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Studies on role of plant growth regulators and rooting media on rooting and survival of air-layers of Guava (*Psidium guajava*) var. G-27

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Abstract
The present investigation was taken up during rainy season of 2012-13 at Horticultural Nursery, College of Agriculture, Gwalior. The treatment consisted of 7 levels of PGRs (control, IBA-5000 ppm, IBA-7500 ppm, NAA-5000 ppm, NAA-7500 ppm, IBA+NAA-5000 ppm each and IBA+NAA-7500 ppm each) and two rooting media (Moss grass and Moss grass + coco-peat). Significantly maximum percentage of callus formation (0.948 cm/air layer), number of primary roots (15.50/air layer), length of primary roots (4.56 cm), diameter of primary roots (2.995 mm), number of secondary roots (31.39/air-layer), length of secondary roots (2.551 cm), diameter of secondary roots (0.673 mm), dry weight of roots (0.692 g), rooting success (80.17%), survival percentage of air-layers (72.66%), number of new branches (6.66/air layer) and length of shoots (11.33 cm) were recorded from IBA+NAA-7500 ppm each. Application of IBA at 7500 ppm ranked second and was found significantly superior to rest of the treatments in respect of all root and growth characters. Maximum callusing (0.693 cm/air layer), number of primary roots (10.16/air layer), length of primary roots (3.55 cm), diameter of primary roots (2.430 mm), number of secondary roots (22.90/air-layer), length of secondary roots (1.768 cm), diameter of secondary roots (0.530 mm), dry weight of roots (0.564 g), rooting success (62.80%), survival percentage of air-layers (55.14%), number of new branches (5.38/air layer) and length of shoots (8.83 cm) were noted under the rooting media M_2 (Moss grass + coco-peat), which significantly proved superior over rooting media M_1 (moss grass) in respect of all these characters. Significantly maximum length of primary root (4.99 cm), diameter of primary root (3.286 mm), number of secondary roots (34.08/ air layer), length of secondary roots (2.858 cm), rooting success (82.68%) and survival percentage (74.39%) was obtained by the treatment combination G_6M_2 (IBA+NAA 7500 ppm each with Moss grass+coco-peat). Treatment G_6M_2 (IBA+NAA 7500 ppm each with Moss grass+coco-peat) has secured the highest net return (Rs. 2482.60) followed by G_2M_2 (Rs. 2334.40) and G_6M_1 (Rs. 2328.80). But, the treatment G_2M_2 (IBA 7500 ppm with Moss grass+coco-peat) gave highest B: C ratio (6.12) closely followed by G_6M_2 (6.04) and G_4M_2 (5.86).

Keywords: Plant growth regulators, rooting media, survival, rooting, guava, air layering, G-27

Introduction
Guava (*Psidium guajava* L.) which belongs to the family Myrtaceae, is the most popular fruit in the tropical and sub-tropical parts of India because of its low cost of cultivation, being tolerant to drought and semi-arid conditions as well as salinity problems and wide adaptability to varying soil and climatic conditions. It has gained considerable prominence owing to its high nutritive value, easy availability at moderate price with pleasant aroma and good flavour of fruits. Guava is a rich source of vitamin C and pectin. Guava fruits are also used for many preparations like jam, jelly and RTS beverage. Guava is one of the commonest fruits liked by the rich and the poor alike. It is known as “Poor man’s apple”. It occupies an important place in Horticultural wealth of our nation. In India, its rank is fourth after mango, banana and citrus so far as arid area and production of major fruits is concerned. Guava fruit, Guava area is increasing steadily in the subtropical regions of India because of its high production, profitability. India is the leading producer of guava in the world. The total area and production of guava in India is about 2.05 million hectares and 2.46 million tonnes, respectively. The productivity of guava in India is 12.0 mt/ha. The total area and production of guava in Madhya Pradesh are 9.70 thousand hectares and 0.28 million tonnes, respectively. Madhya Pradesh ranks first in productivity with 37.6mt/ha. Guava shares 3.4 % area and 3.9 % production in India (NHB, 2015) [16]. Major guava producing districts in Madhya Pradesh are Jabalpur, Gwalior, Bhopal, Rewa, Neemuch, Ratlam, Khandwa and Mandsaur etc.

Multiplication of fruit plants through vegetative method is one of the important aspects of modern fruit culture. Guava can be propagated by grafting, budding and also by layering which has numerous advantages. Layering is the cheapest, rapid and simple method. It does not require any special techniques as in grafting and budding. The success in layering of guava and other fruit crops depends upon mother plants, time of layering, rainfall, humidity, temperature, rooting media, growth regulators and care at the time of removal of bark/ringing of shoot. Guava is generally propagated by seeds but vegetative, inarching, layering, cutting, budding and grafting are commonly practiced. These methods have their own merits and demerits. However, layering or air-layering are easy method of propagation of this crop.

Many workers have used growth regulators them in different fruit species. Growth regulators such as Auxins particularly IBA and NAA have been reported to induce rooting in many of the plant species with varied success. However, the response of different growth substances to percent success varied from species to species, changing physiological and environmental condition. Most of the workers have reported IBA and NAA as better growth regulators than other for inducing rooting in cuttings and air- layering due to their stable nature. Air layering are reported to have yielded good results Hartmann and Kester, 1972. As a rooting media, various mixtures of soil, peat, leaf mould, farm yard manure and artificial inorganic substances like sphagnum moss, Vermiculture and perlite have been extensively used. The rooting media used in air layers, must be sufficiently firm and dense to hold the air layers during rooting and it must retain enough moisture so that watering does not have to be too frequent. Gwalior-27 is a popular variety in Northern Madhya Pradesh but propagation method of this variety has not been standardized.

Material and Methods

To study the effect of plant growth regulators and rooting media on rooting of air-layers of Guava (*Psidium guajava*) var. G-27 an experiment was conducted during the rainy season of July 2012 to November 2012. The experiment was carried out in the Nursery of the department of Horticulture, College of Agriculture, Gwalior.

Location and site

The experimental field is located between 26°14' N and 78°50' E latitude and longitude, respectively and at an elevation of 207 m above the sea levels belonging to the northern part of the Madhya Pradesh.

Climate

The locality of the experimental area was a typical sub-tropical monsoon climate with extremes of temperature both in summer and winter. Severe frost is of rare occurrence but cold waves are experienced from the middle of December to end of February. The average annual rainfall is between 760 to 1060 mm, most of which occurs in the months of July, August and September with scanty rains during winter months of November to January. The meteorological information's regarding temperature, rainfall, relative humidity and evaporation were collected from the Agriculture Meteorology, College of Agriculture, Gwalior during the period of experiment.

Design and layout of the experiment

The two-factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications and 14 (7 × 2) treatment combinations. Twenty shoots were layered per replication of a treatment combination. The total number of air-layers was 840 (14 × 20 × 3).

Treatment details

(A) Growth regulators

1) Control 0 ppm	G_0
2) IBA 5000 ppm	G_1
3) IBA 7500 ppm	G_2
4) NAA 5000 ppm	G_3
5) NAA 7500 ppm	G_4
6) IBA + NAA 5000 ppm each	G_5
7) IBA + NAA 7500 ppm each	G_6

(B) Rooting media

1) Moss grass	M_1
2) Moss grass + coco-peat	M_2

Details of treatment combinations

Details of the treatment combinations and their notations

S. No.	Treatment details	Notation
1	Control (0 ppm) + Moss grass	G_0M_1
2	Control (0 PPM) + Moss grass +coco-peat	G_0M_2
3	IBA 5000 ppm + Moss grass	G_1M_1
4	IBA 5000 ppm + Moss grass + coco-peat	G_1M_2
5	IBA 7500 ppm + Moss grass	G_2M_1
6	IBA 7500 ppm + Moss grass + coco-peat	G_2M_2
7	NAA 5000 ppm + Moss grass	G_3M_1
8	NAA 5000 ppm + Moss grass + coco-peat	G_3M_2
9	NAA 7500 ppm + Moss grass	G_4M_1
10	NAA 7500 ppm + Moss grass + coco-peat	G_4M_2
11	IBA+NAA 5000 ppm each + Moss grass	G_5M_1
12	IBA+NAA 5000 ppm + Moss grass + coco-peat	G_5M_2
13	IBA+NAA 7500 ppm each + Moss grass	G_6M_1
14	IBA+NAA 7500 ppm + Moss grass + coco-peat	G_6M_2

Selection of plants and their branches

Four plants for each replication (12 plants for experiment) of uniform size and vigour were selected. For air layering; healthy, disease free, vigorously growing lateral shoots having green and brown portion at the apical and basal portion respectively of past season growth with approximate diameter from 0.847 to 1.135 cm as juvenile shoot were selected. The average length of the selected branches was 47-60 cm. Careful observations were also made to ensure that the selected branches had sufficient leaves on them.

280 selected branches were layered on four plants in each replication. Thus, number of branches layered was 840 in all the three replications and all the treatments.

Preparation of mixture of growth regulators

In the present experiment growth regulators were prepared in talc powder base. First of all stock powder IBA and NAA with 5000 ppm strength was prepared. For this purpose, 0.5 gm of growth regulator was weighed on electrical balance and then dissolved in about 10.00 cc absolute alcohol (95%). Then, three or four drops of Ammonium hydroxide were also mixed to make it absolutely transparent. This solution was then thoroughly mixed with 99.50 gm of talc powder.

The quantity of powder required for preparing 7500 ppm alone and 5000 ppm and 7500 ppm mixture is given below:

IBA 7500 ppm: 0.75 gm IBA + 49.25 gm talc powder

NAA 7500 ppm: 0.75 gm NAA + 49.25 gm talc powder

IBA+NAA 5000 ppm each: 0.50 gm each of IBA + NAA + 99.00 gm talc powder

IBA+NAA 5000 ppm each: 0.75 gm each of IBA + NAA + 98.50 gm talc powder
After preparation, the powder was kept in broad mouthed bottles covered with black paper to protect it from light. Every time fresh powder was prepared.

Preparation of rooting media
(i) Moss
Firstly, sphagnum moss was soaked in water for eight hours before use and then a small quantity of moss was applied to cover the ring of the shoot.

(ii) Moss + coco-peat
Firstly, sphagnum moss was soaked in water for eight hours before use. Coco-peat were sieved and mixed together in the ratio of 1:1 and then a small quantity of mixture was applied to cover the ring of the shoot.

Method of treatment
On the selected branches of pencil size, a ring of bark about 2 cm wide was removed carefully just below the bud without injuring the under=lying wood. Previously prepared powder containing the growth regulators was applied evenly on all sides of uppercut of the ring with camel hairbrush. For different treatments, different brushes were used. The cut portion was covered with rooting media containing a mixture of moss + coco-peat (1:1) and moss and then wrapped with transparent polythene film of 400 gauge and then tied with the help of Sutli. Control branches were treated only with talc powder without growth regulator.

Detachment of air-layers
After 50 days, air layers were ready for detachment. These were detached by making a cut just below the lower end of the ringed surface with a sharp secatear. 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. + leaf mould (2:1:1).

Observations recorded
Three air-layers per treatment/replication were selected randomly and following 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.

A. Rooting parameters
(i) Callus formation (cm)
Observations on callusing of air layers were recorded after 15 days of operation. Callus cells were measured with the help of Vernier's calipers.

(ii) Number of primary roots per air-layer
Roots were separated from air-layers with the help of sharp blade and number of primary roots was counted.

(iii) Length of primary roots per air-layer (cm)
Length of detached roots was measured by keeping these roots on graph paper and average length per root was worked out.

(iv) Diameter of primary roots (mm)
Three roots per air layer were selected randomly and their diameter was taken with the help of screw gauge and their mean was calculated.

(v) Number of secondary roots per air-layer
Secondary roots were detached from the primary roots and were counted as per procedure adapted for primary roots.

(vi) Length of secondary roots (cm)
Length of secondary roots detached from primary roots was measured as per the procedure adopted for primary roots.

(vii) Diameter of secondary roots (mm)
Five secondary roots per air layer were selected randomly and their diameter was taken in mm with the help of screw gauge and their mean was calculated.

(viii) Average dry weight of roots per air-layer (g)
For dry weight of roots, detached roots were kept in oven for twelve to eighteen hours. The weight of well-dried roots was recorded with the help of electric balance and average dry weight/air-layer was calculated.

(ix) Rooting percentage or per cent success (%)
Observations were recorded at the time of planting.

B. Growth parameters
(i) Survival percentage after planting (%)
Observations were taken at 60 days of planting.

(ii) Average number of new branches
Observations were recorded at 15 days intervals after planting.

(iii) Average length of shoots (cm)
Observations were recorded with the help of scale at 15 days intervals after planting.

Cultural practices
Irrigation and weeding
Irrigation was given to the plants after fifteen days starting from the date of transplanting after detachment and Weedings were done at 15 days intervals after transplanting of air-layers.

Statistical analysis
The various data on root and growth characters were subjected to statistical analysis by adopting appropriate method of analysis. Wherever, variance ratio (calculated 'F' values) were found significant, critical difference (C.D.) values were computed by using following formula for making comparisons between the treatments:

$$C.D. = \sqrt{\frac{\text{Error variance}}{n}} \times \sqrt{2} \times t$$

Where,
n = The number of observations averaged,
Error variance = mean sum of squares due to error (MSE) and 't' is the value from 't' table at 5% level.

Result and Discussion

A. Root studies of air layers

1. Callus formation (cm)

The variation in the callus formation was highly significant due to the main effect of growth regulators and rooting media but not their interaction.

The average callus formation was higher with the treatment G_6 (IBA + NAA 7500 ppm each) (0.948 cm) which was significantly superior with rest of the treatments of growth regulators. However, minimum callus formation was recorded in control (0.383). Application of growth regulators individually or in combination at higher concentration significantly increased the callus formation over lower concentration.

The maximum diameter (0.693 cm) of callus cell was recorded under M_2 (Moss grass + coco-peat) which was significantly superior M_1 (Moss grass) the value being 0.569 cm.

Treatment combination between growth regulators and rooting media did not show any significant effect on callus formation. However, maximum diameter of callus (1.016 cm) was recorded under the combination G_6M_2 (IBA+NAA 7500 ppm each with Moss grass + coco-peat) and minimum (0.311 cm) under G_0M_1 [control (0 ppm) with Moss grass].

2. Number of primary roots

Plant growth regulators and rooting media significantly influenced the number of primary roots per air-layer individually but not jointly. All the concentrations of both growth regulators applied alone or in combination significantly increased the number of primary roots over control. Higher concentration of both the growth regulators applied alone or in combination increased the number of primary roots over its respective lower level. Among all the treatments of both growth regulators, G_6 (IBA + NAA 7500 ppm each) resulted insignificantly highest number of primary roots (15.50/air-layer).

Data on number of primary roots indicated that rooting media M_2 (Moss grass + coco-peat) resulted highest number of primary roots (10.16/air-layer) and recorded 28.28% significantly higher number of primary roots over rooting media M_1 (Moss grass).

In case of interaction G×M, the maximum number of primary roots (16.85/air-layer) was obtained from the treatment combination G_6M_2 (IBA+NAA 7500 ppm each with Moss grass+coco-peat). On the other hand, G_0M_1 (control with Moss grass) recorded the lowest number of primary roots (3.32/air-layer). However, interaction of growth regulators and rooting media did not have any effect on number of primary roots per air-layer.

3. Length of primary roots

The length of primary roots per air-layer was found to deviate significantly due to treatments of various plant growth regulators. Both plant growth regulators applied alone or in combination significantly increased the length of primary roots at different concentrations when compared with control. Between different treatments of growth regulators, maximum length of primary roots (4.56 cm) was recorded in case of treatment G_6 (IBA + NAA 7500 ppm each), whereas minimum length of primary roots (1.87 cm) was obtained with NAA 5000 ppm (G_3) against 1.29 cm length of primary roots in control. Data further indicate that the performance of IBA growth regulator at each concentration in respect of increasing the length of primary roots was found significantly better than the corresponding concentration of NAA.

Length of primary roots differed significantly due to rooting media. Rooting media M_2 (Moss grass + coco-peat) recorded significantly longer primary roots than M_1 (Moss grass).

Among treatment combinations of rooting media and growth regulators, combination G_6M_2 (IBA+NAA 7500 ppm each with Moss grass+coco-peat) gave the maximum length of primary roots (4.99 cm), which was statistically higher than all the remaining treatment combinations. Minimum length of primary roots (0.74 cm) was recorded under treatment combination G_0M_1.

4. Diameter of primary roots

Plant growth substances, rooting media and their interaction significantly influenced the diameter of primary roots.

All the treatments of IBA and NAA applied alone or in combination at any concentration significantly increased the diameter of primary roots over control. Diameter of primary roots significantly increased with each increase in concentration under both IBA and NAA applied alone or in combination and highest diameter was recorded with treatment G_6 (IBA + NAA 7500 ppm each). Data further indicate that the performance of IBA growth regulator at each concentration in respect of increasing the diameter of primary roots was found significantly better than the corresponding concentration of NAA.

Rooting media M_2 (Moss grass + coco-peat) significantly exhibited wider primary roots than M_1 (Moss grass).

Interaction between growth regulator and rooting media showed significant effect on diameter of primary roots. Significantly maximum (3.286 mm) diameter of primary roots were noted under treatment combination G_6M_2 (IBA+NAA 7500 ppm each with Moss grass+coco-peat) while minimum in G_0M_1 (control with moss grass).

5. Number of secondary roots

Number of secondary branches per air-layer were significantly influenced by main as well as interaction of growth regulators and rooting media. All the treatments of IBA and NAA applied alone or in combination at any concentration significantly increased the number of secondary roots over control. The maximum number of secondary roots (31.39/air-layer) was noted with G_6 (IBA + NAA 7500 ppm each), which was significantly higher than rest of the treatments of both PGRs. Among the two growth regulators, IBA performed significantly better result as compared to NAA at any concentration.

Maximum number of secondary roots (22.90/air layer) was produced by rooting media M_2 (Moss grass + coco-peat) which was significantly superior to M_1 (Moss grass).

Treatment combination G_6M_2 (IBA+NAA 7500 ppm each with Mossgrass+coco-peat) resulted in significantly higher number of secondary roots over rest of the treatment combinations, the value being 34.08/air-layer. Minimum number of secondary roots (10.78/air-layer) recorded under the treatment combination G_0M_1.

6. Length of secondary roots

Growth regulator IBA and NAA applied alone or in combination at both concentrations significantly increased the length of secondary roots per air-layer over control. Among the treatments of both growth regulators, the maximum length of 2.551 cm of secondary roots were obtained with G_6 (IBA + NAA 7500 ppm each) as compared to 0.842 cm length of

secondary roots in control. The data further indicates that combination of both growth regulators applied at highest concentration (7500 ppm each) resulted in significantly longer secondary roots as compared to its lower concentration when applied alone or in combination.
Rooting media M_2 (Moss grass + coco-peat) significantly improved the length of secondary roots over M_1 (Moss grass).
Among the treatment combinations, highest length of secondary roots (2.858 of the treatment combinations cm) was recorded under treatment G_6M_2 (IBA+NAA 7500 ppm each with Moss grass+coco-peat), which was statistically superior over rest. The lowest length of secondary roots (0.765 cm) was recorded under treatment (G_0M_1).

7. Diameter of secondary roots
Diameter of secondary roots was significantly affected by plant growth regulator and rooting media. However, the effect of their interaction on this parameter was not found significant. All the concentrations of IBA and NAA applies alone or in combination significantly increased the diameter of secondary roots over control. The diameter of secondary roots increased significantly with the increase in concentration under both IBA and NAA when applied separately or in jointly. Application IBA + NAA at 7500 ppm each gave significantly maximum diameter (0.673 mm) of secondary roots compared to rest of the treatments of both growth regulators. In between the two growth regulators, IBA gave better results as compared to NAA.
Significantly more diameter of secondary roots (0.530 mm) was recorded in rooting media M_2 (Moss grass + cock-peat) than M_1 (Moss grass + coco-peat).
Treatment combination of growth regulators and rooting media did not exhibit any significant effect on diameter of secondary roots of air-layers. However, maximum diameter of secondary roots (0.694 mm) was recorded under the combination G_6M_2 (IBA+NAA 7500 ppm each with Moss grass+coco-peat) while minimum under G_0M_1.

8. Dry weight of roots
The growth regulators and rooting media had significant effect on dry weight of roots per air-layer individually but not jointly. All the treatments of both IBA and NAA applied singly or jointly at both 5000 and 7500 ppm significantly increased the dry weight of roots per air layer over control. Dry weight of roots increased significantly with the increase in concentration under both IBA and NAA. Application of IBA+NAA at 7500 ppm each significantly produced the maximum dry weight of roots (0.692 g) among all the treatments of both IBA and NAA. In between the two growth regulators, IBA produced more dry weight of primary roots than NAA.
Rooting media M_2 (Moss grass + coco-peat) resulted in significantly highest dry weight of roots (0.564 g) over M_1 (Moss grass).
Growth regulators and rooting media did not interact to each other in respect of this character. However, maximum dry weight of roots (2.93 g) was obtained from the treatment combination G_6M_2 (IBA+NAA 7500 ppm each with Moss grass+coco-peat) while minimum from G_0M_1 (control with Moss grass).

9. Success in rooting percentage of air layers
The different concentrations of both PGR and different rooting media affected success in rooting percentage of air-layers significantly. Furthermore, the interaction of experimental variables produced significant variation in the success in rooting percentage of air-layers.
The success percent of air-layers increased significantly with the increase in concentrations under both IBA and NAA when applied alone or in combination. The rooting

B. Growth studies of air layers
1. Survival percentage
all the concentrations of both growth regulators IBA and NAA significantly enhanced the survival percentage of air-layers over control when applied alone or in combination. Results further indicated that the growth regulator IBA at each concentration performed better in respect of increasing the survival percent of air layers than the corresponding concentration of NAA. Survival percentage of air layers increased significantly with the increase in concentration under both IBA and NAA applied alone or in combination. Thus, the highest survival of air layer (72.66%) was annexed with G_6 (IBA + NAA 7500 ppm each) whereas the lowest survival of air layers (24.78%) was noted in the case of control (0 ppm IBA and NAA).
Among the two rooting media, M_2 (Moss grass + coco-peat) significantly improved the survival percentage of air layering over M_1 (Moss grass).
Maximum survival of air layers (74.39%) was obtained from the treatment combination G_6M_2 (IBA+NAA 7500 ppm each with Moss grass+coco-peat), which gave significantly higher success in air layers than the rest of the treatment combinations.

2. Number of new branches
Number of new branches per air-layer was significantly influenced by the main effects of plant growth regulators and rooting media but not by their interaction. Results indicate that all the treatments of both IBA and NAA when applied alone or in combination at any concentrations significantly increased the number of branches per air-layer over control. Application of both IBA and NAA alone or in combination at increasing concentration opto 7500 ppm increased the number of branches per air-layer. Furthermore, combined application of both growth regulators was also more advantageous over their individual application. Accordingly, the maximum number of branches per air-layer (6.83) was obtained from the G_6 (IBA + NAA 7500 ppm each). In between the two growth regulators, IBA gave significantly better results as compared to NAA in respect of this growth character.
The number of branches per air-layer was significantly higher in M_2 (Moss grass + coco-peat) than that recorded under M_1 (Moss grass).
Interaction between growth regulator and rooting media had failed to affect the number of new branches per air layer. However, maximum branches (6.83/air-layer) was counted under the treatment G_6M_2 (IBA+NAA 7500 ppm each with Moss grass+coco-peat) and the minimum (2.04/air-layer) under G_0M_1.

3. Length of shoot
The growth regulators and rooting media had significant effect on length of shoot individually but not jointly. All the treatments of both IBA and NAA applied singly or jointly at both 5000 and 7500 ppm significantly increased the length of shoot over control. Length of shoot increased significantly with the increase in concentration under both IBA and NAA. Application of IBA+NAA at 7500 ppm each significantly produced the maximum shoot length (11.33 cm) among all the

treatments of both IBA and NAA. In between the two growth regulators, IBA produced longer shoot than NAA.

Rooting media M_2 (Moss grass + cock-peat) resulted in significantly longest shoot (8.83 cm) over M_1 (Moss grass).

Growth regulators and rooting media did not interact to each other in respect of this character. However, maximum length of shoot (11.86 cm) was obtained from the treatment combination G_6M_2 (IBA+NAA 7500 ppm each with Moss grass+coco-peat) while minimum from G_0M_1 (Control with Moss grass), the value being 3.74 cm.

Net profit and benefit cost ratio

The economics of different treatments is usually a deciding factor for its adoption by the farmers for commercial crop production. It is therefore, of wide interest to calculate the economic effect of various treatments on rooting and survival of guava air layers.

Among the various treatments, G_2M_2 (IBA 7500 ppm with Moss grass+coco-peat) has proved most economical on the basis of survival of air-layers. It is followed by G_6M_2 (IBA+NAA 7500 ppm each with Moss grass+coco-peat) and G_4M_2 (NAA 7500 ppm with Moss grass+coco-peat).

Treatment G_6M_2 has secured the highest net return (Rs. 2482.60) followed by G_2M_2 (Rs. 2334.40) and G_6M_1 (Rs. 2328.80). But, the treatment G_2M_2 gave highest B:C ratio (6.12) closely followed by G_6M_2 (6.04) and G_4M_2 (5.86).

Conclusion

After critical consideration of data, it is concluded that:

1. Among the different treatments of growth regulators, IBA+NAA @ 7500 ppm each showed the greatest improvement in all the root and growth characters such as callusing, rooting and survival of air layering of guava.
2. Among the two-rooting media, M_2 (Moss grass+coco-peat) proved significantly better over M_1 (Moss grass) for rooting and survival of guava air layers.
3. Treatment combination of growth regulators IBA+NAA @ 7500 ppm each and rooting media Moss grass+coco-peat was found significantly superior to rest of the treatment combinations in respect of most of the root and growth parameters and net profit point of view.

Table 1: Effect of plant growth regulators and rooting media on callus formation (cm)

Rooting media	Growth regulators							Mean
	G_0	G_1	G_2	G_3	G_4	G_5	G_6	
M_1	0.311	0.483	0.707	0.435	0.630	0.537	0.880	0.569
M_2	0.456	0.532	0.935	0.489	0.689	0.736	1.016	0.693
Mean	0.383	0.507	0.821	0.462	0.660	0.636	0.948	0.631
		Growth regulators (G)		Rooting media (M)		Interaction (G×M)		
S.E. (m)		0.025		0.016		0.035		
C.D. (at 5%)		0.072		0.047		NS		

Table 2: Effect of plant growth regulators and rooting media on number of primary roots per air-layer

Rooting media	Growth regulators							Mean
	G_0	G_1	G_2	G_3	G_4	G_5	G_6	
M_1	3.32	5.66	10.78	4.70	7.88	8.98	14.16	7.92
M_2	4.42	8.15	13.35	6.36	10.22	11.75	16.85	10.16
Mean	3.87	6.91	12.07	5.53	9.05	10.36	15.50	9.04
		Growth regulators (G)		Rooting media (M)		Interaction (G×M)		
S.E. (m)		0.217		0.142		0.307		
C.D. (at 5%)		0.632		0.414		NS		

Table 3: Effect of plant growth regulators and rooting media on length of primary root per air-layer (cm)

Rooting media	Growth regulators							Mean
	G_0	G_1	G_2	G_3	G_4	G_5	G_6	
M_1	0.74	1.83	3.20	1.48	2.40	3.14	4.13	2.42
M_2	1.84	3.50	4.53	2.26	3.57	4.15	4.99	3.55
Mean	1.29	2.66	3.86	1.87	2.98	3.65	4.56	2.98
		Growth regulators (G)		Rooting media (M)		Interaction (G×M)		
S.E. (m)		0.070		0.046		0.099		
C.D. (at 5%)		0.204		0.133		0.288		

Table 4: Effect of plant growth regulators and rooting media on diameter of primary root per air-layer (mm)

Rooting media	Growth regulators							Mean
	G_0	G_1	G_2	G_3	G_4	G_5	G_6	
M_1	1.602	1.974	2.492	1.764	2.066	2.409	2.703	2.144
M_2	1.865	2.223	2.748	2.058	2.302	2.530	3.286	2.430
Mean	1.733	2.098	2.620	1.911	2.184	2.470	2.995	2.287
		Growth regulators (G)		Rooting media (M)		Interaction (G×M)		
S.E. (m)		0.040		0.026		0.056		
C.D. (at 5%)		0.116		0.076		0.164		

Table 5: Effect of plant growth regulators and rooting media on number of secondary roots per air-layer

Rooting media	Growth regulators							Mean
	G_0	G_1	G_2	G_3	G_4	G_5	G_6	

M_1	10.78	15.48	25.37	13.74	18.98	22.33	28.71	19.34
M_2	13.72	18.49	29.82	16.86	21.25	26.10	34.08	22.90
Mean	12.25	16.99	27.59	15.30	20.12	24.22	31.39	21.12
		Growth regulators (G)		**Rooting media (M)**		**Interaction (G×M)**		
S.E. (m)		0.327		0.214		0.462		
C.D. (at 5%)		0.950		0.622		1.344		

Table 6: Effect of plant growth regulators and rooting media on length of secondary root per air-layer (cm)

Rooting media	**Growth regulators**							**Mean**
	G_0	**G_1**	**G_2**	**G_3**	**G_4**	**G_5**	**G_6**	
M_1	0.765	1.086	1.922	0.848	1.539	1.727	2.244	1.447
M_2	0.919	1.408	2.190	1.175	1.748	2.076	2.858	1.768
Mean	0.842	1.247	2.056	1.011	1.644	1.901	2.551	1.607
		Growth regulators (G)		**Rooting media (M)**		**Interaction (G×M)**		
S.E. (m)		0.046		0.030		0.065		
C.D. (at 5%)		0.133		0.087		0.188		

Table 7: Effect of plant growth regulators and rooting media on diameter of secondary root per air-layer (mm)

Rooting media	**Growth regulators**							**Mean**
	G_0	**G_1**	**G_2**	**G_3**	**G_4**	**G_5**	**G_6**	
M_1	0.313	0.413	0.581	0.370	0.472	0.558	0.653	0.480
M_2	0.375	0.477	0.606	0.446	0.510	0.598	0.694	0.530
Mean	0.344	0.445	0.593	0.408	0.491	0.578	0.673	0.505
		Growth regulators (G)		**Rooting media (M)**		**Interaction (G×M)**		
S.E. (m)		0.009		0.006		0.013		
C.D. (at 5%)		0.027		0.018		-		

Table 8: Effect of plant growth regulators and rooting media on dry weight of roots per air-layer (g)

Rooting media	**Growth regulators**							**Mean**
	G_0	**G_1**	**G_2**	**G_3**	**G_4**	**G_5**	**G_6**	
M_1	0.336	0.445	0.621	0.415	0.489	0.577	0.665	0.507
M_2	0.389	0.509	0.679	0.467	0.531	0.653	0.719	0.564
Mean	0.362	0.477	0.650	0.441	0.510	0.615	0.692	0.535
		Growth regulators (G)		**Rooting media (M)**		**Interaction (G×M)**		
S.E. (m)		0.017		0.011		0.024		
C.D. (at 5%)		0.049		0.032		NS		

Table 9: Effect of plant growth regulators and rooting media on rooting percentage

Rooting media	**Growth regulators**							**Mean**
	G_0	**G_1**	**G_2**	**G_3**	**G_4**	**G_5**	**G_6**	
M_1	23.42	46.53	68.75	39.85	60.34	67.75	77.66	54.90
M_2	33.25	54.23	76.44	52.47	68.66	71.85	82.68	62.80
Mean	28.34	50.38	72.60	46.16	64.50	69.80	80.17	58.85
		Growth regulators (G)		**Rooting media (M)**		**Interaction (G×M)**		
S.E. (m)		0.89		0.58		1.26		
C.D. (at 5%)		2.59		1.70		3.67		

Table 10: Effect of plant growth regulators and rooting media on survival percentage

Rooting media	**Growth regulators**							**Mean**
	G_0	**G_1**	**G_2**	**G_3**	**G_4**	**G_5**	**G_6**	
M_1	24.61	44.17	65.90	34.53	58.40	63.98	70.92	51.79
M_2	24.95	48.49	69.76	42.88	61.25	64.22	74.39	55.14
Mean	24.78	46.33	67.83	38.71	59.83	64.10	72.66	53.46
		Growth regulators (G)		**Rooting media (M)**		**Interaction (G×M)**		
S.E. (m)		0.81		0.53		1.15		
C.D. (at 5%)		2.35		1.54		3.33		

Table 11: Effect of plant growth regulators and rooting media on number of new branches

Rooting media	**Growth regulators**							**Mean**
	G_0	**G_1**	**G_2**	**G_3**	**G_4**	**G_5**	**G_6**	
M_1	2.04	4.27	6.14	3.58	4.77	4.95	6.48	4.60
M_2	3.40	5.12	6.31	4.60	5.96	5.46	6.83	5.38
Mean	2.72	4.69	6.22	4.09	5.37	5.20	6.66	4.99
		Growth regulators (G)		**Rooting media (M)**		**Interaction (G×M)**		
S.E. (m)		0.15		0.10		0.22		

C.D. (at 5%)	0.45	0.29	NS	

Table 12: Effect of plant growth regulators and rooting media on length of shoot per plant (cm)

Rooting media	Growth regulators							Mean
	G_0	G_1	G_2	G_3	G_4	G_5	G_6	
M_1	3.74	6.32	9.63	5.68	7.65	8.90	10.80	7.53
M_2	6.00	7.71	10.65	6.89	8.86	9.82	11.86	8.83
Mean	4.87	7.02	10.14	6.28	8.26	9.36	11.33	8.18
		Growth regulators (G)		Rooting media (M)		Interaction (G×M)		
S.E. (m)		0.23		0.15		0.32		
C.D. (at 5%)		0.67		0.44		NS		

Table 13: Treatment wise cost and return of air layers of guava on the basis of their survival

Treatments	Survival percentage	Total cost/100 air layers (Rs.)	Cost/survival plant (Rs.)	Gross profit per 100 air layers (Rs.)	Net return per 100 air layers (Rs.)	Benefit:Cost ratio
G_0M_1	24.61	396	16.09	984.40	588.40	2.49
G_0M_2	24.95	381	15.27	998.00	617.00	2.62
G_1M_1	44.17	446	10.10	1766.80	1320.80	3.96
G_1M_2	48.49	431	8.89	1939.60	1508.60	4.50
G_2M_1	65.90	471	7.15	2636.00	2165.00	5.60
G_2M_2	69.76	456	6.54	2790.40	2334.40	6.12
G_3M_1	34.53	421	12.19	1381.20	960.20	3.28
G_3M_2	42.88	406	9.47	1715.20	1309.20	4.22
G_4M_1	58.40	433	7.41	2336.00	1903.00	5.39
G_4M_2	61.25	418	6.82	2450.00	2032.00	5.86
G_5M_1	63.98	471	7.36	2559.20	2088.20	5.43
G_5M_2	64.22	456	7.10	2568.80	2112.80	5.63
G_6M_1	70.92	508	7.16	2836.80	2328.80	5.58
G_6M_2	74.39	493	6.63	2975.60	2482.60	6.04

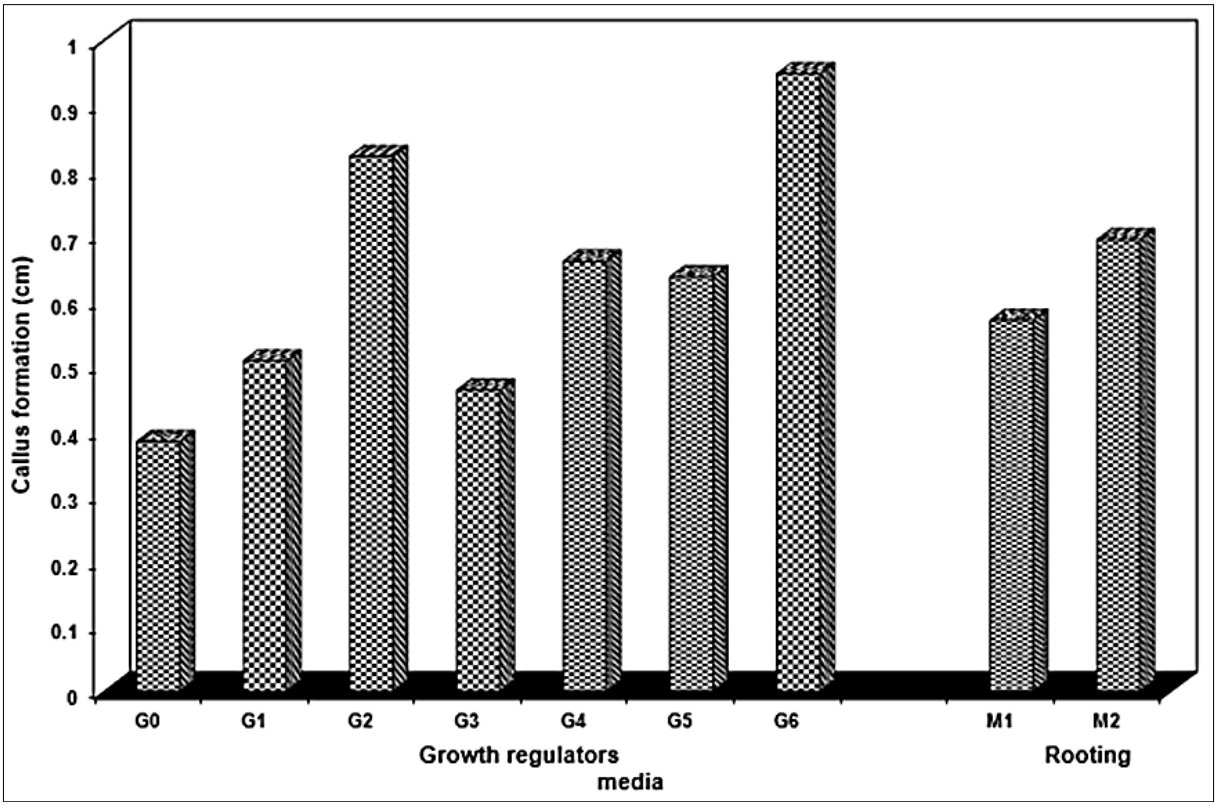

Fig 1: Effect of PGR and rooting media on callusing of air layers of guava

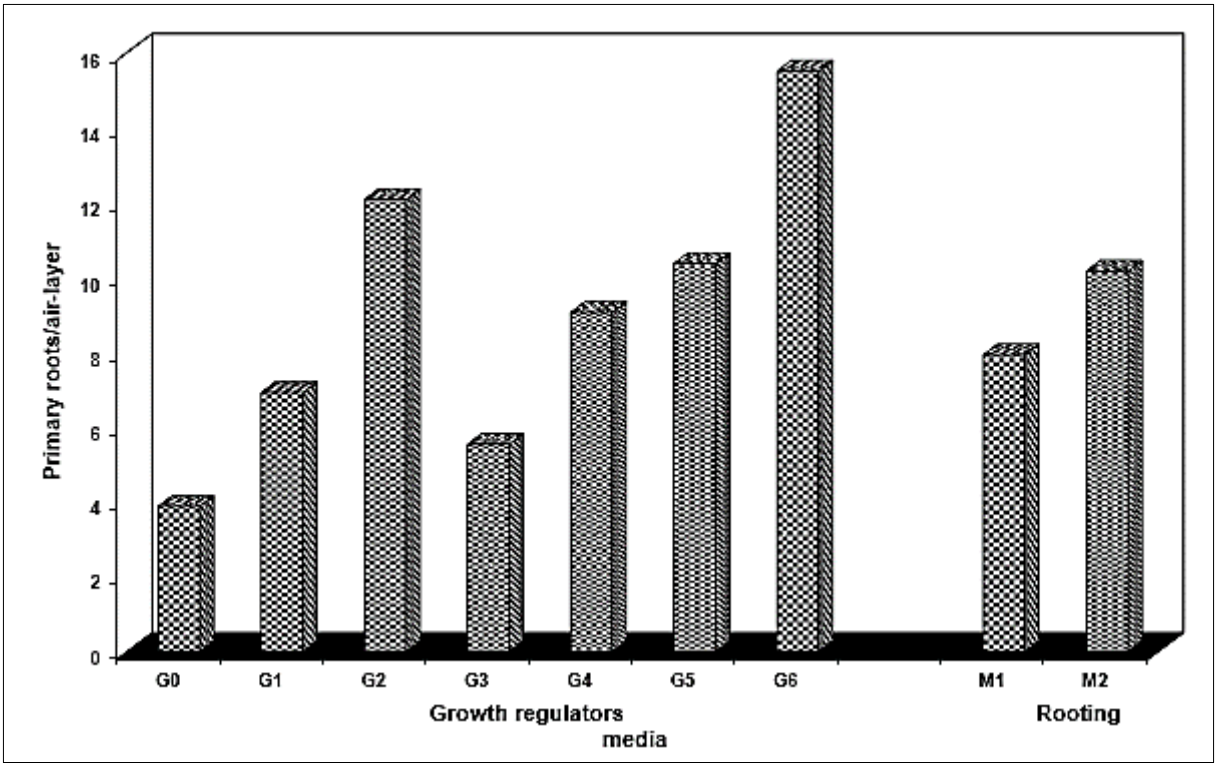

Fig 2: Effect of PGR and rooting media on number of primary roots per air layers of guava

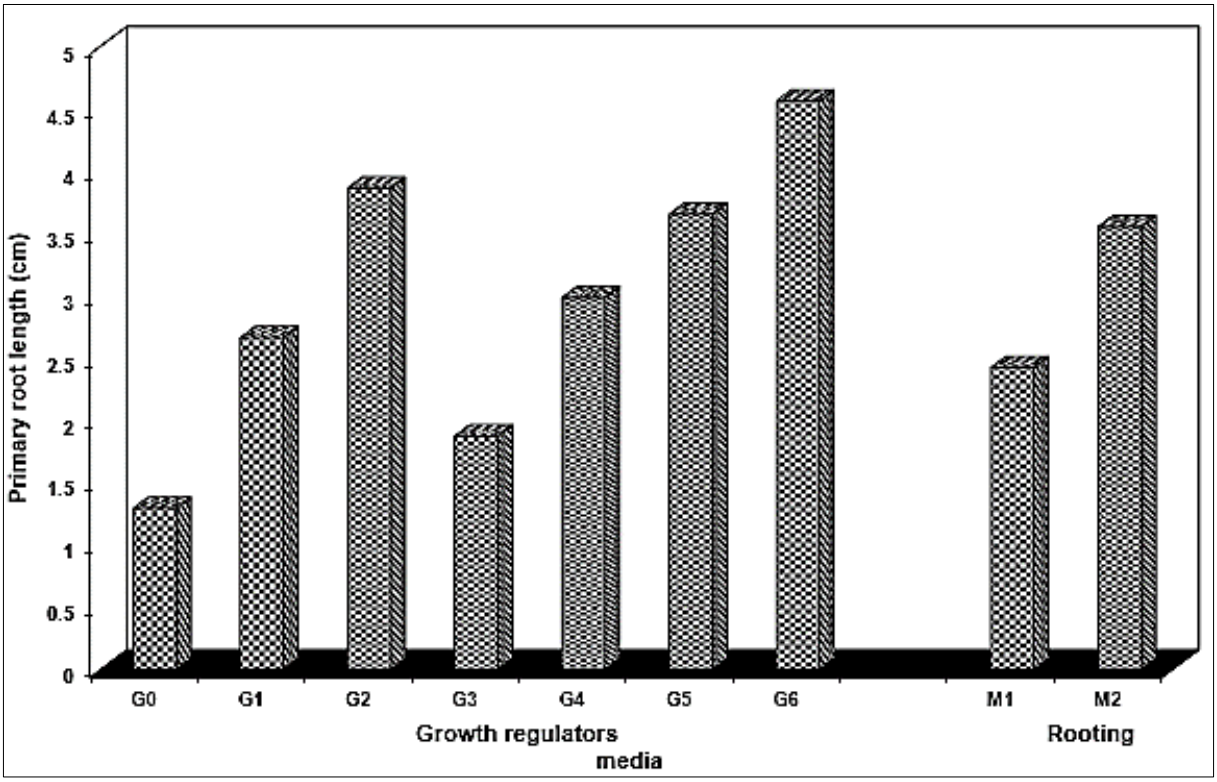

Fig 3: Effect of PGR and rooting media on length of primary root per air layers of guava

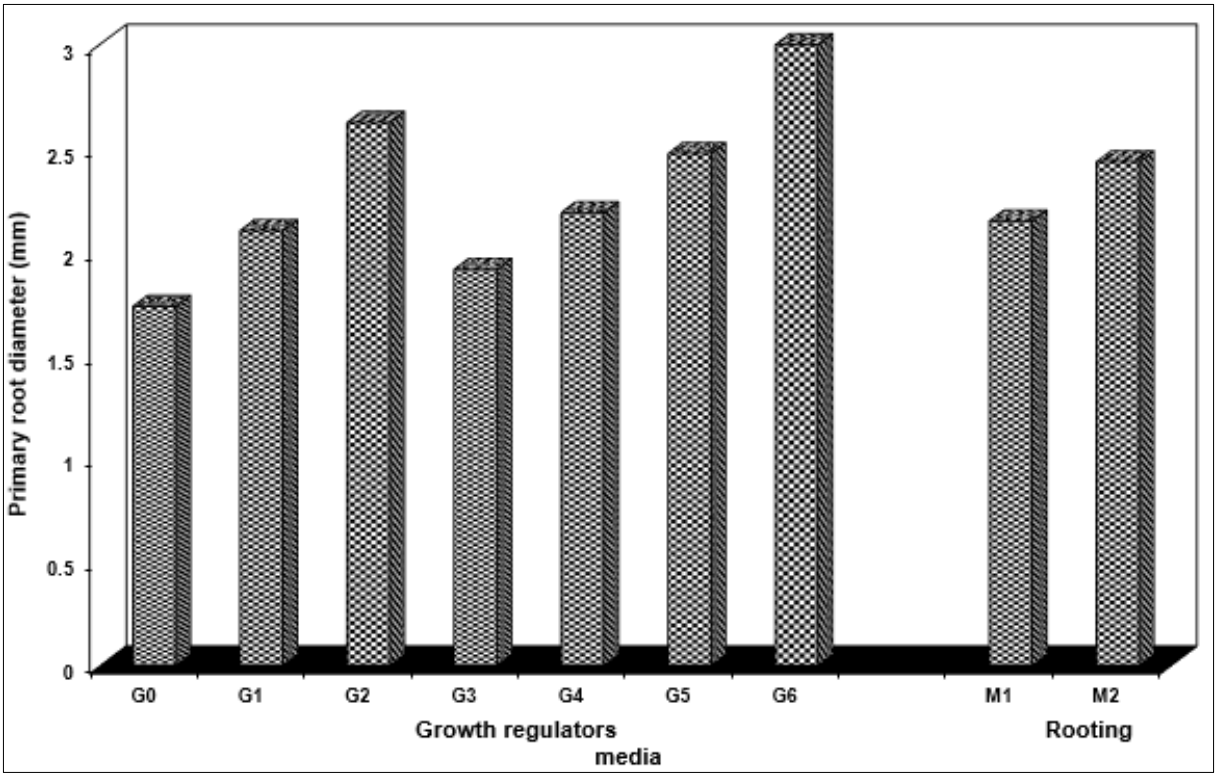

Fig 4: Effect of PGR and rooting media on diameter of primary root per air layers of guava

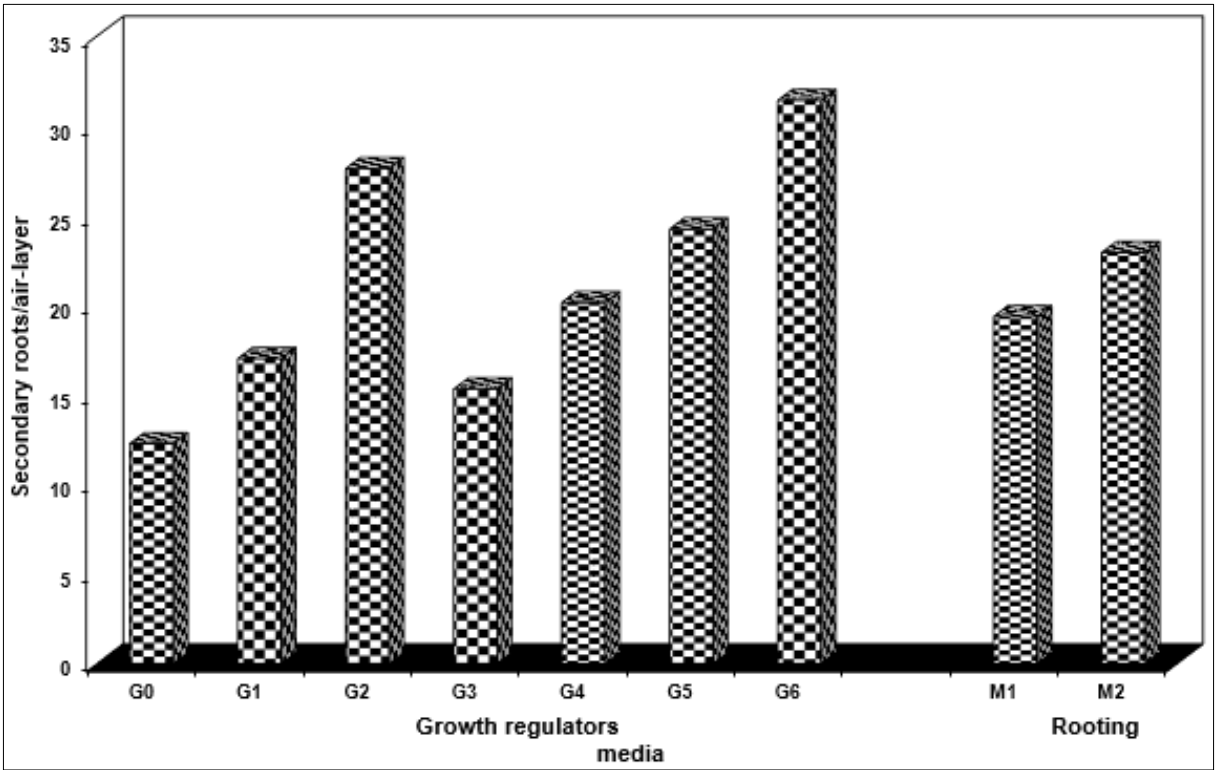

Fig 5: Effect of PGR and rooting media on number of secondary root per air layers of guava

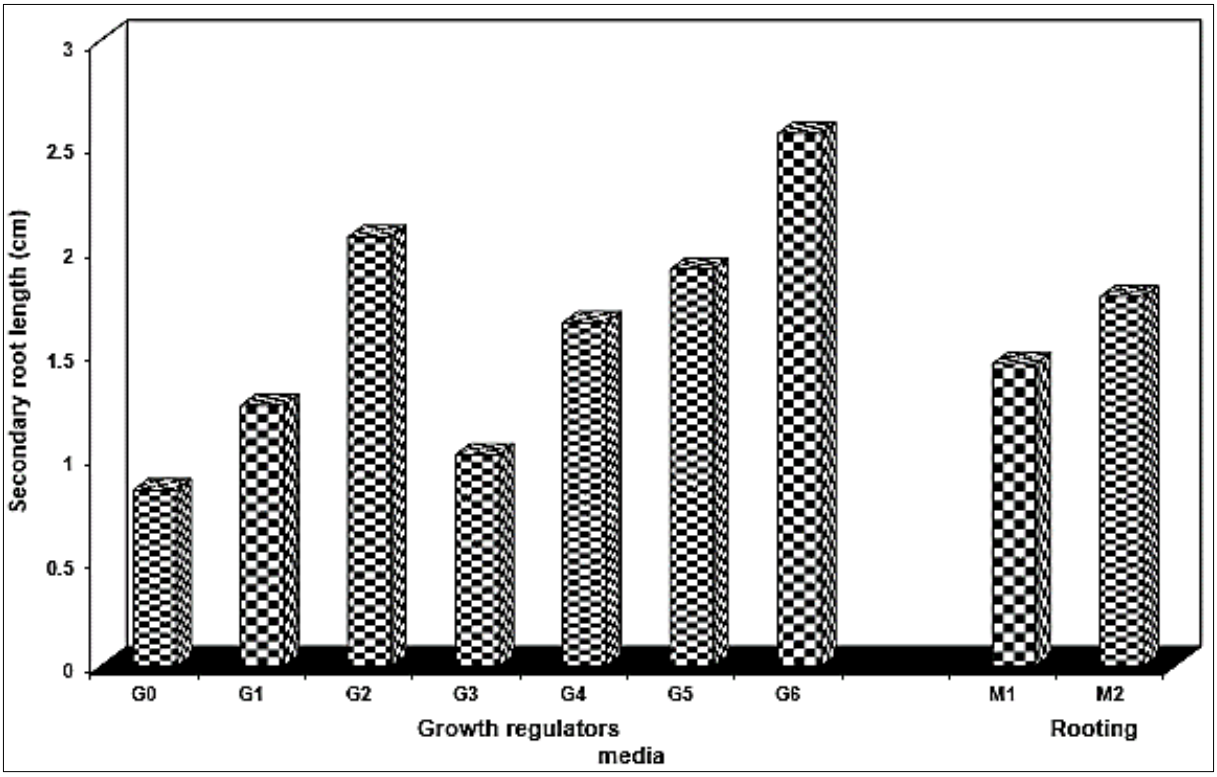

Fig 6: Effect of PGR and rooting media on length of secondary root per air layers of guava

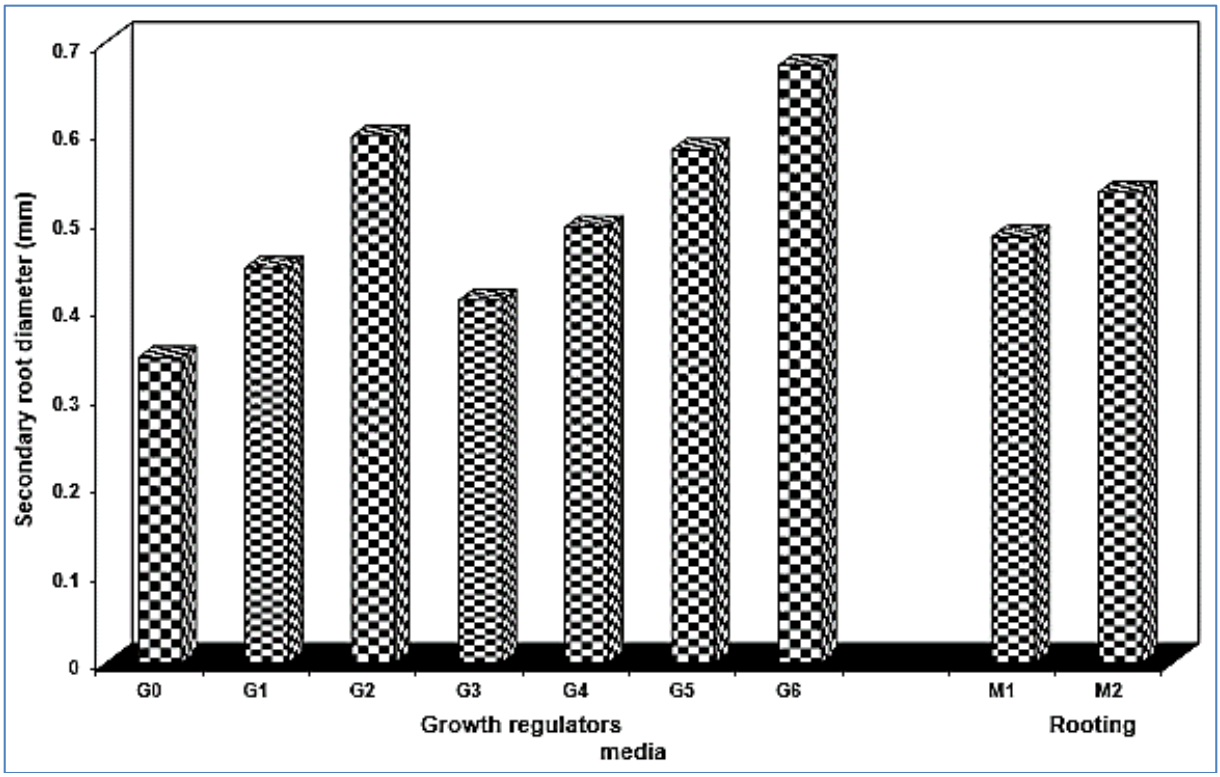

Fig 7: Effect of PGR and rooting media on diameter of secondary root per air layers of guava

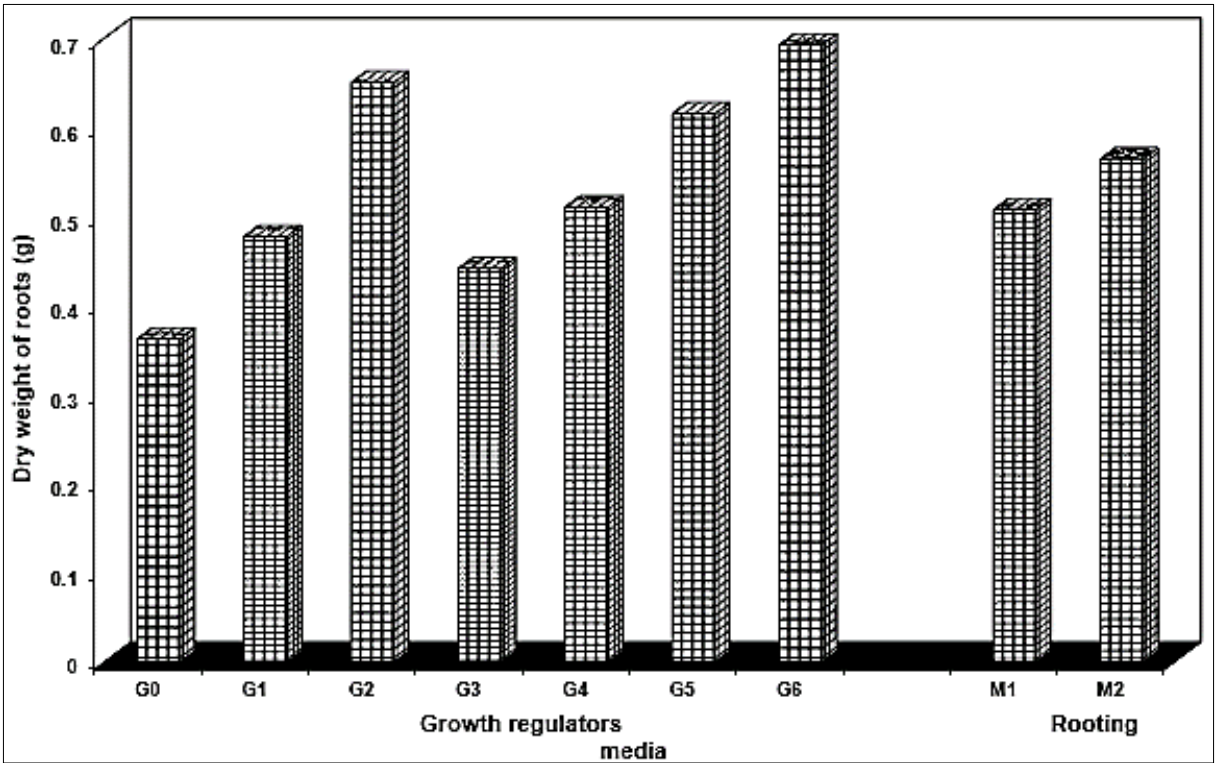

Fig 8: Effect of PGR and rooting media on dry weight of roots per air layers of guava

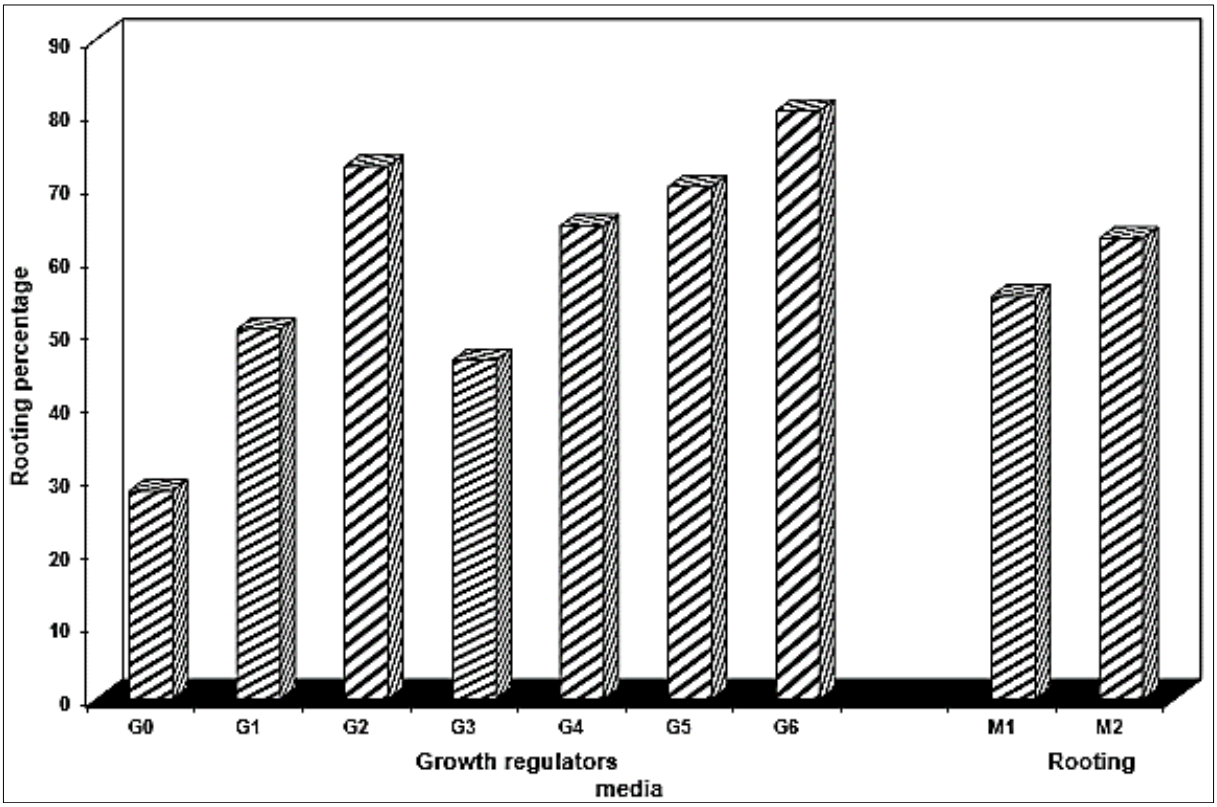

Fig 9: Effect of PGR and rooting media on rooting percentage

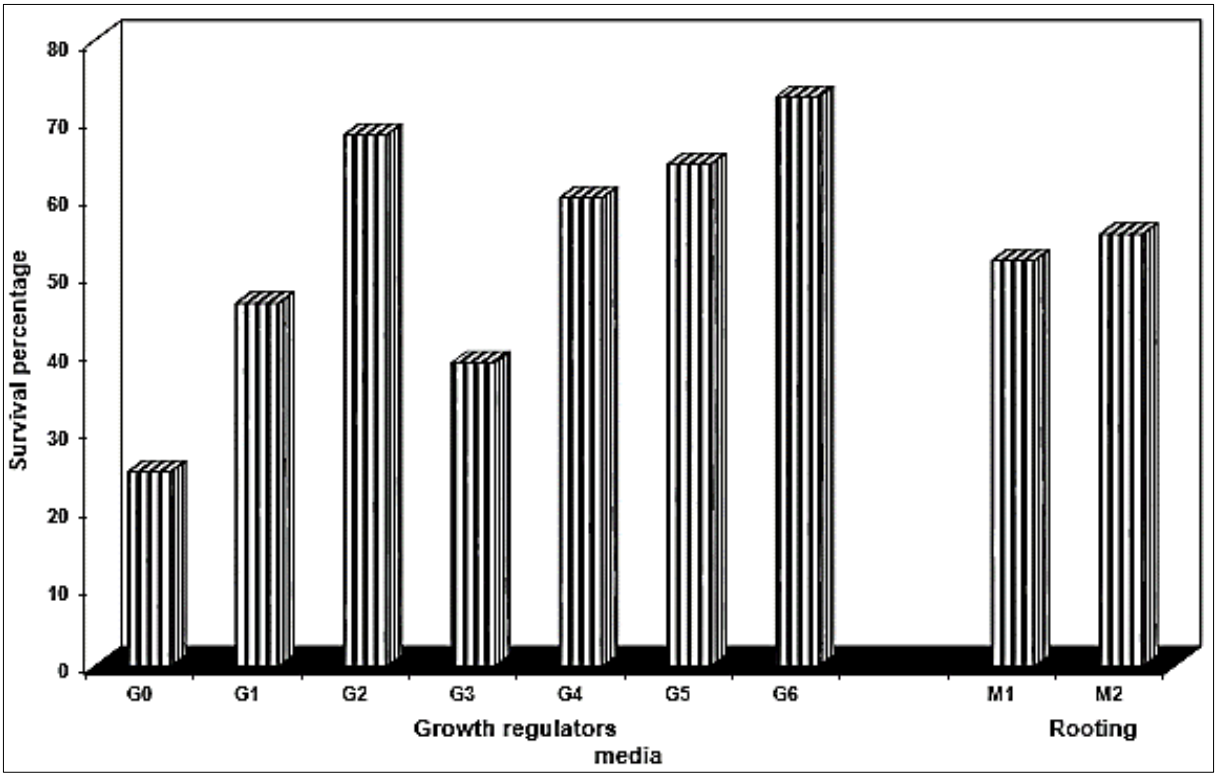

Fig 10: Effect of PGR and rooting media on suvival percentage of air layers of guava

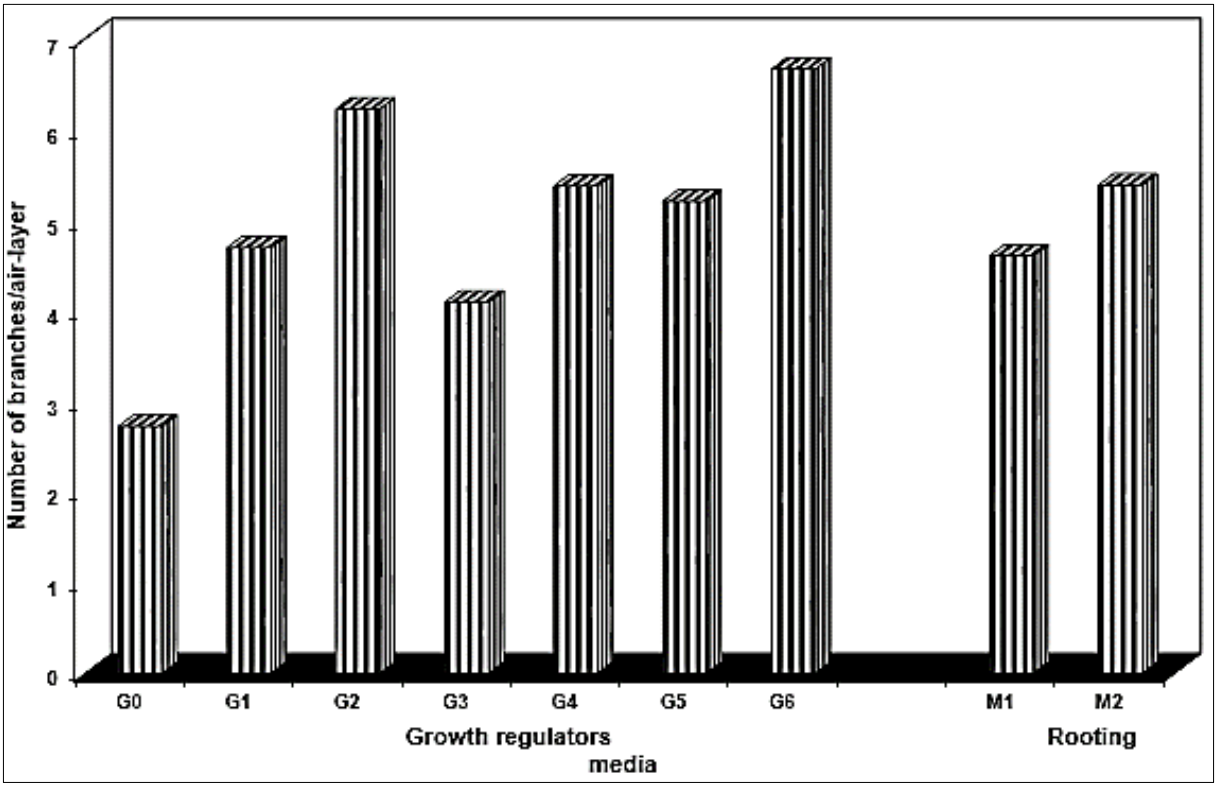

Fig 11: Efect of PGR and rooting media on number of branches per air layers of guava

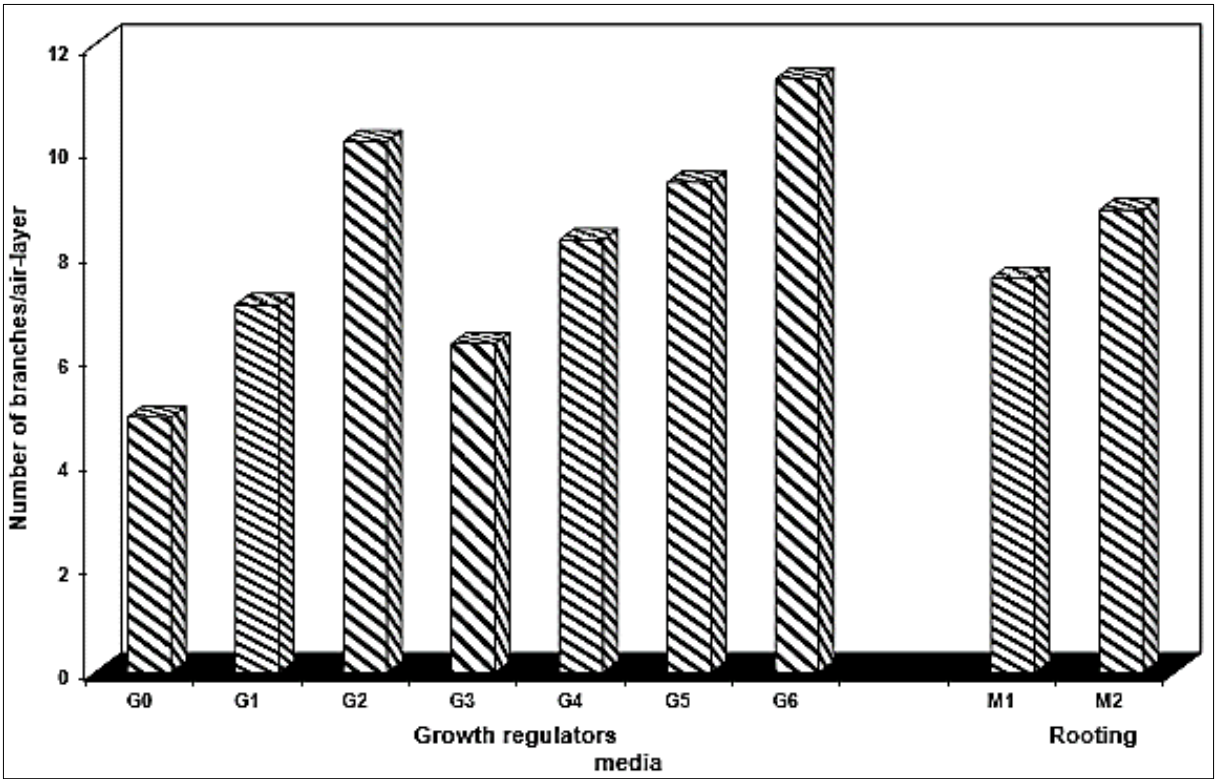

Fig 12: Effect of PGR and rooting media on length of shoot per air layer of guava

References

1. Albany VNR, Vilchez PJA, Viloria ZJ, Castro C, Gadea LJ. Effect of vegetative propagation of guava using air layering technique. Agronomia Tropical (Maracay). 54(1):63-73. Inter academicia. 2004; 5:278-281.
2. Athani SI, Swamy GSK, Patil PB. Effect of different pre treatments on rooting of air layers in guava cv. Sardar. Karnataka, J Agri. Sci. 2001; 14(1):199-200.
3. Bhagat BK, Jain BP, Singh C, Chaudhary BM. Propagation of guava (*Psidium guajava* L.) by ground layering. J. Res. Birsa. Agric. Univ. 1998; 10(2):209-210.
4. Bhujbal BG. Effective concentration of IBA in the air-layering of guava. Res. J. Mahatma Phule Agric. Univ. 1972; 3(1):83-86.
5. Burstorm HC. The influence of hetro-auxin on cell growth and root development. Ann. Agril. Cell Sweden. 1942, 10-19.
6. Cooper WC. Rooting of citrus cuttings with synthetic substance. Florida State Hort. Sci. 1940; 53:174-177.
7. Gardner VR. Basic Horticulure. The Mcmillan Company, New York, 1951, 312p.
8. Gautheret RJ. Investigation of root formation in the tissue of *Halianthus tuberoses* cultured in vitra. Amer. J. Bot. 1969; 56(7):708-17.
9. Haising BE. Influence of Inole-3 acetic acid of incorporation of 14, euridine by adventitious root primordial in brittle willow. Hort. Gaz. 1971; 132(4):263-67.
10. Kakon AJ, Haque MA, Mohisn MG. Effect of three growth regulators on mound layering in the three varieties of guava. SAARC Journal of Agriculture. 2008; 6(2):39-47.
11. Krishnamoorthy HN. Plant growth substances included application in agriculture. Tata Mc. Graw Hill Publishing Company Ltd., New Delhi, 1981.
12. Kunal MM. Effect of etiolation and plant growth substances on rooting and survival of air-layers of guava. Indian Journal of Horticulture. 2005; 62(3):290-292.
13. Mankar JM, Wankhade RS, Bhople SR. Effect of some plant growth regulators on rooting and survival of layerage in guava. Annals of Plant Physiology. 2009; 23(2):192-195.
14. Manna S, Mathew B, Ghosh SN. Air layering in guava cultivars. Journal of Inter acedemicia. 2001; 5:278-281.
15. Mukhtar A, Iftikhar A, Laghari MN, Hidayatullah. Effect of growth regulators on rooting in softwood cuttings of guava under mist condition. Sarhad J. Agric. 1998; 14(5):423-425.
16. NHB. National Horticulture database. National Horticulture Board. Govt. of India, Gurgaon, India, 2015.
17. Oliman, Van du Neer, Pierik RLM, Roest S. Effect of sugar auxin and light on adventitious root formation in isolated stem explants of Pascolus and Rhododendron. Med. Facult. Land Bouw. Weten Genet. 1971; 36(1):511-18.
18. Ram M, Majumdar PK. Propagating litchi through stooling. Indian Hort. 2000; 25:20-21.
19. Ramteke NH, Verma RM, Damke MM, Patil VS, Panchbhai DM. Studies on propagation in guava (*Psidium guajava* L.) under Akola conditions. PKV Research Journal. 1998; 22(2):180-182.
20. Rathore DS. Studies on the propagation of guava by stoo0ling. Punjab Hort. J. 2006; 24(174):75-78.
21. Rathore TR. Studies on the effect of different rooting media and various concentrations of Indole butyric aicd on the rooting, growth and survival of air-layers of guava. (Unpublished) Thesis submitted to JNKVV, Jabalpur for the degree of M.Sc., Ag., 1982.
22. Rymbai H, Reddy GS. Effect of IBA, time of layering and rooting media on air-layers and plantlets survival

under different growing nursery conditions in guava. Indian Journal of Horticulture. 2010; 67:99-104.
23. Sarkar, Animesh, Bikash Ghosh. Air layering in guava cv L-49 as affected by plant growth regulators, wrappers and time of operation. Environ. Ecol. 2006; 24(3A):820-823.
24. Sharfuddin AFM, Hussain A. Effect of growth regulator, rooting and wrapping materials on the success of air-layering in litchi. Bangladesh Hort. 1973; 1(2):44-51.
25. Singh A. Propagation principles and techniques: Fruit physiology and production. Kalyani publishers, New Delhi Ludhiana, 1995, 132-162p.
26. Singh BP, Singh IJ. Studies on the effect of source and plant growth regulators on the performance of air layers of guava (*Psidium guajava* Linn). Balwant Vidyapeeth Journal of Agricultural and Scientific Research. 1970; 12(15):12-15.
27. Singh DK, Bhuj BD. Response of air layering of guava to paclobutrazol and coloured poly wrappers. Agric. Sci. Digest. 2000; 20(3):171-173.
28. Singh, Mahabir. Response of plant growth regulators and wrappers on air-layering of guava (*Psidium guajava* L.). Advances in Plant Sciences. 2002; 15:153-157.
29. Singh, Mahabir. Response of plant growth regulators and wrappers on air-layering of guava (*Psidium guajava* L.). Adv. Pl. Sci. 2002; 15(1):153-157.
30. Singh P, Chandrakar J, Singh AK, Jain V, Agrawal S. Effect on rooting in Guava cv. Lucknow-49 through PGR and organic media under Chhattisgarh condition. Acta Horiculture, 2007, 735.
31. Skoog. Growth and organ formation in tobacco tissue culture. Amar. J. Bot. 1944; 31:19-24.
32. Sukhotskaya SG. Propagation of the sour cherry cultivar Lyubskaya by stooling. Sadovodstvo, 11: 39-43 [Cited from Hort. Abstr. 1982; 54:1635, 1984.
33. Tyagi SK, Patel RM. Effect of growth regulators on rooting of air layering of guava (*Psidium guajava* L.) cv. Sardar Guava. Orissa J. Hort. 2004; 32(1):58-62.
34. Usachev V. Effect of nutritional conditions on the growth and chemical composition of source plants and on the rooting of stem cutting. Report of East Matting Res. Sta. 1991; 55:108-1.41.
35. Verma AN, Shrivastava DC, Raj K, Sharma PK. Effect of plant regulator on air layers in mango and guava, 1971.
36. Vilchez J, Albany N, Martinez LA, María, Casassa-Padrón. Effect of auxins on propagation through air layering of guava tolerant to nematodes of *Meloidogyne* spp. Rev. Fac. Agron. (LUZ), 2011, 28.