

Effect of IBA Concentrations, Time and Rooting Media on the Rooting Behaviour in Guava (*Psidium guajava* L.) Air Layering, under Hadoti Region

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ABSTRACT

The present investigation is entitled “Effect of IBA concentrations, time & rooting media on the rooting behaviour in guava (*Psidium guajava* L.) Air layering, under Hadoti region”. The experiment was conducted at the Department of Horticulture, School of Agriculture Science, Career Point University Kota Rajasthan during the session 2018-2019. The experiment was laid out in factorial Randomized Block Design with four levels of IBA concentrations (C_1 (3000ppm), C_2 (4000ppm), C_3 (6000ppm), C_0 (Control), three different rooting media M_1 (Moss grass), M_2 (Coco-peat), M_3 (Moss grass+ Coco-peat) and two months air layering (T_1 (June) and T_2 (July)). The maximum number of primary roots per air-layer, length of primary roots per air-layer, diameter of primary roots, number of secondary roots per air-layer, length of secondary roots, diameter of secondary roots, average dry weight of roots per air-layer, rooting percentage and survival percentage was observed under $C_3M_3T_2$ (6000 ppm IBA + Moss grass + Coco peat + July) treatments.

Keywords: Guava, IBA, Media, Air layering, Rooting.

INTRODUCTION

Guava (*Psidium guajava* L.), is one of the most important and popular tropical fruit crop cultivated in India because of its pleasant aroma, reasonable price, high nutritious value, low cost of cultivation, being tolerant to drought and semi-arid conditions as well as salinity problems, wide adaptability to varying soil and climatic conditions and availability for a long period of time during the year. It is native to Tropical America (from Mexico to

Peru). It has been in cultivation in India since early 17th century and gradually become a crop of commercial significance (Singh, 2007).

Guava is successfully propagated through sexual and asexual methods such as sexual method (Zamir et al., 2003), layering (Manna et al., 2004), cutting (Kuperberg, 1953), grafting (Singh et al., 2005) and budding (Kaundal et al., 1987).

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Sexual propagation using conventional techniques has been hindered by the long juvenile phase, seasonal dependence, longer time length and requirement of more plant material for propagation (Usman et al., 2014). Among all the vegetative methods Air-layering is the common, cheaper and more convenient method for propagation of economically important woody plants, especially in species which are difficult-to-root on cuttings. Air layering is the most convenient method of propagation in litchi plants in our country (Bose & Mitra, 1990).

The success in air layering of guava is mainly depends upon mother plant, time of layering, rainfall, humidity, temperature, rooting media, growth media, plant growth regulators and care during removal of bark from shoots. Air layering technique is successful in propagating plants because, the layered branch is not detached from the mother plant therefore, it receives continuous supply of water and mineral nutrients through the xylem and remains alive (Hartmann et al., 2010) and intact shoots (with leaves) possibly synthesize some unknown auxiliary substances which help in induction of adventitious roots (Singh et al., 2004). Air layering is practiced during the month of June, July with good success rates due to the relatively low temperature (23°C to 31°C), high relative humidity (80 to 90 %) and rainfall which provides the conducive environment for the root initiation (Ahmed, 1964). Layers prepared during these months get an additional advantage of longer duration of a favourable season for establishing the layer in the soil after preparation. In layering, success depends on the early beginning of the root and on the formation of sufficient fibrous roots. Several workers have reported successful results by the use of plant growth regulators in stimulating of root primordia in air layering of guava crop (Singh et al., 2007). Air layering with the help of plant growth regulators and rooting media is reported to stimulate root primordial in the air layers (Tyagi & Patel, 2004 & Singh et al., 2016). The highest percentage of rooting and root character of air layers of guava is

successfully achieved by exogenous application of IBA (Rymbai & Reddy 2011) Hence, the present investigation was conducted to study the effect of IBA concentrations time & rooting media on the rooting behaviour in guava (*Psidium guajava* L.) Air layering, under Hadoti region”.

MATERIALS AND METHODS

The present investigation entitled “Effect of IBA concentrations, time and rooting media on the rooting behaviour in guava (*Psidium guajava* L.) Air layering, under Hadoti region”. The experiment was conducted at the Department of Horticulture, School of Agriculture Science, Career Point University Kota Rajasthan during the session 2018-2019. The experimental field is located in the city of Kota, Rajasthan. It is situated at a centre of the south-eastern region of Rajasthan and this region widely known as Hadoti (the land of the Hadas). Kota is located along eastern bank of the Chambal River in the southern part of Rajasthan. It is the third largest city of Rajasthan after Jaipur and Jodhpur. The cartographic coordinates are 25.18°N 75.83°E. It covers an area of 318 km² (3.63 % of the Rajasthan State). It has an average elevation of 271 m (889 ft). Kota has a semi-arid climate with high temperatures throughout the year. Summers are long, hot and dry, starting in late March and lasting till the end of June. The brief, mild winter starts in late November and lasts until the last week of February. The average annual rainfall in the Kota district is 660.6 mm.

In the present investigation three air-layers per treatment/replication were selected randomly with total number of layers in the experiment – 30 X 24 = 720, and observations were recorded at 15 days intervals. The growth observations were also recorded at fortnightly intervals in nursery after detachment. The last observations of growth were recorded in the first week of November. In the trial guava Variety Sardar of uniform vigour and size were selected and about 1 (1-2) years old healthy branches of pencil thickness were selected during June and July for air-layering.

The experiment was laid out in Factorial Randomized Block Design with four levels of IBA concentrations (C_1 (3000 ppm), C_2 (4000 ppm), C_3 (6000 ppm), C_0 (Control), three different rooting media M_1 (Moss grass), M_2 (Coco-peat), M_3 (Moss grass+ Coco-peat) and two months air layering (T_1 (June) and T_2 (July)). For all treatment same rooting media were used which were prepared with moss grass, coco peat and (1:1) moss grass+ coco peat and transparent polythene film of 400-gauge wrapper was used at the time of operation. After 60 days, air layers were ready for detachment. These were detached with sharp secateurs by given three installations cut at an interval of one week, to reduce the shock of sudden detachment. The air layers were brought under shade after detachment and their polythene covers were removed gently. Care was taken to ensure that the roots were not injured at the time of removing polythene wrapper. After detachment the air layers were brought under the shade of a tree and their polythene covers were removed gently. Care was taken to ensure that the roots were not injured at the time of removing polythene. After this, rooted air layers were planted in polythene bags containing mixture of soil+ F.Y.M. + Vermicompost (2:1:1). Data recorded during the course of investigations were subjected to statistical analysis under FRBD as described by (Cochran & Cox, 1992).

RESULTS AND DISCUSSION

The data pertaining to rooting & growth character of guava air layering affected by different concentrations of IBA, rooting media and operation time were recorded and statistically analyzed with FRBD. The results are presented in Table.1 clearly shows that different concentrations of IBA, rooting media and operation time and their combinations had significant effect on rooting and growth characters of guava air layering.

Effect of IBA Concentrations on rooting and growth characters of guava air layering

The data pertaining to effect of IBA in relation to rooting parameters the maximum callus

formation after 15 days (16.481mm) and after 30 days (21.620 mm) was noticed under the treatment C_3 (6000 ppm) while, minimum callus formation after 15 days (6.362 mm) and after 30 days (11.193 mm) was observed under the treatment C_0 (Control). The higher percentage of callus formation may be due to synergistic effect of the plant growth regulators controlling the initiation of root primordial and development of profuse root system as it is a well-known phenomenon that callus formation in air-layered twigs is the first apparent system of the auxin adenine balance. It arises from cells in the region of the vascular cambium and adjustment phloem. Results obtained from the present investigation have conformity with the findings of Parmar et al. (2018) in guava. Among all the concentration of IBA, the maximum number of primary (17.843) and secondary roots (23.323) was recorded under the treatment C_3 (6000 ppm), whereas the number of minimum primary (8.182) and secondary roots (10.354) was observed under 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. The increase in number of roots may be due to the accumulation of rooting co-factors above the ringed portion as influenced of IBA (Saroj et al., 2020). Similar results were observed by (Verma et al., 2019).

Among the different IBA concentrations, C_3 (6000 ppm) treatment gave the maximum length of primary (8.209 cm) and secondary roots (5.833 cm) per layer, while the minimum length of primary (5.740 cm) and secondary roots (3.407 cm) per layers was observed under by C_0 (Control) treatment. The increase in length of root at higher concentrations of IBA might be due to hormonal effect and accumulation of other internal substances and their basipetal (downward) movement These findings are

closely similar to the results obtained by Patil et al. (2011) in guava, Chouhan (2016) in Guava cv. Gwalior-27. Among the different concentrations of IBA, the C₃ (6000ppm) treatment was found best to produce maximum diameter of primary (0.636 mm) and

secondary roots (1.571 mm) per layer, while the minimum diameter of primary (0.420 mm) and secondary roots (0.731 mm) per layer was found in the C₀ (Control) treatment. These findings are closely matched with the findings of Kumar (2013) in guava.

Table 1: Effect of IBA concentrations, rooting media and operation time on the rooting behaviour in guava (*Psidium guajava* L.) Air layering

Treatments	Rooting parameters										Growth parameters		
	Callus formation After 15 days (mm)	Callus formation After 30 Days (mm)	Number of primary roots	Length of primary roots (cm)	Diameter of primary root (mm)	Number of Secondary roots	Length of secondary roots: (cm)	Diameter of secondary roots: (mm)	Average dry weight of roots(g)	Rooting percentage (%)	Survival Percentage after planting: (%)	Average number of new branches	Average length of shoots (cm)
IBA Concentration													
C ₁ (3000 ppm)	11.789	17.390	12.086	7.044	0.520	15.513	4.711	1.209	0.546	60.723	62.746	4.09	40.143
C ₂ (4000 ppm)	12.852	18.154	14.347	7.373	0.509	17.964	5.094	1.314	0.565	64.895	65.258	4.73	41.650
C ₃ (6000 ppm)	16.481	21.620	17.843	8.209	0.636	23.323	5.833	1.571	0.686	76.213	72.459	5.77	53.434
C ₀ (Control)	6.362	11.193	8.182	5.740	0.420	10.354	3.407	0.731	0.389	46.919	44.089	3.30	27.656
SEm+	0.159	0.267	0.196	0.105	0.008	0.264	0.112	0.015	0.009	0.740	0.724	0.07	0.511
C D at 5 %	0.451	0.760	0.558	0.299	0.022	0.752	0.318	0.042	0.027	2.106	2.062	0.20	1.455
CV (%)	5.668	6.631	6.341	6.295	6.33	6.681	9.961	5.244	7.355	5.048	5.026	6.65	5.324
Rooting media													
M ₁ (Moss grass)	8.789	13.475	10.618	6.500	0.454	14.015	4.167	0.968	0.474	57.399	54.023	3.59	35.143
M ₂ (Coco peat)	12.223	17.478	13.345	7.039	0.527	17.228	4.727	1.264	0.572	63.13	62.289	4.42	42.043
M ₃ (Moss grass+ Coco peat)	14.601	20.315	15.381	7.735	0.580	19.122	5.390	1.387	0.594	66.026	67.102	5.41	44.977
SEm+	0.137	0.231	0.170	0.091	0.007	0.229	0.097	0.013	0.008	0.641	0.627	0.06	0.443
C D at 5 %	0.391	0.658	0.483	0.259	0.019	0.652	0.276	0.037	0.023	1.824	1.785	0.17	1.260
CV (%)	5.668	6.631	6.341	6.295	6.33	6.681	9.961	5.244	7.355	5.048	5.026	6.65	5.324
Operation time													
T ₁ (June)	10.826	15.901	12.649	6.656	0.483	15.247	4.316	1.142	0.520	59.969	59.154	3.98	37.593
T ₂ (July)	12.916	18.277	16.868	7.527	0.559	18.329	5.206	1.271	0.573	64.406	63.122	4.96	43.848
SEm+	0.112	0.189	0.139	0.074	0.005	0.187	0.079	0.011	0.007	0.523	0.512	0.05	0.361
C D at 5 %	0.319	0.538	0.395	0.212	0.016	0.532	0.225	0.030	0.019	1.489	1.458	0.14	1.029
CV (%)	5.668	6.631	6.341	6.295	6.33	6.681	9.961	5.244	7.355	5.048	5.026	6.65	5.324

Among all the concentration of IBA, the maximum average dry weight of roots (0.686 g) per layer was observed under C₃ (6000 ppm) treatment followed by C₂ (4,000 ppm) (0.565 g) and C₁ (3,000 ppm IBA) (0.546 g), whereas C₀ (Control) treatment gave the minimum mean dry weight of roots (0.389 g) per layer during the experiment. This may be due to external application of auxin generally stimulate the movement of natural auxin and other materials in downward direction from the leaves and shoot tips, which accumulate at the incision made on the shoot resulted in the formation of roots with higher fresh weight as reported by Baghel et al. 2016. Similar result was obtained by Maurya et al. (2012).

Among all the IBA concentrations, maximum rooting percentage (76.213 %) was recorded under the C₃ (6000 ppm) treatment, whereas C₀ (Control) treatment gave the minimum mean rooting percentage (46.919 %) per layer during the experiment. maximum concentration of IBA may have caused mobilization and utilization of carbohydrates and nitrogen fraction with the presence of co-factor at wound (girdled) site which may have helped in better root initiation. Hence, IBA at higher concentration resulted better rooting in guava air layer. 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 primordia. These findings are in accordance with the results reported by Tomar (2011), Naithani et al. (2018).

It is observed from Table 1 that the maximum survival percentage after planting (72.459 %) in air-layers of guava cv. Sardar was obtained in under the C₃ (6000 ppm) treatment, whereas C₀ (Control) treatment gave the minimum mean survival percentage (44.089%) per layer during the experiment. The maximum number of new branches (5.77) was recorded with the treatment C₃ (6000 ppm) followed by C₂ (4,000 ppm) (4.73) and C₁ (3000 ppm) (4.09), While it was minimum in Control C₀ treatment (3.30). It might be due to the rooting co-factors and their balance with nutritive substances and auxin. In case of IBA concentrations, the maximum mean average length of shoots (53.434 cm) was observed in the C₃ (6000 ppm) treatment, whereas, the minimum mean length of shoots (27.656 cm) was found under the C₀ (Control) treatment. These results are in concurrence with the findings of Baghel et al. (2016).

Effect of rooting media on rooting and growth characters of guava air layering

The data related to the effect of various rooting media on air layers (Table 1) indicated a significant difference with respect to callus formation of air-layering. The maximum callus formation after 15 days (14.601 mm) and after 30 days (20.315 mm) was found with the treatment M₃ (Moss grass+ Coco peat) followed by M₂ (Coco peat) (12.223 mm and 17.478 mm), while the minimum callus formation was found in M₁ (Moss grass) (8.789 mm and 13.475 mm). In relation to the rooting media, the maximum number of primary (15.381) and secondary roots (19.122) per layer was obtained under the treatment M₃ (Moss grass+ Coco peat) followed by M₂ (Coco peat) (13.345 and 17.228). The minimum number of primary (10.618) and secondary roots (14.015) per layer was recorded under the M₁ (Moss grass) treatment. These findings are similar to the results recorded by Rymbai and Reddy (2012) in Guava cv. L-49.

The length of primary roots and secondary roots differed significantly due to different rooting media (Table 1). Maximum length of primary (7.735 cm) and secondary roots (5.390 cm) were recorded in case of rooting media M₃ (Moss grass+ Coco peat), while the minimum length of primary (6.500 cm) and secondary roots (4.167cm) was observed under M₁ (Moss grass) treatments. These findings are similar to the results recorded by Rymbai, H., Reddy (2012) in Guava cv. L-49, Naithani et al. (2018). The maximum diameter of primary (0.580 mm) and secondary roots (1.387 mm) was found with the treatment M₃ (Moss grass+ Coco peat), while the minimum diameter of primary (0.454 mm) and secondary roots (0.968 mm) was observed under M₁ (Moss grass). This increase could be attributed to proper aeration, good nutrient availability and high water holding capacity by the media M₃ (Moss grass+ Coco peat). The similar results were also recorded by Rymbai and Reddy (2010).

The different rooting media significantly influenced dry weight of roots (g). The maximum mean dry weight of roots (0.594 g) was recorded under M₃ (Moss grass+ Coco peat) while the minimum mean dry weight of roots (0.474 g) was recorded under rooting M₁ (Moss grass). In relation to the growing media, maximum rooting percentage (66.026 %) per layer was noticed under the treatment M₃ (Moss grass+ Coco peat), whereas M₁ (Moss grass) treatment has the minimum rooting percentage (57.399 %) per layer. The similar results were also recorded by Rymbai and Reddy (2012) in Guava cv. L-49.

The maximum survival percentage after planting (67.102 %) was recorded with the treatment M₃ (Moss grass+ Coco peat). The minimum survival percentage (54.023 %) was noticed under M₁ (Moss grass) treatment during the experimentation. The increase in survival percentage could be due to more number of primary and secondary roots, and root length at this combination which might have induced better absorption of nutrients, food material and moisture from the soil and ultimately leading to higher establishment

percentage. Among the various growing media used in the experimentation, the maximum number of new branches (5.41) was noticed in M₃ (Moss grass+ Coco peat) treatment, while the minimum number of new branches (3.59) was found in the treatment M₁ (Moss grass). In respect to the different growing media evaluated, the maximum average length of shoots (44.977 cm) per air-layer was recorded under M₃ (Moss grass+ Coco peat) treatment, while the minimum mean length of shoots (35.143 cm) was observed under the M₁ (Moss grass) treatment. The similar results were also recorded by Parmar et al. (2018).

Effect of operation time on rooting and growth characters of guava air layering

Between both the time of air-layering, maximum callus formation after 15 days (12.916 mm) and after 30 days (18.277 mm) was recorded under the T₂ (July) treatment whereas minimum mean callus formation (10.826 mm and 15.901 mm) was noticed under the T₁ (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 callus formation in July treatment. In case of operation time, significantly higher number of primary (16.868) and secondary roots (18.329) in air-layers of guava cv. Sardar was obtained in July month, while in the month of June, number of primary (12.649) and secondary roots (15.247) was lowest. IBA concentrations and growing media were found significant in relation to the rooting percentage. It may be due to a particular correlation of temperature, humidity and rainfall. (Prasad et al., 1990) observed that IBA at higher concentration helped in triggering the activity of hydrolyzing enzymes like amylase, invertase, which catalysis the degradation of starch into sugars required during initial substances and their downward movement increase number of roots and percent rooting (Tyagi & Patel, 2004). The similar findings have also been reported by Sarker and Ghose (2006) in Guava.

The maximum length of primary (7.527 cm) and secondary roots (5.206 cm), was

found under T₂ (July) treatment. The minimum length of primary (6.656 cm) and secondary roots (4.316 cm) was observed when air-layering was performed during T₁ (June). It may be due to a particular correlation of temperature, humidity and rainfall and favourable environmental condition. Etiolation along with exogenous application of auxin had stimulating effect on producing longer roots (Kumar & Syamal, 2005). The similar findings have also been reported by Naithani et al. (2018). In case of both the time of air layering, the maximum diameter of primary (0.559 mm) and secondary roots (1.271 mm), per layer was observed under the treatment T₂ (July), whereas the minimum diameter of primary (0.483 mm) and secondary roots (1.142 mm) per layer was found in the T₁ (June) treatment. The similar findings have also been reported by Kamleshkar Singh and Jain (1996). Among the different time of air layering, T₂ (July) treatment recorded the maximum dry weight of roots (0.573 g) per layer, while the minimum dry weight of roots (0.520 g) per layer was noticed under the treatment T₁ (June). These findings are similar to the results recorded by Sharma et al. (1991) and Kumar et al. (2007).

The maximum rooting percentage (64.406 %) was found when air layering was performed on T₂ (July) treatment, while, the minimum rooting percentage (59.969%) when air-layering was done on T₁ (June) treatment. This might be due to variation in climatic and environmental factors as reported by Baghel et al. (2016). The maximum survival percentage (63.122%) per layer was obtained under the treatment T₂ (July). The minimum survival percentage (59.154%) per layer was recorded under the T₁ (June) treatment. It might be due to favourable external environmental factors, good sun shine, aeration, optimum temperatures and relative humidity during root initiation, quality of roots, subsequent growth and development of layers. These findings are similar to the results recorded by Sharma et al. (1991). The maximum number of new branches per layering (4.96) was obtained during T₂ (July). The minimum number of new

branches per layering (3.98) was recorded under T₁ (June) treatments. This result show that time of air-layering operation is an important factor for number of new branches in air-layering of Guava. The maximum average length of shoots (43.848 cm) was recorded during T₂ (July) month, while it was minimum (37.593 cm) during T₁ (June). These findings are similar to the results recorded by Tyagi and Patel (2004).

CONCLUSION

Guava (*Psidium guajava* L.), is one of the most important and popular tropical fruit crop cultivated in India because of its pleasant aroma, reasonable price, high nutritious value, low cost of cultivation and availability round the year. The effect of different IBA concentrations, rooting media and operation time was studied on the air-layer of the guava plant. On the basis of the experimental findings, the study concludes that July time of air layering, with the exogenous application of IBA @ 6000 ppm concentration and rooting media (moss grass + coco peat) was the best to enhance rooting and growth characters of air-layers and can be used for increasing the success rate of air-layers of Sardar Guava through air layering under the sub-tropical condition of Hadoti region in Rajasthan.

REFERENCES

- Ahmed, R. (1964). Propagation of guava by aerial layering. *W. Pakistan J. Agri. Res.*, 2, 62-74.
- Baghel, M., Raut, U. A., & Ramteke, V. (2016). Effect of IBA Concentrations and Time of Air-layering in Guava cv. L-49. *Research Journal of Agricultural Sciences*. 7(1), 117-120.
- Bose, T. K., & Mitra, S. K. (1990). *Fruits: Tropical and subtropical*, 6, 280-303.
- Chouhan, S. (2016). Effects of different concentration of NAA and IBA on rooting and growth of air layers in guava (*Psidium guajava* L.) cv. Gwalior-27. M.Sc. Thesis, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh (India).
- Cochran, W. G., & Cox, G. M. (1992). *Experimental Designs*. John Wiley and Sons, Inc. New York.
- Gorakh, S., Gupta, S., Mishra, R., & Singh, G. P. (2005). Wedge grafting in guava – A novel vegetative propagation technique, Pub. CISH, Lucknow, 12 p.
- Hartman, H. T., Kester, D. E., Davies, F. T., & Geneve, R. L. (2010). *Hartmann and Kester's Plant Propagation: Principles and Practices*. (8 th Edition). Prentice Hall. NJ, (USA). 928 p.
- Singh, K., & Jain, B. P. (1996). Propagation of Guava (*Psidium Guajava* L.) by air layering. *Scientific Hort.*, 5, 49-50.
- Kaundal, G. S., Gill, S. S., & Minhas, P. P. (1987). Budding techniques in clonal propagation of guava. *Punjab Hort. J.*, 27, 208-11.
- Kumar, A., & Jadhav, S. (2007). Studies on propagation of Phalsa (*Grewia asiatica* L.) by cutting. M.Sc. Thesis University of Agriculture Sciences, Dharwad (Karnataka).
- Kumar, H. (2013). Effect of different levels of IBA and methods of application on rooting, survival and growth of success air layers in guava cv. Allahabad Safeda. M.Sc. Thesis, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh (India).
- Kumar, K., & Syamal, M. M. (2005). Effect of etiolation and plant growth substances on rooting and survival of air-layers of guava. *Indian J. Hort.*, 62(3), 290-292.
- Kuperberg, Joel. (1953). Rooting guava (*Psidium guajava* c. supreme) stem cutting in a hydroponic mist type plant propagator. *Fla. State Hort. Soc. Proc.* 220-223: 1953.
- Manna, A., Mathew, B., & Ghosh, S. N. (2004). Air layering in guava cultivars. *Journal of Inter academica*. 2, 278- 281.
- Maurya, R. K., Ray, N. R., Chavda, J. C., Chauhan, V. B., & Patil, A. K. (2012). Evaluation of different organic media and water holding materials with IBA

- on rooting and survival of air layering in guava (*Psidium guajava* L.) cv. Allahabad Safeda. *The Asian Journal of Horticulture*, 7(1), 44-47.
- Naithani, D. C., Nautiyal, A. R., Rana, D. K., & Mewar, D. (2018). 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. *Int. J. Pure App. Biosci.* 6(3), 169-180.
- Parmar, J. P., Tiwari, R., Gautam, K. K., Yadav, L., & Upadhyay N. (2018). Effect of Indole 3-butyric acid (IBA), rooting media and their interaction on different rooting and growth characteristic of air-layers in guava (*Psidium guajava* L. cv. L-49) *Journal of Applied and Natural Science.* 10(1), 241 – 246.
- Patil, K. D., Patel, B. N., Aklade, S. A., & Patil, S. J. (2011). Influence of time of ringing, wrappers and IBA on air-layering in guava (*Psidium guajava* L.) cv. Sardar. *Haryana J. Hort. Sci.*, 40(1&2), 22-26.
- Prasad, P. V., Suryanaryana, V., & Naramnaidu. (1990), Studies on certain aspects of veneer grafting in mango. *South Indian Hort.*, 38(1), 1-7.
- Rymbai, H., & Reddy, G. S. (2010). Effect of IBA, time of layering and rooting media on air-layers and plantlets survival under different growing nursery conditions in guava. *Indian J. Hort.*, 67, 99-104.
- Rymbai, H., & Reddy, G. S. N. (2011). Influence of open field and polyhouse nursery on survival characters of rooted layers in guava (*Psidium guajava* L.). *Life sciences Leaflets*, 21, 996-1002.
- Rymbai, H., Reddy, G. S., & Reddy, K. C. S. (2012). Effect of Cocopeat and Sphagnum Moss on Guava Air Layers and Plantlets Survival under Open and Polyhouse Nursery. *Agric. Sci. Digest*, 32(3), 241-243.
- Sarkar, A., & Ghosh, B. (2006), Air layering in guava cv L-49 as affected by plant growth regulators, wrappers and time of operation. *Environ. Ecol.* 24(3A), 820-823.
- Saroj & Singh, K. K. (2020). Vegetative Propagation of Guava (*Psidium Guajava* L.) Through air Layering: A review. *Plant Archives*, 20(1), 1179-1188.
- Sharma, R. S., Sharma, T. R., & Sharma, R. C. (1991). Influence of growth regulators and time of operation on rooting of air layering in guava (*Psidium guajava* L.) cv. 'Allahabad Safeda'. *Orissa Journal of Horticulture.* 19(1/2), 41-45.
- Singh, A. K., & Singh, G. N. (2004). Effect of IBA and NAA on rooting media of air-layers of jackfruit (*Artocarpus heterophyllus* Lam.). *Scientific Hort.*, 9, 41-46.
- Singh, K. K., & Mahato, S. (2016). Influence of indol-3-butyric acid (IBA) and various time on rooting of guava (*Psidium guajava* L.) air layering. *Journal of Plant Development Sciences*, 8(4), 193-196.
- Singh, P., Chandrakar, J., Singh, A. K., Jain, V., & Agrawal, S. (2007), Effect on rooting in guava cv. Lucknow-49 through PGR and organic media under Chhattisgarh condition. *Acta. Horticulture.* 7(35), 197-200.
- Singh, P., Chandrakar, J., Singh, A. K., Jain, V., & Agrawal, S. (2007). Effect on Rooting in Guava cv. L-49 through PGR and Organic Media under Chhattisgarh condition. *Acta Horticulturae*, 735, 197-200.
- Tomar, Y. K. (2011). Effect of various concentrations of bio-regulators and time of air-layering on the multiplication of jackfruit (*Artocarpus heterophyllus* Lam.). *International Journal of Current Research.* 3(6), 316-318.

- Tyagi, S. K., & Patel, R. M. (2004), Effect of growth regulators on rooting of air layering of guava (*Psidium guajava* L.) cv. Sardar. *Orissa J. Hort.*, 32(1), 58-62.
- Usman, M., Shah, M. H., Badar, A., Fatima, B., Sabir, M., & Zaman, Q. (2014). Media steaming and coco-coir enhance growth of rough lemon (*Citrus jambhiri* L.) stock. *Pakistan Journal of Agricultural Science*. 51(3), 615-623.
- Verma, B., Bhadauriya, P., Parmar, U., Dhakad, R. K., & Tomar, K. S. (2019). Impact of IBA and NAA on Rooting and its Growth Parameters of Air Layers in Guava (*Psidium guajava* L.). *Int.J. Curr. Microbiol. App. Sci*, 8(10), 2041-2047.
- Zamir, R., Khattak, G. S. S., Mohammad, T., & Ali, N. (2003). In vitro mutagenesis in guava (*Psidium guajava* L.). *Pakistan J. Bot.*, 35, 825-828.