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# Effect of Time of Air Layering, IBA Concentrations, Growing Media and their Interaction on the Rooting Behaviour of Pant Prabhat Guava (*Psidium guajava* L.) under Sub-Tropical Condition of Garhwal Himalaya

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**ABSTRACT**

*An experiment was conducted at the Orchard Section, Horticultural Research Centre and Department of Horticulture, Chauras Campus, School of Agriculture and Allied Science, HNB Garhwal University (A Central University), Srinagar Garhwal, Uttarakhand, India during the rainy season of the year 2016 to evaluate the effect of different time of air layering, IBA concentrations and growing media on the rooting behaviour of Pant Prabhat Guava (Psidium guajava L.). Experiment was laid out in Factorial Randomized Block Design having forty eight treatment combinations of air-layering time (15th June, 30th June, 15th July and 30th July ), IBA concentrations (1500 ppm, 3000 ppm, 4500 ppm and Control) and growing media (Sphagnum moss, Coco peat and Sphagnum moss+ Coco peat). The treatments were replicated thrice. The response of Pant Prabhat guava to the treatments was evaluated on the basis of rooting attributes those are best under $T_3C_3M_1$ treatment viz., minimum days taken to root appearance (26.11days), maximum rooting percentage (100%), maximum number of roots per layer (26.22), maximum length of longest root per layer (16.07cm), maximum diameter of thickest root per layer (1.94mm) and maximum percentage of layers showing secondary roots (80%). On the basis of results obtained in the present investigation, it can be concluded that air-layering performed during 15th July, treated with 4500ppm IBA concentration and use of sphagnum moss as growing media have been found significantly superior on all other treatments under subtropical condition of Garhwal Himalaya.*

***Key words:*** *Air-layering, IBA, Coco peat, Sphagnum moss, Percentage.*

## INTRODUCTION

Guava is the fourth most valuable fruit crop of India in area and production after mango, banana, and citrus. It is also called as "Apple of Tropics" because it is sold at moderate prices. It is widely grown in different parts of the tropics and subtropics. Guava botanically known as *Psidium guajava* L. and belongs to the family Myrtaceae.

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It is originated in Tropical America. Most of the cultivars are diploid (2n=22), but some natural and artificial triploids (3n=33), these generally produce seedless fruits[14]. Guava fruits are the rich source of Vitamin C. The various products like jam, jelly, juices, canned segments, cheese, nector etc. can be prepared from guava fruits. In Uttarakhand the major guava producing districts are Pithoragarh, Udham Singh Nagar, Haridwar, Dehradun, Pauri, Tehri and Uttarkashi. Guava is commonly propagated through seeds because it is an easy method to adopt but the plants/progeny/off-springs obtained through seed propagation affect the fruit quality, precocity and yield. For getting true-type-plants with better characters viz., precocity, high yielding, and quality fruits, air-layering is a common, cheaper and more convenient method for propagation of guava. There are various factors which affect the rooting behaviour of air-layers like- physiology of mother plants, nutritional status of plant and soil, wrapping material used, girdling, etiolation, time of air-layering, use of root inducing exogenous hormones and growing/rooting medium used. It is well-known fact that rooting success in air-layering largely depends on appropriate time, use of growth regulators and growing media used for air-layering which may vary from place to place. In view of above facts, the present investigation "Effect of Time of Air Layering, IBA Concentrations and Growing Media on the Rooting Behaviour of Pant Prabhat Guava (*Psidium guajava* L.) under Sub-Tropical Condition of Garhwal Himalaya" was carried out.

## MATERIAL AND METHODS

### Detail of Experiment

The present experiment was conducted under the open field condition at Orchard Section, Horticultural Research Centre and Department of Horticulture, Chauras Campus, School of Agriculture and Allied Science, H.N.B. Garhwal University (A Central University), Srinagar Garhwal, Uttarakhand India during the rainy season of the year 2016. The detail of experiment is as follows-

| Factors | Levels | Notations |
|---|---|---|
| **1) Time** | 15th June | $T_1$ |
| | 30th June | $T_2$ |
| | 15th July | $T_3$ |
| | 30th July | $T_4$ |
| **2) IBA** | 1500 ppm | $C_1$ |
| | 3000 ppm | $C_2$ |
| | 4500 ppm | $C_3$ |
| | Control | $C_0$ |
| **3) Growing Media** | Sphagnum moss | $M_1$ |
| | Coco peat | $M_2$ |
| | Sphagnum moss+ Cocopeat | $M_3$ |

**Treatment Combinations**

| | | | |
|---|---|---|---|
| $T_1C_1M_1$ | $T_1C_2M_1$ | $T_1C_3M_1$ | $T_1C_0M_1$ |
| $T_1C_1M_2$ | $T_1C_2M_2$ | $T_1C_3M_2$ | $T_1C_0M_2$ |
| $T_1C_1M_3$ | $T_1C_2M_3$ | $T_1C_3M_3$ | $T_1C_0M_3$ |
| | | | |
| $T_2C_1M_1$ | $T_2C_2M_1$ | $T_2C_3M_1$ | $T_2C_0M_1$ |
| $T_2C_1M_2$ | $T_2C_2M_2$ | $T_2C_3M_2$ | $T_2C_0M_2$ |
| $T_2C_1M_3$ | $T_2C_2M_3$ | $T_2C_3M_3$ | $T_2C_0M_3$ |
| | | | |
| $T_3C_1M_1$ | $T_3C_2M_1$ | $T_3C_3M_1$ | $T_3C_0M_1$ |
| $T_3C_1M_2$ | $T_3C_2M_2$ | $T_3C_3M_2$ | $T_3C_0M_2$ |
| $T_3C_1M_3$ | $T_3C_2M_3$ | $T_3C_3M_3$ | $T_3C_0M_3$ |
| | | | |
| $T_4C_1M_1$ | $T_4C_2M_1$ | $T_4C_3M_1$ | $T_4C_0M_1$ |
| $T_4C_1M_2$ | $T_4C_2M_2$ | $T_4C_3M_2$ | $T_4C_0M_2$ |
| $T_4C_1M_3$ | $T_4C_2M_3$ | $T_4C_3M_3$ | $T_4C_0M_3$ |

**Total number of treatments:** 4×4×3= 48
**Number of replication:** 3
**Number of layers/ replication:** 10
**Total number of layers/treatment:** 3×10= 30
**Total number of layers in the experiment:** 48×30= 1440
**Cultivar:** Pant Prabhat

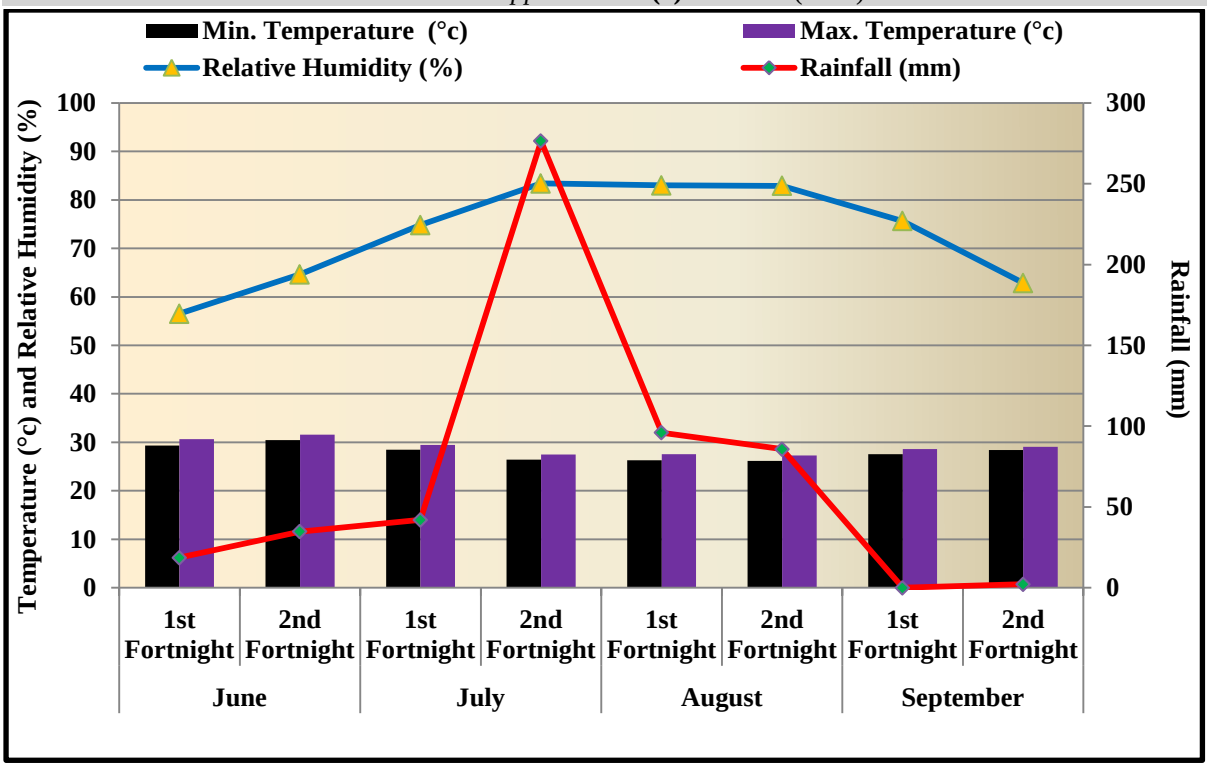


**Fig. 1: Fortnightly meteorological data during the period of experimentation (June-September)**

**Materials Used for the Experiment**

Mother plants of guava cultivar Pant Prabhat of fourteen years old were selected for air-layering operation. Transparent polythene sheet (size 20×20cm), sharp knife, thread, rooting media, IBA etc. were used.

**Methods Followed to Perform Air Layering**

On dated 15th June, 30th June, 15th July and 30th July of the year 2016, air layering was done on the 1.5-2 year old shoots by removing a strip of bark (phloem) 2.0-2.5cm wide cut below the bud by giving two circular cuts about 30cm below from shoot tip and then the exposed portion of shoot was rubbed without causing any injury to the xylem with the help of a knife. After that, the upper portion of exposed shoots was sprayed with different concentrations of IBA according to the treatments. The exposed wood with two centimeter above and below portions was then covered with different growing media i.e. sphagnum moss, coco peat and sphagnum moss+coco peat soaked overnight in water. The control shoots were treated with only respective media according to treatments soaked overnight in water. To wrap the rooting media completely a piece of transparent polythene sheet (size: 20×20cm) was wrapped. The two ends of the wrapping material were carefully tied up thoroughly with thread and left for rooting.

**Separation of Air-layers form mother plants**

All the air-layers were separated from the mother plants sixty days after air-layering operation with the help of secateurs by giving a horizontal cut just below the lower end of air-layers. After separation of the air-layers from mother plants, all the tying material (thread) and polythene sheet were removed carefully without damaging the roots.

**Observations Recorded**

The following observations were recorded after 60 days of air-layering in respect to the rooting behaviour during the period of the experimentation.

1. Mean days taken to root appearance (Days)
2. Mean rooting percentage (%)
3. Mean number of roots per layer
4. Mean length of the longest root per layer (cm)
5. Mean diameter of the thickest root per layer (mm)
6. Mean percentage of layers showing secondary roots (%)

**Statistical Analysis**

All the data recorded during the period of experimentation were subjected to statistical analysis under the three-factor factorial randomized block design as described by Snedecar and Cochran[35]. Valid conciliations were drawn after the determination of the significance of difference between the treatments at 5 percent level of probability. Critical difference was calculated in order to compare the treatment means.

## RESULT AND DISCUSSION

The results obtained during the present experimentation clearly showed that the main and interaction effect of time of air-layering, IBA concentrations and growing media have the significant effect on the rooting behaviour of Pant Prabhat guava air-layering except the interaction effect of time of air-layering, IBA concentration and growing media on the percentage of planted layers showing secondary roots.

**Main Effect of Time-**

The main effect of time of air-layering, IBA concentrations and growing media have significantly affected the days taken to root appearance in Pant Prabaht guava as presented in Table 1. Among all the time of air-layering, the minimum mean days taken to root appearance (35.64days) was recorded under the $T_3$ (15$^{th}$ July) treatment whereas maximum mean days taken to root appearance (41.40days) was noticed under the $T_2$ (30$^{th}$ June) treatment. It might be due to the favourable environmental conditions viz., temperature, relative humidity and rainfall, which results in the lesser days taken to root appearance in 15$^{th}$ July treatment. The results obtained from the present investigation are in agreement with the findings of Rehman *et al.*[28] in Olive, Mozumder *et al.*[24] in Plum. Tayade *et al.*[36] observed the minimum days taken to root initiation (21.85days) in air-layers of pomegranate cv. Bhagwa when layering was performed in July month.

The data pertaining to the rooting percentage (Table 1) clearly shows that the main effect of time of air-layering, IBA concentrations and growing media were found significant in relation to the rooting percentage. In respect to all the time of air-layering, the maximum rooting percentage (74.44%) was found under $T_3$ (15$^{th}$ July) treatment. The minimum rooting percentage (53.33%) was observed when air-layering was performed during 30$^{th}$ June ($T_2$). It may be due to a particular correlation of temperature, humidity and rainfall. The similar findings have also been reported by Shrivastava[33] in *Punica granatum*, Ahmad[1] in Guava, Misra and Agarwal[23] in Kagzi Kalan, Kunwar and Kahlon[20] in Litchi, Sharma and Grewal[32] in Litchi, Sarker and Ghose[31] in Guava, Hossain *et al.*[13] in Litchi, Ghose[11] in Water Apple and Tayade *et al.*[36] in Pomegranate cv. Bhagwa.

It is clear from Table 1 that the main effect of time of air-layering, IBA concentrations and growing media were found significant in respect to the number of roots per layer. In case of various time of air-layering, the maximum mean number of roots (15.25) per layer was observed under the treatment $T_3$ (15$^{th}$ July), whereas the minimum mean number of roots (9.70) per layer was found in the $T_1$ (15$^{th}$ June) treatment. The similar results were reported by, Sarker and Ghose[31] in Guava, Ghose[11] in Water Apple and Mozumber *et al.*[24] in Plum.

The perusal of Table 1 shows that the significant main effect of time or air-layering, IBA concentrations and growing media on mean length of the longest root per layer during the experimentation. In relation to the time of air-layering, the maximum mean length of the longest root (9.99cm) per layer was obtain under the treatment $T_3$ (15$^{th}$ July). The minimum mean length of the longest root (6.44) per layer was recorded under the $T_1$ (15$^{th}$ June) treatment. These findings are similar to the results obtained Litchi (Litchi sinensis Sonn.), Hossain *et al.*[13] in Litchi, Ghosh[11] in Water Apple, Mozumder *et al.*[24] in Plum and Tayade *et al.*[36] in Pomegranate cv. Bhagwa.

It is clear from the Table 1 that the main effect of time of air-layering, IBA concentrations and growing media were found

significant in mean diameter of the thickest root per layer. Among the different time of air-layering, $T_3$ (15th July) treatment recorded the maximum mean diameter of the thickest root (1.53mm) per layer, while the minimum mean diameter of the thickest root (1.29mm) per layer was noticed under the treatment $T_1$ (15th June).

The data related to the percentage of layers showing secondary roots are presented in Table 1 indicated that there is a significant difference with respect to time of air-layering, IBA concentrations and growing media. The maximum percentage of layers showing secondary roots (38.89%) was found when air-layering was performed on $T_3$ (15th July) treatment, while, the minimum percentage of layers showing secondary roots (23.33%) when air-layering was done on $T_4$ (30th July) treatment. Tomar[37] in Jackfruit reported the maximum percentage of layers showing secondary roots when layering was done during 25-26th July. This results show that time of air-layering operation is an important factor for secondary roots formation in air-layering of Guava.

**Main Effect of IBA Concentrations-**

Results indicated that among the various concentrations of IBA treatments, the minimum mean days taken to root appearance (31.32days) was noticed under the treatment $C_3$ (4500ppm) while, maximum mean days taken to root appearance (44.71days) was observed under the treatment $C_0$ (Control). Status of soil and plant nutrients and the positive impact of growth regulator may be the possible reason for early rooting. The response of IBA at higher concentration might be due to the activity of auxin at cambial may be adequate for callus formation and initiation of root primordia. In addition, exogenous application of auxin could have converted starch into simple sugars, which is required to a greater extent for the production of new cells and for the increased respiratory activity in the regenerating tissues at the time of initiation of new root primordial. Results obtained from the present investigation have more or less conformity with the findings of Chawala[6] in Litchi, Chauhan[5] in Fig (*Ficus carica* L.) cv. Poona under middle Gujarat conditions, Khandade *et al.*[15] in Rose Apple (*Syzigium jambos* L.) and Udavrao[38] in pomegranate cv. Bhagwa.

Among all the concentration of IBA, the maximum rooting percentage (82.22%) was recorded under the treatment $C_3$ (4500ppm) treatment. Whereas, the minimum rooting percentage (43.33%) under $C_0$ (Control) treatment. The results obtained in the present investigation are found to be more or less conformity with studies of Athani *et al.*[2] in guava, Dessalegn and Reddy [10] in Jojoba, Haque *et al.*[12] in guava, Kumar[17] in guava, Patil *et al.*[25] in guava, Purohit *et al.*[27] in *Cinnamomum tamala*, Chawla[6] in Litchi, Birla[3] in Guava cv. Gwalior-27, Kumar[18] in guava, Maurya *et al.*[21] in Jamaican ackee (*Blighia sapida* L.), Das *et al.*[8] in Litchi cv. Purbi, Das and Prasad[9] in Litchi, Yadav[40] in Guava cv. Gwalior-27, Chouhan[7] in Guava cv. Gwalior-27, Khandade *et al.*[15] in Rose apple (*Syzigium jambos* L.), Singh and Mahato[34] in Guava, Kumari *et al.*[19] in Guava and Udhavrao[38] in Pomegranate cv. Bhagwa.

Among the IBA concentrations, $C_3$ (4500ppm) treatment gave the maximum mean number of roots (19.01) per layer, while the minimum mean number of roots (4.80) per layers was observed under by $C_0$ (Control) treatment. Increased number of roots in the air-layering with the higher concentration of IBA might be due to increased cell wall elasticity which further may have increased cell division and in turn, increased number of roots. IBA at higher concentration increased root length by affecting the synthesis of enzymes which are related to cell enlargement. These results are more or less similar to the results obtained by Athani *et al.*[2] in guava, Dessalegn and Reddy[10] in Jojoba, Haque *et al.*[12] in guava, Kumar[17] in guava, Patil *et al.*[25] in guava, Chawla[6] in Litchi, Chauhan[5] in Fig (Ficus carica L.) cv. Poona under middle Gujarat conditions, Birla[3] in Guava cv. Gwalior-27, Kumar[18] in guava, Maurya *et al.*[21] in Jamaican ackee (*Blighia sapida* L.), Yadav[39] in Acid Lime cv. Vikram, Das *et al.*[8,9] in Litchi cv. Purbi, Yadav[40] in

Guava cv. Gwalior-27, Chouhan[7] in Guava cv. Gwalior-27, Khandade *et al.*[15] in Rose apple (*Syzigium jambos* L.), Singh and Mahato[34] in Guava and Udhavrao[38] in Pomegranate cv. Bhagwa.

Among the different concentrations of IBA, the $C_3$ (4500ppm) treatment was better to produce maximum mean length of the longest root (12.07cm) per layer, while the minimum mean length of the longest root (4.20cm) per layer was found in the $C_0$ (Control) treatment. These findings are more or less close to the results obtained by Athani *et al.*[2] in guava, Dessalegn and Reddy[10] in Jojoba, Haque *et al.*[12] in guava, Kumar[17] in guava, Patil *et al.*[25] in guava, Chawla[6] in Litchi, Chauhan[5] in Fig (Ficus carica L.) cv. Poona under middle Gujarat conditions, Birla[3] in Guava cv. Gwalior-27, Kumar[18] in guava, Maurya *et al.*[21] in Jamaican ackee (*Blighia sapida* L.), Yadav[39] in Acid Lime cv. Vikram, Das *et al.*[8,9] in Litchi cv. Purbi, Yadav[40] in Guava cv. Gwalior-27, Chouhan[7] in Guava cv. Gwalior-27, Khandade *et al.*[15] in Rose apple (*Syzigium jambos* L.), and Udhavrao[38] in Pomegranate cv. Bhagwa.

In case of IBA concentrations, the maximum mean diameter of the thickest root (1.64mm) per layer was observed under $C_3$ (4500ppm) treatment, whereas $C_0$ (Control) treatment gave the minimum mean diameter of the thickest root (1.07mm) per layer during the experiment. These findings are more or less match with the findings of Kumar[17] in guava, Chawla[6] in Litchi, Chauhan[5] in Fig (Ficus carica L.) cv. Poona under middle Gujarat conditions, Birla[3] in Guava cv. Gwalior-27, Kumar[18] in guava, Yadav[39] in Acid Lime cv. Vikram, Yadav[40] in Guava cv. Gwalior-27, Chouhan[7] in Guava cv. Gwalior-27, Khandade *et al.*[15] in Rose apple (*Syzigium jambos* L.), and Udhavrao[38] in Pomegranate cv. Bhagwa.

In case of IBA concentrations, the maximum mean percentage of layers secondary roots (53.89%) was observed in the $C_3$ (4500ppm) treatment, whereas, the minimum mean percentage of layers showing secondary roots (4.17%) was found under the $C_0$ (Control) treatment. Tomar[37] recorded maximum percentage of layers showing secondary roots in those jackfruit air-layering which were treated with 10000ppm IBA concentration.

**Main Effect of Growing Media-**

In respect to the various growing media evaluated, the minimum mean days taken to root appearance (38.26days) was observed under the $M_1$ (Sphagnum moss) treatment. The maximum mean days taken to root appearance (39.95days) was recorded under $M_3$ (Sphagnum moss + Coco peat) treatment. This might be due to proper aeration and good water holding capacity of sphagnum moss which causes early root initiation. Similar results were reported by Bhosale *et al.*[4] in Pomegranate (*Punica granatum* L.) cv. Sindhuri, Maurya *et al.*[22] in Guava cv. Allahbad Safeda, Patel *et al.*[26] in Pomegranate cv. Ganesh.

In case of growing media, the maximum rooting percentage (68.33%) was found under $M_1$ (Sphagnum moss) treatment. While, the minimum mean rooting percentage (57.29%) was observed under $M_2$ (Coco peat) treatment. The increased rooting percentage in sphagnum moss might have been due to better initiation of roots and increased amount of rooting co-factors at the time of callus formation and root initiation. The similar results were also recorded by Rymbai and Reddy[30] in Guava cv. L-49, Yeboah *et al.*[41] in Shea (*Vitellaria paradoxa*)

In case of growing media used in the air-layering operation, $M_1$ (Sphagnum moss) treatment gave the maximum mean number of roots (12.86) per layer, whereas, $M_2$ (Coco peat) treatment gave the minimum mean number of roots (10.31) per layer. The similar results were also recorded by Rymbai and Reddy[30] in Guava cv. L-49. Bhosale *et al.*[4] in Pomegranate (*Punica granatum* L.) cv. Sindhuri, Maurya *et al.*[22] in Guava cv. Allahbad Safeda, Patel *et al.*[26] in Pomegranate cv. Ganesh,

In relation to the growing media, maximum mean length of the longest root (9.30cm) per layer was noticed under $M_1$ (Sphagnum moss) treatment, whereas $M_2$

(Coco peat) treatment has the minimum mean length of the longest root (7.01cm) per layer. The similar results were also recorded by Rymbai and Reddy[30] in Guava cv. L-49. Bhosale *et al.*[4] in Pomegranate (*Punica granatum* L.) cv. Sindhuri, Maurya *et al*.[22] in Guava cv. Allahbad Safeda, Patel *et al.*[26] in Pomegranate cv. Ganesh, Yeboah *et al.*[41] in Shea (*Vitellaria paradoxa*)

In respect to the growing media, the maximum mean diameter of the thickest root (1.47mm) per layer was recorded with $M_1$ (Sphagnum moss) treatment. The minimum mean diameter of the thickest root (1.28mm) per layer was noticed under $M_2$ (Coco peat) treatment during the experimentation. The superiority of sphagnum moss over other rooting media might be owing to its unique ability like- proper aeration and increased water holding capacity which in later stage help in thicker roots formation.

Among the various growing media used in the experimentation, the maximum mean percentage of layers showing secondary roots (33.96%) was noticed in $M_1$ (Sphagnum moss) treatment. The minimum mean percentage of layers showing secondary roots (23.13%) was found in the treatment $M_2$ (Coco peat).

**Interaction effect of Time of Air-layering, IBA concentrations and Growing Media**

The interaction effect among time of air-layering, IBA concentrations and growing media showed the significant effect on days taken to root appearance (Table 2). The minimum mean days taken to root appearance (26.11days) was noted under the $T_3C_3M_1$ ($15^{th}$ July+4500ppm IBA+Sphagnum moss) treatment combination. Whereas, maximum mean days taken to root appearance (56.89days) was recorded under the $T_1C_0M_3$ ($15^{th}$ June + control + sphagnum moss + coco peat) treatment combination. However, it was also noticed that the treatment combination $T_1C_0M_2$ ($15^{th}$ June + control + coco peat) was failed to produce roots during the experimentation.

Table 3 shows that the interaction effect among time of air-layering, IBA concentrations and growing media was also found significant in rooting percentage. The maximum rooting percentage (100%) was found under $T_3C_3M_1$ ($15^{th}$ July+4500ppm IBA+Sphagnum moss) treatment combination. While, the treatment combination $T_2C_1M_2$ ($30^{th}$ June+1500ppm IBA+ coco peat), $T_2C_1M_3$ ($30^{th}$ June+1500ppm IBA+sphagnum moss+coco peat), $T_2C_0M_1$ ($30^{th}$ June+control+sphagnum moss), $T_2C_0M_2$ ($30^{th}$ June+control+coco peat) and $T_2C_0M_3$ ($30^{th}$ June+control+sphagnum moss+coco peat) treatments gave the minimum rooting percentage (40.00%). The $T_1C_0M_2$ ($15^{th}$ June+control+coco peat) treatment combination was failed to produce any root during the investigation. Kumar *et al.*[16] also found a significant difference while working on Guava cv. Allahabad Safeda air-layering. Rymbai and Reddy[29] observed that the interaction effect of different treatment combination has shown significant differences regarding rooting percentage. They found the treatment combination IBA@4000ppm+ Sphagnum moss+$15^{th}$ August was best in relation to the rooting percentage (86%) in Guava cv. L-49 air-layering under Andhra Pradesh.

Table 4 shows that the interaction effect among time of air-layering, IBA concentrations and growing media was also found significant in the mean number of roots per layer. The maximum mean number of roots (26.22) per layer was recorded under the $T_3C_3M_1$ ($15^{th}$ July+4500ppm IBA+Sphagnum moss) treatment combination. The minimum mean number of roots (3.67) per layer was noticed under the treatment combination $T_1C_0M_3$ ($15^{th}$ June+control+Sphagnum moss+coco peat). Kumar *et al.*[16] also found a significant difference while working on Guava cv. Allahabad Safeda air-layering. Rymbai and Reddy[29] also found the maximum number of roots (10.80) in Guava cv. L-49 air-layers with the treatment combination IBA@4000ppm+ Sphagnum moss+$15^{th}$ August under Andhra Pradesh conditions.

Data in Table 5 pertaining to the mean length of the longest root per layer indicate that the interaction effect of time of air-

layering, IBA concentrations and growing media were found significant during the period of experimentation. Maximum mean length of the longest root (16.07cm) per layer was recorded in the treatment combination $T_3C_3M_1$ (15th July+4500ppm IBA+Sphagnum moss). The minimum mean length of the longest root (2.64) per layer was obtained under $T_2C_0M_2$ (30th June+control+coco peat) treatment combination. Kumar *et al.*[16] also found a significant difference while working on Guava cv. Allahabad Safeda air-layering. Rymbai and Reddy[29] found that the treatment combination IBA@4000ppm+Sphagnum moss+ 15th August is the best combination with respect to the maximum length of the longest root (10.32cm) in Guava cv. L-49 air-layering under Andhra Pradesh condition.

Table 6 shows that the interaction effect among time of air-layering, IBA concentrations and growing media was also found significant in respect to the mean diameter of the thickest root per layer. The maximum mean diameter of the thickest root (1.94mm) per layer was found under the treatment combination $T_3C_3M_1$ (15th July+4500ppm IBA+Sphagnum moss). The minimum mean diameter of the thickest root (0.98mm) per layer was obtained under $T_2C_0M_2$ (30th June+control+coco peat) treatment combination. Favourable climatic conditions, increased concentration of IBA and sphagnum moss all in combination might be responsible for increased diameter of the roots.

A perusal of data on the percentage of layers showing secondary roots presented in Table 7 reveals that the interaction effect among time of air-layering, IBA concentrations and growing media was found non-significant. The maximum mean percentage of layers showing secondary roots (80.00%) was observed under the $T_3C_3M_1$ (15th July+4500ppm IBA+Sphagnum moss) treatment combination, while, the minimum mean percentage of layers showing secondary roots (3.33%) were observed under $T_3C_0M_2$ (15th July + Control + Coco peat) treatment combination. The treatment combinations viz., $T_1C_0M_1$, $T_1C_0M_2$, $T_1C_0M_3$, $T_2C_0M_1$, $T_2C_0M_2$, $T_2C_0M_3$, $T_4C_0M_2$ and $T_4C_0M_3$ did not produce secondary roots during the investigation.

**Table 1: Main effect of time of air-layering, IBA concentrations and growing media on rooting behaviour of Pant Prabhat guava (*Psidium guajava* L.)**

| Treatments | Days taken to root appearance (Days) | Rooting percentage (%) | Number of roots per layer | Length of the longest root per layer (cm) | Diameter of the thickest root per layer (mm) | Percentage of layers showing secondary roots (%) |
|---|---|---|---|---|---|---|
| **Time of air-layering (T)** | | | | | | |
| $T_1$ (15th June) | 39.15 | 56.94 | 9.70 | 6.44 | 1.29 | 24.44 |
| $T_2$ (30th June) | 41.40 | 53.33 | 11.20 | 8.34 | 1.35 | 26.11 |
| $T_3$ (15th July) | 35.64 | 74.44 | 15.25 | 9.99 | 1.53 | 38.89 |
| $T_4$ (30th July) | 39.57 | 66.94 | 10.48 | 7.94 | 1.38 | 23.33 |
| **S.Em.±** | **0.31** | **0.89** | **0.24** | **0.17** | **0.007** | **0.97** |
| **C.D. at 5%** | **0.88** | **2.50** | **0.67** | **0.49** | **0.021** | **2.74** |
| **Significance** | * | * | * | * | * | * |
| **IBA concentrations (C)** | | | | | | |
| $C_1$ (1500ppm) | 42.68 | 56.67 | 8.71 | 6.97 | 1.34 | 18.33 |
| $C_2$ (3000ppm) | 37.06 | 69.44 | 14.10 | 9.46 | 1.49 | 36.39 |
| $C_3$ (4500ppm) | 31.32 | 82.22 | 19.01 | 12.07 | 1.64 | 53.89 |
| $C_0$ (Control) | 44.71 | 43.33 | 4.80 | 4.20 | 1.07 | 4.17 |
| **S.Em.±** | **0.31** | **0.89** | **0.24** | **0.17** | **0.007** | **0.97** |
| **C.D. at 5%** | **0.88** | **2.50** | **0.67** | **0.49** | **0.021** | **2.74** |
| **Significance** | * | * | * | * | * | * |
| **Growing media (M)** | | | | | | |
| $M_1$ (Sphagnum moss) | 38.26 | 68.33 | 12.86 | 9.30 | 1.47 | 33.96 |
| $M_2$ (Coco peat) | 38.61 | 57.29 | 10.31 | 7.01 | 1.28 | 23.13 |
| $M_3$ (Sphagnum moss + Coco peat) | 39.95 | 63.13 | 11.80 | 8.21 | 1.41 | 27.50 |
| **S.Em.±** | **0.27** | **0.77** | **0.20** | **0.15** | **0.006** | **0.84** |
| **C.D. at 5%** | **0.76** | **2.16** | **0.58** | **0.43** | **0.018** | **2.37** |
| **Significance** | * | * | * | * | * | * |

**Table 2: Interaction effect among time of air-layering, IBA concentrations and growing media on days taken to root appearance**

| Time of air-layering | IBA concentrations | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $C_1$ | | | $C_2$ | | | $C_3$ | | | $C_0$ | | |
| | Growing media | | | Growing media | | | Growing media | | | Growing media | | |
| | $M_1$ | $M_2$ | $M_3$ | $M_1$ | $M_2$ | $M_3$ | $M_1$ | $M_2$ | $M_3$ | $M_1$ | $M_2$ | $M_3$ |
| $T_1$ | 44.33 | 50.78 | 45.78 | 37.22 | 41.45 | 38.22 | 33.67 | 35.67 | 33.56 | 52.22 | 00.00 | 56.89 |
| $T_2$ | 41.89 | 46.22 | 44.45 | 38.33 | 40.33 | 38.33 | 30.78 | 33.33 | 31.22 | 48.33 | 53.22 | 50.33 |
| $T_3$ | 37.00 | 39.78 | 37.67 | 31.11 | 34.00 | 32.56 | 26.11 | 30.22 | 28.78 | 41.00 | 46.11 | 43.33 |
| $T_4$ | 39.00 | 44.11 | 41.11 | 35.89 | 39.22 | 38.00 | 29.11 | 32.33 | 31.00 | 46.11 | 51.00 | 48.00 |
| S.Em.± | 1.08 | | | | | | | | | | | |
| C.D. at 5% | 3.05 | | | | | | | | | | | |

**Table 3: Interaction effect among time of air-layering, IBA concentrations and growing media on rooting percentage**

| Time of air-layering | IBA concentrations | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $C_1$ | | | $C_2$ | | | $C_3$ | | | $C_0$ | | |
| | Growing media | | | Growing media | | | Growing media | | | Growing media | | |
| | $M_1$ | $M_2$ | $M_3$ | $M_1$ | $M_2$ | $M_3$ | $M_1$ | $M_2$ | $M_3$ | $M_1$ | $M_2$ | $M_3$ |
| $T_1$ | 60.00 | 50.00 | 60.00 | 66.67 | 60.00 | 66.67 | 76.67 | 73.33 | 76.67 | 46.67 | 00.00 | 46.67 |
| $T_2$ | 46.67 | 40.00 | 40.00 | 70.00 | 46.67 | 53.33 | 80.00 | 66.67 | 76.67 | 40.00 | 40.00 | 40.00 |
| $T_3$ | 80.00 | 66.67 | 50.00 | 86.67 | 80.00 | 86.67 | 100.00 | 86.67 | 90.00 | 56.67 | 53.33 | 56.67 |
| $T_4$ | 66.67 | 60.00 | 60.00 | 73.33 | 70.00 | 73.33 | 93.33 | 80.00 | 86.67 | 50.00 | 43.33 | 46.67 |
| S.Em.± | 3.08 | | | | | | | | | | | |
| C.D. at 5% | 8.66 | | | | | | | | | | | |

**Table 4: Interaction effect among time of air-layering, IBA concentrations and growing media on the number of roots per layer**

| Time of air-layering | IBA concentrations | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $C_1$ | | | $C_2$ | | | $C_3$ | | | $C_0$ | | |
| | Growing media | | | Growing media | | | Growing media | | | Growing media | | |
| | $M_1$ | $M_2$ | $M_3$ | $M_1$ | $M_2$ | $M_3$ | $M_1$ | $M_2$ | $M_3$ | $M_1$ | $M_2$ | $M_3$ |
| $T_1$ | 9.56 | 5.67 | 8.00 | 11.67 | 13.33 | 14.00 | 16.00 | 14.11 | 15.78 | 4.56 | 00.00 | 3.67 |
| $T_2$ | 7.56 | 9.67 | 8.33 | 15.67 | 12.00 | 14.11 | 18.67 | 15.78 | 17.56 | 6.22 | 3.78 | 5.00 |
| $T_3$ | 12.67 | 9.56 | 11.00 | 21.00 | 15.22 | 18.33 | 26.22 | 23.11 | 25.00 | 7.78 | 5.78 | 7.33 |
| $T_4$ | 9.22 | 6.56 | 6.78 | 12.67 | 9.89 | 11.33 | 21.00 | 16.55 | 18.33 | 5.33 | 3.89 | 4.22 |
| S.Em.± | 0.83 | | | | | | | | | | | |
| C.D. at 5% | 2.33 | | | | | | | | | | | |

**Table 5: Interaction effect time of air-layering, IBA concentrations and growing media on length of the longest root per layer**

| Time of air-layering | IBA concentrations | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $C_1$ | | | $C_2$ | | | $C_3$ | | | $C_0$ | | |
| | Growing media | | | Growing media | | | Growing media | | | Growing media | | |
| | $M_1$ | $M_2$ | $M_3$ | $M_1$ | $M_2$ | $M_3$ | $M_1$ | $M_2$ | $M_3$ | $M_1$ | $M_2$ | $M_3$ |
| $T_1$ | 6.66 | 5.15 | 6.24 | 8.91 | 6.82 | 7.43 | 10.30 | 10.10 | 8.77 | 3.61 | 00.00 | 3.25 |
| $T_2$ | 9.03 | 5.89 | 7.88 | 8.39 | 9.52 | 10.18 | 15.01 | 11.53 | 11.82 | 5.19 | 2.64 | 2.94 |
| $T_3$ | 8.63 | 8.14 | 5.77 | 12.87 | 9.61 | 13.20 | 16.07 | 11.27 | 13.5 | 8.29 | 4.75 | 7.76 |
| $T_4$ | 7.58 | 5.10 | 7.51 | 10.04 | 7.05 | 9.45 | 13.13 | 11.27 | 12.10 | 5.06 | 3.34 | 3.59 |
| S.Em.± | 0.61 | | | | | | | | | | | |
| C.D. at 5% | 1.72 | | | | | | | | | | | |

**Table 6: Interaction effect among time of air-layering, IBA concentrations and growing media on diameter of the thickest root per layer**

| Time of air-layering | IBA concentrations | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $C_1$ | | | $C_2$ | | | $C_3$ | | | $C_0$ | | |
| | Growing media | | | Growing media | | | Growing media | | | Growing media | | |
| | $M_1$ | $M_2$ | $M_3$ | $M_1$ | $M_2$ | $M_3$ | $M_1$ | $M_2$ | $M_3$ | $M_1$ | $M_2$ | $M_3$ |
| $T_1$ | 1.41 | 1.25 | 1.34 | 1.51 | 1.45 | 1.49 | 1.61 | 1.56 | 1.58 | 1.19 | 0.00 | 1.03 |
| $T_2$ | 1.32 | 1.27 | 1.31 | 1.44 | 1.36 | 1.42 | 1.60 | 1.48 | 1.55 | 1.26 | 0.98 | 1.19 |
| $T_3$ | 1.49 | 1.34 | 1.41 | 1.67 | 1.54 | 1.62 | 1.94 | 1.79 | 1.84 | 1.29 | 1.15 | 1.22 |
| $T_4$ | 1.37 | 1.27 | 1.32 | 1.51 | 1.42 | 1.46 | 1.61 | 1.56 | 1.58 | 1.21 | 1.09 | 1.18 |
| S.Em.± | 0.026 | | | | | | | | | | | |
| C.D. at 5% | 0.072 | | | | | | | | | | | |

**Table 7: Interaction effect among time of air-layering, IBA concentrations and growing media on percentage of layers showing secondary roots**

| Time of air-layering | IBA concentrations | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $C_1$ | | | $C_2$ | | | $C_3$ | | | $C_0$ | | |
| | Growing media | | | Growing media | | | Growing media | | | Growing media | | |
| | $M_1$ | $M_2$ | $M_3$ | $M_1$ | $M_2$ | $M_3$ | $M_1$ | $M_2$ | $M_3$ | $M_1$ | $M_2$ | $M_3$ |
| $T_1$ | 23.33 | 16.67 | 20.00 | 36.67 | 26.67 | 30.00 | 53.33 | 43.33 | 43.33 | 00.00 | 00.00 | 00.00 |
| $T_2$ | 26.67 | 13.33 | 20.00 | 36.67 | 26.67 | 33.33 | 56.67 | 46.67 | 53.33 | 00.00 | 00.00 | 00.00 |
| $T_3$ | 30.00 | 16.67 | 20.00 | 53.33 | 43.33 | 50.00 | 80.00 | 60.00 | 70.00 | 23.33 | 3.33 | 16.67 |
| $T_4$ | 16.67 | 6.67 | 10.00 | 40.00 | 30.00 | 30.00 | 60.00 | 36.67 | 43.33 | 6.67 | 00.00 | 00.00 |
| S.Em.± | 3.38 | | | | | | | | | | | |
| C.D. at 5% | NS | | | | | | | | | | | |

## CONCLUSION

On the basis of the experimental findings, it can be concluded that the 15th July time of air-layering, IBA @ 4500ppm concentration and sphagnum moss as a growing medium individually and in combination is the best and can be used for mass multiplication of true-to-type plants of Pant Prabhat Guava through air-layering under the sub-tropical condition of Garhwal-Himalaya.

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