different plant growth regulators (Table 1). The result revealed that the highest survival percentages (90.0%) of rooted cutting were recorded in two treatments i.e. T3 750 ppm IBA and T6 500 ppm IAA. The lowest survival percentage (80.0%) of rooted cuttings was recorded in control. Higher survival percentage in treated cuttings might be attributed to auxin activity which enhances the translocation of metabolites causing increased survival percentage of Rosemary cuttings. The result of present observation of survival percentage was similar to the findings of Padekar *et al*., (2018) [14] in Momordica dioica Roxb and Venugopal *et al*., (2018) [24] in Rosemary

**B. Number of sprouts per cutting**
There was a significant effect of growth regulators on number of sprouts. The numbers of sprouts were more in IBA treated cuttings than IAA treated cuttings (Table 1).It is apparent from the data that IBA at different concentrations significantly influenced the number of sprouts per cutting at 60 and 90 DAP. No sprouting was observed at 30 days after planting.
After 60 days of planting, the highest number of sprouts (19.0) per cutting was noted under T3 (750 ppm IBA). The lowest number of sprouts (12.7) was recorded in T9 (control) being closely preceded by T5 IAA 250 ppm (12.9) which was significantly at par with T6.
Similarly, at 90 days after planting, the highest number of sprouts per cutting (24.2) was recorded in T3 (750 ppm IBA) which was statistically at par with T4 IBA 1000 ppm (24.1) which was significantly superior over other treatments. In IAA treated cuttings, maximum number of sprouts 18.7 was recorded in T7 (750 ppm IAA) which was statistically at par with T6 and T8 and significantly different value 16.1 was found in T5 (IAA 250 ppm). The lowest number of sprouts (15.4) per cutting was recorded under control. Number of sprouts increases due to better utilization of stored carbohydrates, nitrogen and other factors with the aid of growth regulators (Chandramouli 2001). This result coincides with the findings of Padekar *et al*. (2018) [14] in Momordica dioica Roxb, Venugopal *et al*. (2018) [24] in Rosemary and Rajashekara (2004) in Stevia.

**C. Number of roots per cutting**
There were significant differences for number of roots per cutting among different treatments, except in IBA treated cuttings. The number of roots in IBA treated cuttings were more than in IAA treated cuttings (Table 1).
In case of 60 days after planting, the results revealed that the number of roots per cutting ranged from 19.6 to 68.1. The maximum number (68.1) of roots per cutting was recorded in T3 (750 ppm IBA) which was statistically at par with T4 (67.9) and the minimum (19.6) number of roots per cutting was recorded in control.
Similarly 90 days after planting of cuttings, the number of roots ranged from 30.8 to 91.7. The maximum number (91.7) of roots per cutting was recorded in T3 (750 ppm IBA) which was statistically at par with T4 (90.7) and found significantly superior to all other treatments. The minimum number (30.8) of roots per cutting was noted in control.
The more number of roots were obtained in IBA treated cuttings than IAA ones. it might be due to the fact that stimulation of cambial activity involved in root initiation by growth regulators as observed in many species (Ullah *et al*., 2005) [23]. Auxins promote adventitious root formation by their ability to promote the initiation of lateral roots and also enhanced the transport of carbohydrates to basal portion of the cuttings. Padekar *et al*. (2018) [14] showed the similar result.

**D. Root length per cutting (cm)**
There was no root length observed after 30 days of planting (Table 1). The maximum root length per cutting was recorded under T3 , 750 ppm IBA (9.3 cm) which was statistically at par with T4 IBA 1000 ppm (8.9 cm) which was superior to other treatments as well as over control, T9 (5.3 cm).
Similarly at 90 DAP, the maximum root length per cutting was observed under T3 750 ppm IBA (19.1 cm) which was statistically at par with T4 IBA 1000 ppm (18.3 cm). The minimum root length (13.7 cm) per cutting was recorded in untreated cuttings.
This effect may be due to rapid translocation property or fast destruction by auxin, increasing the enzymatic activity. Similar results were found by Padekar *et al*. (2018) [14] in Momordica dioica Roxb, Masomeh *et al*. (2014) [12], Goutam *et al*. (2013) [7], Wazir (2014) [23], and Al-Zebar *et al*. (2015) [1] with different concentrations of IBA.

**E. Fresh weight of roots per cutting (mg)**
The highest fresh weight (193.3 mg) of roots per cutting was recorded at 60 days after planting of cuttings with the application of T3 750 ppm IBA which was statistically at par with T4 IBA 1000 ppm (192.2 mg) and T2 IBA 500 ppm (187.8) which was superior over IAA treated cuttings (Table 1). While fresh weight of roots per cutting was lowest (76.7 mg) in untreated cuttings (control).
Similarly, at 90 DAP the highest fresh weight (297.8 mg) of roots per cutting was recorded for IBA with the concentration of 750 ppm which was superior over other treatments as well as over control (107.8 mg)
Cuttings treated with different concentrations of plant growth regulators help in the better mobilization and translocation of primary metabolites for better root formation and nutrient uptake. Similar results were reported by Padekar *et al*. (2018) [14], Watane *et al*. (2018) [26] and Siddiqua *et al*. (2018) [20].

**F. Dry weight of roots per cutting (mg)**
The highest dry weight (102.2 mg) of roots per cutting at 60 DAP was recorded under T3 750 ppm IBA which was statistically at par with T4 IBA 1000 ppm (101.1 mg) and T2 IBA 500 ppm (97.8 mg) which was superior over other treatments as well as over control (38.9 mg).
However 90 DAP, the highest dry weight (151.1 mg) of roots per cutting was observed with the T3 750 ppm IBA which was superior over all other treatments whereas it was the lowest (60.0 mg) in untreated cuttings (control). IAA treated

cuttings recorded lesser dry weight of roots. Similar results were observed by Tanuja *et al*. (2017) [22] and Watane *et al*. (2018) [26]. Rana and Sood (2012) [16] also found that IBA treatment is better than IAA treatment. Yeshiwas *et al*. (2015) [27] also observed that the highest root dry weight in stem cutting of rose of Natal Break rootstock obtained at 1000 ppm IBA concentration.

**Table 1:** Effect of IBA and IAA on survival percentage, number of sprouts, and number of roots, root length, fresh weight and dry weight of *Rosmarinus officinalis* cuttings

| Treatments | Survival percentage (90 DAP) | No. of sprouts | | No. of roots | | Root length (cm) | | Fresh weight (mg) | | Dry weight (mg) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 60 DAP | 90 DAP | 60 DAP | 90 DAP | 60 DAP | 90 DAP | 60 DAP | 90 DAP | 60 DAP | 90 DAP |
| $T_1$ | 86.7 | 15.9 | 20.5 | 60.8 | 67.0 | 8.0 | 17.7 | 185.6 | 201.1 | 94.4 | 107.8 |
| $T_2$ | 83.3 | 16.7 | 21.7 | 66.9 | 80.2 | 8.5 | 18.1 | 187.8 | 218.9 | 97.8 | 118.9 |
| $T_3$ | 90.0 | 19.0 | 24.2 | 68.1 | 91.7 | 9.3 | 19.1 | 193.3 | 297.8 | 102.2 | 151.1 |
| $T_4$ | 86.7 | 17.2 | 24.1 | 67.9 | 90.7 | 8.9 | 18.3 | 192.2 | 262.2 | 101.1 | 127.8 |
| $T_5$ | 86.7 | 12.9 | 16.1 | 32.8 | 47.0 | 6.2 | 15.2 | 78.9 | 116.7 | 40.0 | 62.2 |
| $T_6$ | 90.0 | 13.6 | 18.5 | 34.0 | 48.6 | 6.9 | 16.5 | 78.9 | 125.5 | 41.1 | 65.5 |
| $T_7$ | 83.3 | 14.3 | 18.7 | 52.0 | 61.5 | 7.6 | 17.5 | 145.5 | 174.4 | 77.8 | 92.2 |
| $T_8$ | 83.3 | 14.2 | 18.6 | 50.2 | 56.1 | 7.3 | 17.1 | 103.3 | 158.9 | 52.2 | 83.3 |
| $T_9$ | 80.0 | 12.7 | 15.4 | 19.6 | 30.8 | 5.3 | 13.7 | 76.7 | 107.8 | 38.9 | 60.0 |
| S. E m ± | | 0.39 | 0.25 | 1.26 | 0.74 | 0.16 | 0.26 | 2.09 | 2.56 | 1.92 | 1.62 |
| C.D @ 5% | | 1.17 | 0.73 | 3.74 | 2.21 | 0.47 | 0.78 | 6.20 | 7.60 | 5.71 | 4.81 |

**2. *Pelargonium graveolens***

**A. Survival percentage**

The data on survival percentage of geranium cuttings at 90 DAP is presented in Table 2.The highest survival percentage (90.0%) of rooted cuttings was recorded in two treatments i.e. T2 IBA 500 ppm and T4 IBA 1000 ppm. The lowest survival percentage (66.7%) of rooted cutting was recorded in control. Higher survival percentage in IBA treated cuttings could be attributed to auxin activity which enhanced the translocation of metabolites causing increased survival percentage of the Geranium cuttings. Increased survival percentage was also reported by Reddy *et al*. (2006) [17] with IBA application in Geranium. These results on survival percentage are similar in line with Kumar and Ahmed (2013).

**B. Number of sprouts per cutting**

The highest number of sprouts (8.0) recorded under T4 1000 ppm IBA which was significantly superior over other treatments and the lowest number of sprouts were recorded under T9 control (3.3) at 60 DAP (Table 2).

At 90 DAP the cutting treated with T4 IBA 1000 ppm produced the highest number of sprouts (10.5) which was statistically at par with T3 750 ppm IBA (10.4). Untreated cuttings recorded the lowest number of sprouts (5.6). Plant growth regulators enhanced sprouting number to better utilization of stored carbohydrates and nitrogen. This may be due to optimum availability of photosynthates for the initiation and growth of the sprouts. Jadhav *et al*. (2003) reported similar results in patchouli and Mishra *et al*., (2010) in Tinospora cordifolia.

**C. Number of roots per cuttings**

In 30 DAP no rooting was observed in cuttings. Growth regulators significantly affected the number of roots in Geranium cuttings at 60 & 90 DAP (Table 2). The treatment T4 1000 ppm IBA recorded maximum number of roots (68.5) which was significantly superior over other treatments while the minimum number of roots (14.9) was recorded in T9 (Control).

Similarly 90 DAP the maximum number of roots were recorded under T4 1000 ppm IBA (85.8) which was statistically at par with T3 IBA 750 ppm (84.2). The minimum number of roots (20.6) was observed in control.

The effects of auxins are significant on rooting as they facilitate the synthesis of ribonucleic acid and also induce ethylene production which is necessary for cell division and root initiation and hence, more number of roots recorded with auxin treated cuttings; but at 90 DAP IAA treated cuttings showed almost similar number of roots. Similar result was revealed by Kumar and Ahmed (2013) and Bhuse *et al*. (2003) in *Pelargonium graveolens*.

**D. Root length per cutting (cm)**

The growth regulators IBA and IAA significantly influenced the root length at 60 and 90 days after planting of cuttings. No rooting was observed at 30 days after planting. After 60 days of planting, the maximum root length per cutting was recorded under T4 1000 ppm IBA (9.8 cm) which was statistically at par with T3 IBA 750 ppm (9.4 cm). The minimum root length (3.9 cm) per cutting was recorded in control (Table 2). Similarly, 90 days after planting the maximum root length per cutting was observed under T4 1000 ppm IBA (17.3 cm) which was statistically at par with T3 IBA 750 ppm (17.0 cm) and T8 IAA 1000 ppm (16.3 cm) the minimum root length (9.5 cm) per cutting was recorded in untreated cuttings. Similar results were found by Khudhur and Omer (2015) and Dahale *et al*. (2018) in Ficus carica with combination of NAA 1000 ppm.

**E. Fresh weight of roots per cutting (mg)**

The highest fresh weight (398.9 mg) of roots per cutting was recorded at 60 days after planting of cuttings with the application of T4 1000 ppm IBA which was superior over other treatments (Table 2). While fresh weight of roots per cutting was lowest (133.3 mg) in untreated cuttings (control).

Similarly, at 90 days after planting of cuttings the highest fresh weight (552.2 mg) of roots per cutting was recorded for IBA with the concentration of 1000 ppm which was superior over other treatments as well as over control (181.1 mg)

The highest fresh weight obtained due to the cuttings treated with plant growth regulators help in the better mobilization and downward translocation of primary metabolites for better root formation and nutrient uptake. Similar results were reported by Mehta *et al*. (2016) in *Pyrus communis* L. and Kumar and Ahmed (2013) in *Pelargonium graveolens*.

F. Dry weight of roots per cutting (mg)

The highest dry weight (210.0 mg) of roots per cutting at 60 days after planting was recorded under T4 1000 ppm IBA which was superior over other treatments (Table 2). The lowest dry weight (74.5 mg) of roots per cutting was recorded in treatment in which no growth regulator was applied (control). At 90 days after planting the highest dry weight of roots per cutting (291.1 mg) was observed with the T4 1000 ppm IBA which was superior over other treatments as well as over control (90.0 mg). Similar results were obtained by Mehta *et al*. (2016) in *Pyrus communis* L. and Kumar and Ahmed (2013) [11] in *Pelargonium graveolens*.

**Table 2:** Effect of IBA and IAA on survival percentage, number of sprouts, number of roots, root length, fresh weight and dry weight of Geranium

| Treatments | Survival percentage (90 DAP) | No. of sprouts | | No. of roots | | Root length (cm) | | Fresh weight (mg) | | Dry weight (mg) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 60 DAP | 90 DAP | 60 DAP | 90 DAP | 60 DAP | 90 DAP | 60 DAP | 90 DAP | 60 DAP | 90 DAP |
| $T_1$ | 83.3 | 5.7 | 8.1 | 38.5 | 73.3 | 8.4 | 15.6 | 242.2 | 404.4 | 130.0 | 202.2 |
| $T_2$ | 90.0 | 6.0 | 9.0 | 39.8 | 77.1 | 8.4 | 15.9 | 258.9 | 427.2 | 133.3 | 226.7 |
| $T_3$ | 80.0 | 7.2 | 10.4 | 43.3 | 84.2 | 9.4 | 17.0 | 382.2 | 538.9 | 200.0 | 284.4 |
| $T_4$ | 90.0 | 8.0 | 10.5 | 68.5 | 85.8 | 9.8 | 17.3 | 398.9 | 552.2 | 210.0 | 291.1 |
| $T_5$ | 86.7 | 4.9 | 7.2 | 34.5 | 59.4 | 5.1 | 11.6 | 158.9 | 258.9 | 77.8 | 153.3 |
| $T_6$ | 83.3 | 5.3 | 7.5 | 36.7 | 70.9 | 5.4 | 13.4 | 170.0 | 318.9 | 85.5 | 167.8 |
| $T_7$ | 86.7 | 5.5 | 7.9 | 38.3 | 71.1 | 7.4 | 15.3 | 198.9 | 334.5 | 104.4 | 174.4 |
| $T_8$ | 76.7 | 6.4 | 9.1 | 42.8 | 81.0 | 9.0 | 16.3 | 306.7 | 493.9 | 163.3 | 252.2 |
| $T_9$ | 66.7 | 3.3 | 5.6 | 14.9 | 20.6 | 3.9 | 9.5 | 133.3 | 181.1 | 74.5 | 90.0 |
| S. Em ± | | 0.16 | 0.17 | 0.48 | 0.49 | 0.19 | 0.35 | 1.99 | 3.40 | 2.21 | 1.52 |
| C.D @ 5% | | 0.46 | 0.52 | 1.43 | 1.45 | 0.57 | 1.05 | 5.91 | 10.10 | 6.55 | 4.51 |

## Conclusion

The study revealed that, among the two different growth regulators i.e. IBA and IAA, IBA registered the highest survival percentage, number of roots per cutting, root length, number of sprouts, fresh and dry weight of roots in both species Rosemary and Geranium in comparison to IAA treated cuttings at 60 and 90 DAP. In case of Rosemary IBA treatment with 750 ppm and in geranium IBA 1000 ppm registered maximum survival percentage, root length, number of sprouts, number of roots, fresh and dry weight of roots it may be due to auxins treatments which enhanced vegetative growth of plants and this method is reliable for nursery plants production as it is quick, easy and economical method of vegetative propagation.

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