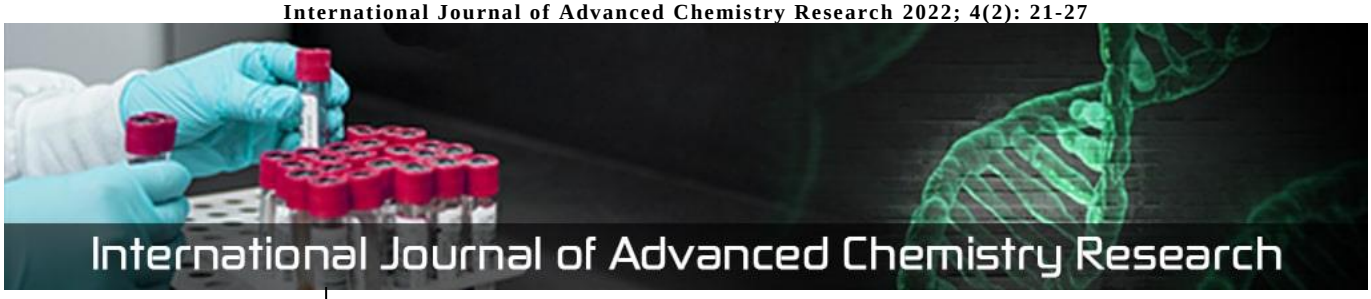


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# Effect of different growing media, *Azotobacter* and $GA_3$ on growth and survivability of transplanted air layers in Guava (*Psidium guajava* L.) C.V. Gwalior-27

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**Abstract**
The present investigation entitled "Effect of different growing media, *Azotobacter* and $GA_3$ on growth and survivability of transplanted air layers in Guava (*Psidium guajava* L.) *C.V.* Gwalior- 27" was conducted at Experimental block, College of Agriculture, R.V.S.K.V.V., and Gwalior (M.P.) during the year 2020-2021. The experiment was laid out in Completely Randomized Design (CRD) with three replications. Among different treatments Soil +Vermicompost (2:1) + $GA_3$ 200 ppm + *Azotobacter* (0.5 ml) resulted in maximum survival percentage of air layers at DAT 135 (87.33%) followed by the treatment with Soil + Leaf mould (2:1) + $GA_3$ 200 ppm + *Azotobacter* (0.5 ml) (77.43%). This treatment also enhanced the growth as well as root parameters of air layers, No. of Sprouts at 15 DAT (8.67), No. of leaves (37.00), Stem length (28.33 cm), and Stem thickness (16.20 mm), Number of primary roots (10.00), Number of secondary roots (21.67), and Length of primary roots (11.97 cm), Length of secondary roots (8.73cm), Diameter of primary roots (3.27 mm), Diameter of secondary roots (2.00 mm), Fresh weight of primary roots (1.84g), Fresh weight of secondary roots (0.79g) at 135 DAT. It may be concluded that Soil +Vermicompost (2:1) + $GA_3$ 200 ppm + *Azotobacter* (0.5 ml) was found best for highest survivability percentage and enhanced root parameters followed by Soil + Leaf mould (2:1) + $GA_3$ 200 ppm + *Azotobacter* (0.5ml).

**Keywords:** Diameter of primary, Stem length, concluded that

## Introduction
Guava (*Psidium guajava* L.), native to Mexico, Central America and belongs to the family Myrtaceae. It is also known as "apple of tropics" and "poor man's apple", is a popular fruit crop in India. It can be grown in tropical and subtropical climate and it is adopted for diverse soil and agro climatic conditions. It is relatively precocious and prolific in fruit bearing nature, could gives highly remunerative for crop production. The guava is highly nutritious, it has a rich source of vitamin 'C' and the content of Vitamin 'C' in fruits vary from 95.75 to 239.00 mg $100^{-1}$ g in cultivars of guava. Guava is the fifth important fruit crop of India after Banana, Mango, Citrus, and Papaya with an area of 276 thousand hectares contribute to total annual production of 4253 million tons and productivity of 14.96 MT/hac (Horticulture at a glance 2018). India is the leading producer of guava in the world.
The total area, production and productivity of Guava in Madhya Pradesh is 139 Ha, 2920 MT, and19.58 MT/hac respectively (Anon.**).** It has been used in traditional medicine in many cultures throughout Central America, the Caribbean, Africa and Asia. It is used for inflammation, diabetes, hypertension, wounds, pain relief, fever, diarrhea, rheumatism, lung diseases and ulcers. In the state guava is commercially propagated through air layering as it is an economical and effortless method of propagation.
The plant growth regulators are organic substances (other than nutrients), which in minute amount promote, inhibit or otherwise modify any physiological process in plants. Thus, the use of $PGR_s$ has resulted in some outstanding achievements in several fruit crops with respect to growth, yield and quality.
Gibberellin is a very potent hormone whose natural occurrence in plants controls their development. Gibberellins are in the third place with 17 % share among the most commonly used herbal hormones within the natural plant growth regulators. It regulates growth; application of very low concentrations can have profound effect. $GA_3$ is the most commonly used Gibberellin; it has number of effects on plant growth and development.

It can stimulate rapid stem and root growth, induce mitotic division in the leaves of some plants and increase seed germination rates. Gibberellins are known to influence both cell division and cell enlargement (Adams *et al.*, 1975) [1].
Biofertilizers are substances that contain living microorganisms. Biofertilizers also synthesizes some biologically active substances including some phytohormones such as auxin, thereby stimulating plant growth.Bio-fertilizers containing beneficial bacteria and fungi improve soil chemical and biological characteristics, phosphate solubility and agricultural production (El-Habbasha *et al*., 2007; Yosefi *et al.*, 2011) [8, 24]. Bio-fertilizers comprised of nitrogen fixers, phosphate and potash dissolvers. (Ezz *et al.*, 2011) [7]. Because it is the most important for plant production and soil health in general as they play an important and complex role in plant growth components of crops by way of various biochemical activities in the soil such as increases the soil fertility naturally, add nutrients through the natural processes biological N fixation, solubilizing phosphorus, the availability of nutrients by their biological activity and uptake of nutrients (Saraswati and Smarno, 2008).
Hence, it is a matter of great interest to find out the best concentration of the growth regulators and suitable biofertilizer for growing media and treatment which can induce better survival of guava air layers after detachment.

## Materials and Methods

### Experimental site

The experiment was conducted at Experimental block, Department of Horticulture, College of Agriculture, R.V.S.K.V.V. Gwalior, Madhya Pradesh India. The experiment was conducted during the year 2020-2021.The experimental site is situated at 26˚ 13` N latitude and 78˚ 14' E longitudes at an altitude of 211.5 m above Mean Sea Level in Gird belt.

### Planting material

Eight years old plants of Guava *cv*. Gwalior-27 were selected for this research work.

### Preparation of growing media

In the experiment, the layers were detached in November and subjected to various treatments after treating the growing media with nano-silver @ 35 ml/L of water. 120 kg sterilized Soil was taken by removing small stones and pebbles. Soil and Vermicompost were mixed in the ratio 2:1 by volume and Soil and Leaf mould were mixed in the ratio 2:1 by volume, after that biofertilizer i.e., *Azotobacter* @ 0.5 ml per poly bag is mixed.

**Table 1:** Preparation of $GA_3$ solution

| S. No. | Solution prepared | | $GA_3$ powder |
|---|---|---|---|
| | Concentration | Volume | |
| 1. | 100 ppm | 1 lit | 100 mg |
| 2. | 150 ppm | 1 lit | 150 mg |
| 3. | 200 ppm | 1 lit | 200 mg |

### Detachment of air layers

Air layers were detached by making a cut just below the lowest end of the ring surface with the help of sharp secateurs. The air layers were brought under shade after detachment and their polyethylene were removed gently without hurting the roots.

### Preparation and planting of air layers in poly bags

The air layers were detached from eight year old mother plants and unwrapped from polyethylene thereafter. They were cut into equal length (15 cm) and made entirely leafless before planting. Initially leafless air layers were dipped into the solution of Copper oxychloride for fungus control after that the layers were dipped in different concentrations of $GA_3$ solution for about two minutes and then planted in the prearranged growing media filled poly bags thereafter. After the planting of detached air layers, the poly bags were placed in open conditions and individually irrigated. The sizes of the polybags were 15 x 10 cm.

### Observations recorded

For the present study, 21 air layers of guava (*Psidium guajava* L.) *cv*. Gwalior-27 per treatment were randomly selected and replicated thrice. The observations were recorded from 5 air layers that were selected randomly and tagged in each replication. The observations were determined and their means were worked out for statistical analysis.

### Growth Parameters

#### Stem length (cm)

The stem length was measured with the help of meter scale at 45, 90 &135 days after their planting. The average of five selected air layers in each treatment were computed and presented in cm.

#### Stem thickness (mm)

The stem diameter was measured with Digital Vernier Calipers at monthly intervals 45, 90 &135 days after planting and expressed in mm. The average of five selected layers in each treatment was recorded.

#### Plant survival percentage

The air layers were planted in the polyethylene bags and it was observed that whether the layers were established in the polyethylene bags after transplanting or not. The survival percentage of air layers was calculated by the following formula-

$$\text{Survival \%} = \frac{\text{Total no. of survived layered plants} \times 100}{\text{Total no. of layered plants}}$$

### Root Parameters

#### Number of primary roots

Five rooted layers were randomly sampled from each treatment. The polythene sheet was removed carefully using forceps and care was taken to avoid damage to roots. Number of primary roots was counted in each layer, averaged and expressed in number.

#### Number of secondary roots

The same five roots were used for primary roots used for counting for secondary roots. The polythene sheet was removed carefully using forceps and care was taken to avoid damage to roots.

#### Length of primary roots (cm)

Five rooted transplanted layers were randomly sampled from each treatment. The polythene sheet was removed carefully using forceps and care was taken to avoid damage to roots. With the help of scale length of primary roots was

measured from the collar region to the tip of primary root in centimeters (cm).

**Length of secondary roots (cm)**
The layers which were used for the measurement of length primary roots, the same were used for the length of secondary roots. The care was taken while measuring the length so that roots did not get hurt. The length was measured with the help of scale in centimeters (cm).

**Diameter of primary roots (mm)**
Five roots per layer were selected randomly and their diameter was taken with the help of Digital Vernier Calipers and average was calculated and expressed in mm.

**Diameter of secondary roots (mm)**
The five roots per layer were selected randomly and their diameter was taken with the help of Digital Vernier Calipers and average was calculated and expressed in mm.

**Fresh weight of primary roots (g)**
The fresh weight of primary roots was measured with the help of digital weighing balance from randomly selected five layers from each treatment and each replication, averaged and expressed in numbers.

**Fresh weight of secondary roots (g)**
The fresh weight of secondary roots was also measured with the help of digital weighing balance from randomly selected five layers from each treatment and each replication, averaged and expressed in numbers.

## Results and Discussion

### Growth parameters

**Number of sprouts**
The data recorded for number of sprouts recorded at 15 DAT is presented in table1.It is perceptible from the observations recorded that, the maximum no. of sprouts (8.67) were recorded under treatment $T_4$ (Soil +Vermicompost (2:1) + $GA_3$ 200 ppm + *Azotobactor* (0.5ml).The improvement in no. of days taken in number of sprouts with application of Vermicompost and leaf mould might be due to better moisture holding capacity and availability of major and micro nutrients due to favorable soil conditions. The present investigation findings are in accordance with earlier reports in recorded by Slakins *et al*., (1973) [21], Tyagi and Patel (2004) [22], Singh *et al*.,(2007), Rolaniya *et al*., (2018) [13], Dawar *et. al*.,(2020) [6].

**Number of leaves**
The data regarding number of leaves at 45, 90 and 135 DAT is presented in table1.The maximum number of leaves (20.33, 28.67 and 37.00) was found in treatment $T_4$ (Soil + Vermicompost (2:1)+ $GA_3$ 200 ppm + *Azotobacter* (0.5 ml)) over control and other treatments. The similar findings were also reported by Bhandulkar *et al*.,(2017) [3] results reported that Vermicompost with *Azotobacter* had significantly greater effect on no. of leaves, Singh *et al*., (2007), Rymbai *et al*., (2012), Damar *et al*., (2014) [5] and Muthia *et al*., (2015) [9].

**Table 1:** Effect of *Azotobacter*, $GA_3$ and growing media on number of sprouts and Number of leaves

| Treatment Details | | Number of sprouts at 15 DAT | Number of leaves | | |
|---|---|---|---|---|---|
| | | | 45 DAT | 90 DAT | 135 DAT |
| $T_0$ | Soil (Control) | 2.33 | 14.33 | 21.67 | 32.00 |
| $T_1$ | Soil + Vermicompost (2:1) | 3.33 | 16.33 | 25.33 | 33.33 |
| $T_2$ | Soil + Vermicompost (2:1) + $GA_3$ 100 ppm + *Azotobacter* (0.5 ml) | 4.67 | 17.33 | 26.67 | 34.67 |
| $T_3$ | Soil + Vermicompost (2:1) + $GA_3$ 150 ppm + *Azotobacter* (0.5 ml) | 5.33 | 18.67 | 27.33 | 35.67 |
| $T_4$ | Soil + Vermicompost (2:1) + $GA_3$ 200 ppm + *Azotobacter* (0.5 ml) | 8.67 | 20.33 | 28.67 | 37.00 |
| $T_5$ | Soil + Leaf mould (2:1) | 2.67 | 15.33 | 25.00 | 32.67 |
| $T_6$ | Soil + Leaf mould (2:1) + $GA_3$ 100 ppm + *Azotobacter* (0.5 ml) | 4.00 | 16.67 | 25.67 | 34.33 |
| $T_7$ | Soil + Leaf mould (2:1) + $GA_3$ 150 ppm + *Azotobacter* (0.5 ml) | 5.00 | 17.67 | 24.67 | 36.33 |
| $T_8$ | Soil + Leaf mould (2:1) + $GA_3$ 200 ppm + *Azotobacter* (0.5 ml) | 6.00 | 19.33 | 27.00 | 36.67 |
| S.E m ± | | 0.430 | 1.171 | 0.949 | 1.128 |
| CD at 5% | | 1.279 | 3.478 | 2.821 | 3.351 |

**Stem length (cm)**
The data observed for stem length (cm) at 45, 90 and 135 DAT is presented in table 2. The maximum stem length (cm) (18.00, 24.00 and 28.33) was recorded under treatment $T_4$ (Soil +Vermicompost (2:1) + $GA_3$ 200 ppm+ *Azotobacter* (0.5ml). Soil, vermicompost, leaf mould, $GA_3$ and *Azotobacter* were appreciably affected the shoot parameters, Sevik *et al*., (2013) [18] the results of study showed that $GA_3$ application has a considerable effect on stem height, Bhandulkar *et al*.,(2017) [3] obtained highest plant height media containing Vermicompost (22.54cm), Kashyap *et al*., (2019) [11], and recorded findings are significantly superior than Singh *et al*.,(2007) Rajpoot *et al*., (2012) [12].

**Stem thickness (mm)**
The data contemplated for stem thickness (mm) at 45, 90 and 135 DAT is presented in table 2. The table clearly demonstrate that the maximum stem thickness (mm) (8.03, 12.77 and 16.20) was recorded under treatment $T_4$ (Soil +Vermicompost (2:1) + $GA_3$ 200 ppm+ *Azotobacter* (0.5ml). Similar findings for the above experiment are in agreement with Bhandulkar *et al*.,(2017) [3], Rajpoot *et al*., (2012) [12], Canli *et al*., (2008) [4] reported that overall stem thickness of pears seedlings significantly affected by $GA_3$ treatments.

**Table 2:** Effect of *Azotobacter*, $GA_3$ and growing media on Stem length and Stem thickness

| Treatment Details | | Stem length (cm) | | | Stem thickness (mm) | | |
|---|---|---|---|---|---|---|---|
| | | 45 DAT | 90 DAT | 135 DAT | 45 DAT | 90 DAT | 135 DAT |
| $T_0$ | Soil (Control) | 12.97 | 17.50 | 21.00 | 5.00 | 7.63 | 12.00 |
| $T_1$ | Soil + Vermicompost (2:1) | 14.83 | 20.00 | 24.00 | 5.80 | 8.90 | 13.50 |
| $T_2$ | Soil + Vermicompost (2:1) + $GA_3$ 100 ppm + *Azotobacter*(0.5 ml) | 15.67 | 22.60 | 24.83 | 6.50 | 10.03 | 14.50 |
| $T_3$ | Soil + Vermicompost (2:1) + $GA_3$ 150 ppm + *Azotobacter* (0.5 ml) | 16.67 | 23.50 | 23.50 | 6.92 | 11.03 | 15.50 |
| $T_4$ | Soil + Vermicompost (2:1) + $GA_3$ 200 ppm + *Azotobacter* (0.5 ml) | 18.00 | 24.00 | 28.33 | 8.03 | 12.77 | 16.20 |
| $T_5$ | Soil + Leaf mould (2:1) | 13.90 | 19.50 | 22.43 | 5.50 | 8.50 | 13.03 |
| $T_6$ | Soil + Leaf mould (2:1) + $GA_3$ 100 ppm + *Azotobacter*(0.5 ml) | 14.80 | 21.00 | 25.10 | 6.00 | 9.50 | 14.13 |
| $T_7$ | Soil + Leaf mould (2:1) + $GA_3$ 150 ppm + *Azotobacter* (0.5 ml) | 16.33 | 23.00 | 26.57 | 6.80 | 10.43 | 15.07 |
| $T_8$ | Soil + Leaf mould (2:1) + $GA_3$ 200 ppm + *Azotobacter* (0.5 ml) | 17.53 | 23.90 | 27.67 | 7.50 | 12.33 | 15.73 |
| S.E m ± | | 0.499 | 0.513 | 1.501 | 0.573 | 0.824 | 0.807 |
| CD at 5% | | 1.483 | 1.525 | 4.461 | 1.702 | 2.447 | 2.396 |

**Plant survival (%)**

The data inferred for plant survival (%) at 45, 90 and 135 DAT is presented in table3.It is observable from the experiment that, numerous treatments had significant effect on the plant survival (%). The table clearly shows that the maximum survival percentage of air layers (87.33%) was recorded under treatment $T_4$ (Soil +Vermicompost (2:1) + $GA_3$ 200 ppm+ *Azotobacter* (0.5ml). This may be due to pre treatment of $GA_3$ in plant improved root and shoot growth. Furthermore, Wang *et al*., (1995) demonstrated that application of $GA_3$ can promote xylem and phloem production, provided and elevated IAA at cambial region. This results in reduced mortality of transplanted air layers and hence increased the survivability percentage, ultimately gave higher ceaselessness to layers.

The equivalent results were also reported by Ramteke (1998) [14], Singh *et al*., (2007), Rajpoot *et al*.,(2012) [12], Damar *et al*., (2014) [5], Kashyap *et al*., (2016) [10], Dawar *et al*.,(2020) [6].

**Table 3:** Effect of biofertilizer, $GA_3$and growing media on plant survival (%)

| | Treatment Details | Plant survival (%) | | |
|---|---|---|---|---|
| | | 45 DAT | 90 DAT | 135 DAT |
| $T_0$ | Soil (Control) | 80.50 | 72.07 | 64.57 |
| $T_1$ | Soil + Vermicompost (2:1) | 83.13 | 76.00 | 68.60 |
| $T_2$ | Soil + Vermicompost (2:1) + $GA_3$ 100 ppm + *Azotobacter*(0.5 ml) | 85.03 | 80.20 | 72.43 |
| $T_3$ | Soil + Vermicompost (2:1) + $GA_3$ 150 ppm + *Azotobacter* (0.5 ml) | 88.53 | 83.07 | 76.00 |
| $T_4$ | Soil + Vermicompost (2:1) + $GA_3$ 200 ppm + *Azotobacter* (0.5 ml) | 93.33 | 90.00 | 87.33 |
| $T_5$ | Soil + Leaf mould (2:1) | 82.07 | 74.10 | 68.10 |
| $T_6$ | Soil + Leaf mould (2:1) + $GA_3$ 100 ppm + *Azotobacter*(0.5 ml) | 84.00 | 79.50 | 70.13 |
| $T_7$ | Soil + Leaf mould (2:1) + $GA_3$ 150 ppm + *Azotobacter* (0.5 ml) | 87.00 | 82.60 | 75.00 |
| $T_8$ | Soil + Leaf mould (2:1) + $GA_3$ 200 ppm + *Azotobacter* (0.5 ml) | 89.00 | 83.83 | 77.43 |
| S.E m ± | | 2.042 | 1.892 | 1.965 |
| CD at 5% | | 6.068 | 5.622 | 5.839 |

**Root parameters**

**Number of primary roots**

The observations recorded for number of primary roots at 45, 90 and 135 DAT is presented in table 4. The higher number of primary roots in air layers (5.00, 7.33 and 10.00) was recorded under treatment $T_4$ (Soil +Vermicompost (2:1) + $GA_3$ 200 ppm+ *Azotobacter* (0.5ml).

**Number of secondary roots**

It is manifested from the present study that, the maximum number of secondary roots in air layers (14.33, 18.00 and 21.67) was recorded under treatment $T_4$(Soil +Vermicompost (2:1) + $GA_3$ 200 ppm+ *Azotobacter* (0.5ml).

**Table 4:** Effect of *Azotobacter*, $GA_3$and growing media on number of primary and secondary roots

| Treatment Details | | Number of Primary roots | | | Number of Secondary roots | | |
|---|---|---|---|---|---|---|---|
| | | 45 DAT | 90 DAT | 135 DAT | 45 DAT | 90 DAT | 135 DAT |
| $T_0$ | Soil (Control) | 2.00 | 4.33 | 6.67 | 9.33 | 12.67 | 15.33 |
| $T_1$ | Soil + Vermicompost (2:1) | 2.67 | 5.33 | 7.33 | 10.33 | 15.00 | 18.00 |
| $T_2$ | Soil + Vermicompost (2:1) + $GA_3$ 100 ppm + *Azotobacter*(0.5 ml) | 3.67 | 6.00 | 7.00 | 11.00 | 16.67 | 19.33 |
| $T_3$ | Soil + Vermicompost (2:1) + $GA_3$ 150 ppm + *Azotobacter* (0.5 ml) | 4.33 | 6.67 | 8.33 | 12.67 | 17.33 | 20.00 |
| $T_4$ | Soil + Vermicompost (2:1) + $GA_3$ 200 ppm + *Azotobacter* (0.5 ml) | 5.00 | 7.33 | 10.00 | 14.33 | 18.00 | 21.67 |
| $T_5$ | Soil + Leaf mould (2:1) | 2.33 | 4.67 | 7.67 | 9.67 | 14.33 | 16.00 |
| $T_6$ | Soil + Leaf mould (2:1) + $GA_3$ 100 ppm + *Azotobacter*(0.5 ml) | 3.33 | 5.67 | 8.33 | 11.00 | 15.67 | 18.67 |
| $T_7$ | Soil + Leaf mould (2:1) + $GA_3$ 150 ppm + *Azotobacter* (0.5 ml) | 4.00 | 6.33 | 8.90 | 12.33 | 16.33 | 19.67 |
| $T_8$ | Soil + Leaf mould (2:1) + $GA_3$ 200 ppm + *Azotobacter* (0.5 ml) | 4.67 | 7.00 | 9.00 | 13.67 | 17.00 | 20.33 |
| S.E m ± | | 0.544 | 0.351 | 0.648 | 1.024 | 0.981 | 1.054 |
| CD at 5% | | 1.617 | 1.044 | 1.926 | 3.044 | 2.916 | 3.132 |

**Length of primary roots (cm)**

The data collected for length of primary roots (cm) at 45, 90 and 135 DAT is presented in table 5. The maximum length of primary roots (cm) (8.60, 9.20 and 11.97) was observed under treatment $T_4$ (Soil +Vermicompost (2:1) + $GA_3$ 200 ppm+ *Azotobacter* (0.5ml). The above result is in accordance with earlier reports in Rolaniya *et al.*, (2018) [13] with root length 28.24 cm in grape, Damar *et al.*, (2014) [5] in pomegranate (10.36cm), Bhandulkar *et al*.,(2017) [3] with root length of 2.77 cm.

**Length of secondary roots (cm)**

The observed data for length of secondary roots (cm) at 45, 90 and 135 DAT is displayed in table 5.The maximum length of secondary roots (cm) (6.17, 7.60 and 8.73) was observed in treatment $T_4$(Soil +Vermicompost (2:1) + $GA_3$ 200 ppm+ *Azotobacter* (0.5ml).

**Table 5:** Effect of biofertilizer, $GA_3$and growing media on length of primary and secondary roots (cm)

| Treatment Details | | Length of primary roots (cm) | | | Length of secondary roots (cm) | | |
|---|---|---|---|---|---|---|---|
| | | 45 DAT | 90 DAT | 135 DAT | 45 DAT | 90 DAT | 135 DAT |
| $T_0$ | Soil (Control) | 3.20 | 4.67 | 6.87 | 3.00 | 4.10 | 4.70 |
| $T_1$ | Soil + Vermicompost (2:1) | 5.40 | 6.57 | 8.50 | 4.00 | 5.13 | 6.07 |
| $T_2$ | Soil + Vermicompost (2:1) + $GA_3$ 100 ppm + *Azotobacter*(0.5 ml) | 6.53 | 8.53 | 9.57 | 4.50 | 6.10 | 7.17 |
| $T_3$ | Soil + Vermicompost (2:1) + $GA_3$ 150 ppm + *Azotobacter* (0.5 ml) | 7.50 | 8.80 | 10.50 | 5.47 | 6.80 | 7.80 |
| $T_4$ | Soil + Vermicompost (2:1) + $GA_3$ 200 ppm + *Azotobacter* (0.5 ml) | 8.60 | 9.20 | 11.97 | 6.17 | 7.60 | 8.73 |
| $T_5$ | Soil + Leaf mould (2:1) | 3.67 | 6.00 | 7.77 | 3.53 | 3.70 | 5.17 |
| $T_6$ | Soil + Leaf mould (2:1) + $GA_3$ 100 ppm + *Azotobacter*(0.5 ml) | 6.03 | 7.10 | 9.13 | 4.20 | 5.70 | 6.40 |
| $T_7$ | Soil + Leaf mould (2:1) + $GA_3$ 150 ppm + *Azotobacter* (0.5 ml) | 7.10 | 8.13 | 10.17 | 5.13 | 6.53 | 7.50 |
| $T_8$ | Soil + Leaf mould (2:1) + $GA_3$ 200 ppm + *Azotobacter* (0.5 ml) | 8.07 | 9.07 | 10.67 | 5.87 | 7.13 | 8.50 |
| S.E m ± | | 1.056 | 0.885 | 0.985 | 0.668 | 0.810 | 0.811 |
| CD at 5% | | 3.139 | 2.628 | 2.928 | 1.986 | 2.406 | 2.409 |

**Diameter of primary roots (mm)**

The data recorded for diameter of primary roots at 45, 90 and 135 DAT is presented in table 6. The thickest primary roots (mm) (2.13, 2.53 and 3.27) were recorded under treatment $T_4$ (Soil +Vermicompost (2:1) + $GA_3$ 200 ppm+ *Azotobacter* (0.5ml).

**Diameter of secondary roots (mm)**

The recorded observations for diameter of secondary roots at 45, 90 and 135 DAT is presented in table 6.The maximum diameter of secondary roots (mm) (1.20, 1.37 and 2.00) were recorded in treatment $T_4$(Soil +Vermicompost (2:1) + $GA_3$ 200 ppm+ *Azotobacter* (0.5ml). The above results are in agreement with earlier reports in Rolaniya *et al.*, (2018) [13], Damar *et al.*, (2014) [5], Bhandulkar *et al*., (2017) [3], Dawar *et al.*,(2020) [6].

**Table 6:** Effect of biofertilizer, $GA_3$and growing media on diameter of primary and secondary roots (mm)

| Treatment Details | | Diameter of primary roots (mm) | | | Diameter of secondary roots (mm) | | |
|---|---|---|---|---|---|---|---|
| | | 45 DAT | 90 DAT | 135 DAT | 45 DAT | 90 DAT | 135 DAT |
| $T_0$ | Soil (Control) | 0.30 | 1.20 | 1.37 | 0.57 | 0.83 | 1.32 |
| $T_1$ | Soil + Vermicompost (2:1) | 1.30 | 1.53 | 1.73 | 0.83 | 1.03 | 1.40 |
| $T_2$ | Soil + Vermicompost (2:1) + $GA_3$ 100 ppm + *Azotobacter*(0.5 ml) | 1.47 | 1.80 | 2.53 | 0.84 | 1.08 | 1.27 |
| $T_3$ | Soil + Vermicompost (2:1) + $GA_3$ 150 ppm + *Azotobacter* (0.5 ml) | 1.80 | 2.17 | 2.90 | 1.00 | 1.10 | 1.44 |
| $T_4$ | Soil + Vermicompost (2:1) + $GA_3$ 200 ppm + *Azotobacter* (0.5 ml) | 2.13 | 2.53 | 3.27 | 1.20 | 1.37 | 2.00 |
| $T_5$ | Soil + Leaf mould (2:1) | 1.03 | 1.40 | 1.67 | 0.67 | 0.73 | 1.07 |
| $T_6$ | Soil + Leaf mould (2:1) + $GA_3$ 100 ppm + *Azotobacter*(0.5 ml) | 1.40 | 1.73 | 2.40 | 0.93 | 0.94 | 1.20 |
| $T_7$ | Soil + Leaf mould (2:1) + $GA_3$ 150 ppm + *Azotobacter* (0.5 ml) | 1.77 | 2.10 | 2.83 | 0.93 | 1.14 | 1.42 |
| $T_8$ | Soil + Leaf mould (2:1) + $GA_3$ 200 ppm + *Azotobacter* (0.5 ml) | 1.90 | 2.30 | 3.10 | 1.07 | 1.21 | 1.80 |
| S.E m ± | | 0.340 | 0.278 | 0.426 | 0.110 | 0.107 | 0.180 |
| CD at 5% | | 1.011 | 0.825 | 1.267 | 0.327 | 0.318 | 0.535 |

**Fresh weight of primary roots (g)**

The calculated data for fresh weight of primary roots (g) at 45, 90 and 135 DAT is presented in table 7. The maximum fresh weight of primary roots (g) (1.38, 1.51 and 1.84) were observed in treatment $T_4$ (Soil +Vermicompost (2:1) + $GA_3$ 200 ppm+ *Azotobacter* (0.5ml). The above results are in accordance with earlier reports in Ramteke *et al*., (1998) [14], Rymbai *et al*., (2012) [16], Rolaniya *et al.*, (2018) [13], Damar *et al.*, (2014) [5], Muthia *et al*.,(2015) [9] showed that $GA_3$ has

significantly superior impact on fresh weight of primary roots in *Ceriops decandra*.

**Fresh weight of secondary roots (g)**

The observations for fresh weight of secondary roots (g) at 45, 90 and 135 DAT is presented in table 7.It is detectable from the research findings that, the maximum fresh weight of secondary roots (g) (0.49, 0.58 and 0.79) were recorded under treatment $T_4$(Soil +Vermicompost (2:1) + $GA_3$ 200 ppm+ *Azotobacter* (0.5ml).

**Table 7:** Effect of biofertilizer, $GA_3$and growing media on fresh weight of primary and secondary roots (g)

| Treatment Details | | Fresh weight of primary roots (g) | | | Fresh weight of secondary roots (g) | | |
|---|---|---|---|---|---|---|---|
| | | 45 DAT | 90 DAT | 135 DAT | 45 DAT | 90 DAT | 135 DAT |
| $T_0$ | Soil (Control) | 0.49 | 0.72 | 0.90 | 0.20 | 0.28 | 0.40 |
| $T_1$ | Soil + Vermicompost (2:1) | 0.93 | 1.06 | 1.20 | 0.30 | 0.36 | 0.43 |
| $T_2$ | Soil + Vermicompost (2:1) + $GA_3$ 100 ppm + *Azotobacter*(0.5 ml) | 1.21 | 1.26 | 1.37 | 0.35 | 0.43 | 0.51 |
| $T_3$ | Soil + Vermicompost (2:1) + $GA_3$ 150 ppm + *Azotobacter* (0.5 ml) | 1.27 | 1.31 | 1.47 | 0.43 | 0.49 | 0.62 |
| $T_4$ | Soil + Vermicompost (2:1) + $GA_3$ 200 ppm + *Azotobacter* (0.5 ml) | 1.38 | 1.51 | 1.84 | 0.49 | 0.58 | 0.79 |
| $T_5$ | Soil + Leaf mould (2:1) | 0.54 | 0.81 | 1.00 | 0.28 | 0.32 | 0.36 |
| $T_6$ | Soil + Leaf mould (2:1) + $GA_3$ 100 ppm + *Azotobacter*(0.5 ml) | 1.08 | 1.15 | 1.26 | 0.32 | 0.40 | 0.49 |
| $T_7$ | Soil + Leaf mould (2:1) + $GA_3$ 150 ppm + *Azotobacter* (0.5 ml) | 1.23 | 1.30 | 1.42 | 0.39 | 0.47 | 0.55 |
| $T_8$ | Soil + Leaf mould (2:1) + $GA_3$ 200 ppm + *Azotobacter* (0.5 ml) | 1.32 | 1.40 | 1.63 | 0.47 | 0.51 | 0.68 |
| S.E m ± | | 0.088 | 0.057 | 0.041 | 0.033 | 0.019 | 0.021 |
| CD at 5% | | 0.261 | 0.170 | 0.123 | 0.097 | 0.056 | 0.061 |

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