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Effect of IBA concentrations, time and rooting media on the rooting behaviour in guava (*Psidium guajava* L.) air layering

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Abstract
An experiment was conducted at the Department of Horticulture, School of Agriculture Science, Career Point University Kota Rajasthan during the session 2018; entitled "Effect of IBA concentrations, time & rooting media on the rooting behavior in guava (*Psidium guajava* L.) Air layering, under Rajasthan region". The experiment was laid out in factorial Randomized Block Design with four levels of IBA concentrations (C1 (3000ppm), C2 (4000ppm), C3 (6000ppm), C0 (Control), three different rooting media M1 (Moss grass), M2 (Coco-peat), M3 (Moss grass + Coco-peat) and two months air layering (T1 (June) and T2 (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 C3M3T2 (6000 ppm IBA + Moss grass + Coco peat + July) treatments. On the basis of results obtained, it can be concluded that air-layering performed during July, treated with 6000ppm IBA concentration and use of combination of Moss grass and Coco peat as growing media have been found significantly superior on all other treatments under Rajasthan region.

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 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 co mmercial significance (Singh, 2007) [27]. Guava is successfully propagated through sexual and asexual methods such as sexual method (Zamir *et al*., 2003) [33], cutting (Kuperberg, 1953) [13], budding (Kaundal *et al*., 1987) [9], layering (Manna *et al*., 2004) [14] and grafting (Singh *et al*., 2005) [6]. Requirement of more plant material for propagation, seasonal dependence, long juvenile phase, longer time length etc. has been some hindrance in the Sexual propagation (Usman *et al*., 2014) [31]. Among all the vegetative methods Airlayering is the co mmon, cheaper and more convenient method for propagation of economically important woody plants, especially in species which are difficult-to-root on cuttings. Bose & Mitra, 1990 [3]; In litchi plant propagation air layering is the most handy method in our country. Mother plant, time of layering, plant growth regulators, rooting and growth media, care during removal of bark from shoots, rainfall, humidity and temperature of that particular place effect success in air layering of guava. As the layered branch is not detached from the mother plant in air layering caused successful and remains alive propagation due to receiving constant water and mineral nutrients supply through the xylem (Hartmann *et al*., 2010) [7] and intact shoots might synthesize some unknown auxiliary substances to induce adventitious roots (Singh *et al*., 2004) [25]. Air layering during the month of June, July provides the conducive environment for the root initiation (Ahmed, 1964) [1] because of high relative humidity (80 to 90%), relatively low temperature (23˚C to 31˚C), rainfall and longer duration of a favourable season for establishing the layer in the soil. 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) [27]. Air layering using PGR and rooting media stimulate root primordia in air layering of guava (*Psidium guajava* L.)

cv. Sardar (Tyagi & Patel, 2004 & Singh *et al*., 2016) [26]. Exogenous application of IBA trigger highest rooting percentage and root character of guava air layering (Rymbai & Reddy 2011) [21] Hence, the present investigation was operated to find out the effect of various concentrations in dole butyric acid, time & rooting media on the rooting behavior in guava (*Psidium guajava* L.) air layering under Rajasthan region.

Materials and Methods

The present investigation entitled "Effect of IBA concentrations, time and rooting media on the rooting behavior in guava (*Psidium guajava* L.) air layering under Rajasthan region. The search was operated 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. The experimental field is located in the city of Kota, south-eastern region of Rajasthan; region widely known as Hadoti. Kota is the third largest city of Rajasthan after Jaipur and Jodhpur; located along eastern bank of the Chambal River of Rajasthan. The cartographic coordinates are 25.18°N 75.83°E. It covers an area of 318 km^2 with an average elevation of 271 m. Kota is bound by Sawai Madhopur, Tonk and Bundi districts; separated by the Chambal River, forming the natural boundary.Semi-arid climate with high temperatures throughout the year in Kota has long, hot and dry su mmers, mild winter with an average annual rainfall in of 660.6 mm; attributed to the southwest monsoon during last week of June till September and winter rainfall due to the Western disturbance passing over the region. 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 (C1 (3000 ppm), C2 (4000 ppm), C3 (6000 ppm), C0 (Control), three different rooting media M1 (Moss grass), M2 (Coco-peat), M3 (Moss grass + Coco-peat) and two months air layering (T1 (June) and T2 (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 after having three foundations cut with an interval of one week; to reduce sudden detachment shocking condition. After detachment air layers were brought under shade and gently remove their polythene covering to reduce injury in the rooting area at the time of removal of polythene and placed under the shade of a tree. After this, prepared air layer was planted in polythene bags having mixture of soil + F.Y.M. + Vermi compost (2:1:1). Data recorded during the study period were subordinated to statistical analysis under FRBD as described by (Cochran & Cox, 1992) [5].

Results and Discussion

The data relating 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 found significant impact on rooting and growth characters of guava air layering.

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

The data related to the effect of various IBA Concentrations on air layers (Table 1) indicated a significant difference with respect to callus formation of air-layering. The maximum callus formation after 15 days (mm) and after 30 days (mm) was found with the treatment C3 (6000 ppm) (17.224 mm and 24.489 mm), while the minimum callus formation was found in C0 (Control) (7.032 mm and 11.477 mm). 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-layering is the first articulation of the auxin adenine balance; arised from cells in the region of adjustment phloem and vascular cambium. Results obtained from the present investigation have conformity with the findings of Parmar *et al*. (2018) [17] in guava. In relation to IBA Concentrations, the maximum number of primary (18.271) and secondary roots (24.474) per layer was obtain under the treatment C3 (6000 ppm) followed by C2 (4000 ppm) (16.030 and 18.158). The minimum number of primary (8.289) and secondary roots (10.736) per layer was recorded under the C0 (Control) treatment. Increased number of roots in the air-layering with the higher concentration of IBA might be due to increased cell wall elasticity; increased cell division. IBA at higher concentration increased root length by affecting the synthesis of enzymes which are related to cell enlargement. Accumulation of rooting co-factors above the ringed portion with IBA increased number of roots (Saroj *et al*., 2020) [24], (Verma *et al*., 2019) [33]. The length of primary roots and secondary roots differed significantly due to different IBA concentrations (Table 1). Maximum length of primary (23.933 cm) and secondary roots (5.888 cm) were recorded in case of IBA concentrations C3 (6000 ppm), while the minimum length of primary (9.366 cm) and secondary roots (3.441 cm) was observed under C0 (Control) treatments. Hormonal effect and accumulation of other internal substances and their downward movement caused increase in length of root at higher concentrations of IBA. These findings are closely similar to the results obtained by Patil *et al*. (2011) [15] in guava, Chouhan (2016) [4] in Guava cv. Gwalior-27.

The maximum diameter of primary (0.672 mm) and secondary roots (1.841 mm) was found with the treatment C3 (6000 ppm), while the minimum diameter of primary (0.383 mm) and secondary roots (0.701 mm) was observed under C0 (Control). These findings are closely matched with the findings of Kumar (2013) [11] in guava. The different IBA concentrations significantly influenced dry weight of roots (g). The maximum mean dry weight of roots (0.705 g) was recorded under C3 (6000 ppm) while the minimum mean dry weight of roots (0.423g) was recorded under C0 (Control).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 [2]. Similar result was obtained

by Maurya *et al*. (2012) [15]. In relation to the IBA concentrations, maximum rooting percentage (78.348%) per layer was noticed under the treatment C3 (6000 ppm), whereas C0 (Control) treatment has the minimum rooting percentage (48.439%) per layer. Higher IBA concentration caused mobilization of nitrogen fraction and carbohydrates with the presence of cofactor at girdled place; helped in better root initiation. That's why; high concentration of IBA caused better rooting in guava air layering. Conversion of starch into simple sugars triggered by exogenous application of auxin, 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. These findings are in accordance with the results reported by Tomar (2011) [30], Naithani *et al*. (2018) [16]. The maximum survival percentage after planting (73.666%) was recorded with the C3 (6000 ppm). The minimum survival percentage (45.974%) was noticed under C0 (Control) treatment during the experimentation. It was in dint of rooting co-factors balance with auxin and nutritive substances. The data pertaining to effect of various IBA Concentrations to average number of new branches; maximum number of new branches (5.94) was noticed under the treatment C3 (6000 ppm) while, minimum number of new branches (3.40) was observed under the treatment C0 (control). In respect to the different IBA concentrations evaluated, the maximum average length of shoots (55.327 cm) per air-layer was recorded under C3 (6000 ppm) treatment, while the minimum mean length of shoots (29.201 cm) was observed under the C0 (Control) treatment. These results are in concurrence with the findings of Baghel *et al*. (2016) [2].

Table 1: Effect of IBA concentrations, rooting media and operation time on the rooting behaviour in guava (*Psidium guajava* L.) air layering (2019-20)

	Rooting parameters						Growth parameter						
Treatments	**Callus formation After 15 days**	**Callus formation after 30 days**	**Number of primary roots**	**Length of primary roots**	**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													
3000 ppm	12.324	17.441	12.636	16.261	0.519	15.881	4.763	1.273	0.569	61.979	64.003	3.97	40.829
4000 ppm	13.519	18.162	16.030	17.106	0.521	18.158	5.114	1.422	0.601	65.466	66.572	4.70	42.717
6000 ppm	17.224	24.489	18.271	23.933	0.672	24.474	5.888	1.841	0.705	78.348	73.666	5.94	55.327
Control	7.032	11.477	8.289	9.366	0.383	10.736	3.441	0.701	0.423	48.439	45.974	3.40	29.201
S.Em +	0.186	0.330	0.205	0.213	0.008	0.207	0.106	0.025	0.011	0.764	0.760	0.05	0.502
C D at 5%	0.531	0.940	0.583	0.607	0.024	0.589	0.303	0.072	0.032	2.174	2.163	0.15	1.430
CV (%)	6.314	7.831	6.294	5.432	6.83	5.073	9.395	8.185	8.370	5.099	5.154	5.06	5.071
Rooting media													
Moss grass	9.414	14.372	11.302	12.945	0.473	14.383	4.206	1.123	0.518	58.758	55.317	3.64	37.210
Coco peat	12.908	18.625	13.557	17.375	0.530	17.800	4.760	1.340	0.598	64.636	63.542	4.48	42.473
Moss grass + Coco peat	15.252	20.680	16.561	19.680	0.568	19.754	5.439	1.465	0.608	67.280	68.801	5.37	46.372
S.Em +	0.161	0.286	0.177	0.185	0.007	0.179	0.092	0.022	0.010	0.662	0.658	0.046	0.435
C D at 5%	0.459	0.814	0.505	0.526	0.021	0.510	0.262	0.062	0.028	1.883	1.873	0.13	1.238
CV (%)	6.314	7.831	6.294	5.432	6.83	5.073	9.395	8.185	8.370	5.099	5.154	5.06	5.071
Operation time													
June	13.548	16.721	12.025	15.360	0.492	15.861	4.360	1.245	0.546	60.959	60.460	4.024	39.402
July	25.049	19.063	15.588	17.973	0.556	18.763	5.243	1.373	0.604	66.157	64.647	4.977	44.635
S.Em +	0.132	0.234	0.145	0.151	0.006	0.146	0.075	0.018	0.008	0.540	0.537	0.04	0.355
C D at 5%	0.375	0.665	0.412	0.429	0.017	0.417	0.214	0.051	0.023	1.538	1.529	0.11	1.011
CV (%)	6.314	7.831	6.294	5.432	6.83	5.073	9.395	8.185	8.370	5.099	5.154	5.06	5.071

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

The data pertaining to effect of various rooting media to rooting parameters the maximum callus formation after 15 days (15.252 mm) and after 30 days (20.680 mm) was noticed under the treatment M3 (Moss grass + Coco peat) while, minimum callus formation after 15 days (9.414 mm) and after 30 days (14.372 mm) was observed under the treatment M1 (Moss grass). Among all the combination of rooting media, the maximum number of primary (16.561) and secondary roots (19.754) was recorded under the treatment M3 (Moss grass + Coco peat), whereas the number of minimum primary (11.302) and secondary roots (14.383) was observed under M1 (Moss grass) treatment. These findings are similar to the results recorded by Rymbai and Reddy (2012) [22] in Guava cv. L-49. Among the different rooting media, M3 (Moss grass + Coco peat) treatment gave the maximum length of primary (19.680 cm) and secondary roots (5.439 cm) per layer, while the minimum length of primary (12.945 cm) and secondary roots (4.206 cm) per layers was observed under by M1 (Moss grass) treatments. These findings are similar to the results recorded by Rymbai, H., Reddy (2012) [22] in Guava cv. L-49, Naithani *et al*. (2018) [16]. Among the different rooting media, the M3 (Moss grass + Coco peat) treatment was found best to produce maximum diameter of primary (0.568 mm) and secondary roots (1.465 mm) per layer, while the minimum diameter of primary (0.473 mm) and secondary roots (1.123 mm) per layer was found in the M1 (Moss grass) treatment. 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) [20]. Among all the rooting media, the maximum average dry weight of roots (0.608g) per layer was observed under M3 (Moss grass + Coco peat) treatment followed by M2 (Coco peat) (0.598g) whereas M1 (Moss grass) treatment gave the minimum mean dry weight of roots (0.518g) per layer during the experiment. Among all the growing media, maximum rooting percentage (67.280%) was recorded under the M3 (Moss grass + Coco peat) treatment, whereas M1 (Moss grass) treatment gave the

minimum mean rooting percentage (58.758%) per layer during the experiment. The similar results were also recorded by Rymbai and Reddy (2012) [22] in Guava cv. L-49. It is observed from Table 1 that the maximum survival percentage after planting (68.801%) in air-layers of guava cv. Sardar was obtained in under the M3 (Moss grass + Coco peat) treatment, whereas M1 (Moss grass) treatment gave the minimum mean survival percentage (55.317%) per layer during the experiment. 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. The maximum number of new branches (5.37) was recorded with the treatment M3 (Moss grass + Coco peat) followed by M2 (Coco peat) (4.48), While it was minimum in M1 (Moss grass) treatment (3.64)). In case of different growing media evaluated, the maximum mean average length of shoots (46.372 cm) was observed in the M3 (Moss grass + Coco peat) treatment, whereas, the minimum mean length of shoots (37.210 cm) was found under the M1 (Moss grass) treatment. The similar results were also recorded by Parmar *et al*. (2018) [17].

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

Between both the time of air-layering, maximum callus formation (25.049 mm) was recorded under the T2 (July) treatment whereas minimum mean callus formation (13.548 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 (15.588) and secondary roots (18.763) in air-layers of guava cv. Sardar was obtained in July month, while in the month of June, number of primary (12.025) and secondary roots (15.861) 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) [19] observed that IBA at higher concentration triggered activity of hydrolyzing enzymes such as invertase and amylase; catalyzed degradation of starch into sugars and their downward movement enhanced rooting percentage and number of roots. (Tyagi & Patel, 2004) [31]. The similar findings have also been reported by Sarker and Ghose (2006) in Guava. The maximum length of primary (17.973 cm) and secondary roots (5.243 cm), was found under T2 (July) treatment. The minimum length of primary (15.360 cm) and secondary roots (4.360 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) [12]. The similar findings have also been reported by Naithani *et al*. (2018) [16]. In case of both the time of air layering, the maximum diameter of primary (0.556 mm) and secondary roots (1.373 mm), per layer was observed under the treatment T2 (July), whereas the minimum diameter of primary (0.492 mm) and secondary roots (1.245 mm) per layer was found in the T1 (June) treatment. The similar findings have also been reported by Kamleshkar Singh and Jain (1996) [8]. Among the different time of air layering, T2 (July) treatment recorded the maximum dry weight of roots (0. 0.604 g) per layer, while the minimum dry weight of roots (0.546 g) per layer was noticed under the treatment T1 (June). These findings are similar to the results recorded by Sharma *et al*. (1991) [25] and Kumar *et al*. (2007) [10]. The maximum rooting percentage (66.157%) was found when air layering was performed on T2 (July) treatment, while, the minimum rooting percentage (60.959%) 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) [2]. The maximum survival percentage (64.647%) per layer was obtained under the treatment T2 (July). The minimum survival percentage (60.460%) per layer was recorded under the T1 (June) treatment. It might be due to favorable external environmental conditions such as optimum temperatures and relative humidity, aeration and good sun shine during root initiation for growth and development of layers. These findings are similar to the results recorded by Sharma *et al*. (1991) [25]. The maximum number of new branches per layering (4.977) was obtained during T2 (July). The minimum number of new branches per layering (4.024) 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 (44.635 cm) was recorded during T2 (July) month, while it was minimum (39.402 cm) during T1 (June). These findings are similar to the results recorded by Tyagi and Patel (2004) [31].

Conclusion

The results of present investigation revealed 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 in Rajasthan. Further studies regarding different IBA concentrations, rooting media and operation time should be adapted to commercialize air layering technique in Guava (*Psidium guajava* L.).

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