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VEGETATIVE PROPAGATION OF GUAVA (*PSIDIUM GUAJAVA* L.) THROUGH AIR LAYERING: A REVIEW

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Abstract

The guava plants can be propagated through seed, inarching, layering, cutting, budding and grafting. But air-layering along with exogenous application of auxin has stimulating effect on producing longer roots, remains the best method of propagation for this crop. Growth regulator like IBA has been used to stimulate plant growth and specially root formation with better vigour in layering. The effects of auxins however are significantly influenced by environmental conditions, time and rooting media used. Therefore, this research was mainly conducted to find out the effects of various IBA concentration, time and rooting media on response and performance of rooting in air layering of Guava. In general, growth regulators *viz.*, IBA alone and in combination with rooting media *viz.*, Moss grass, Coco peat, and Moss grass + Coco peat is used in different time of layering *viz.*, June, July favoured rooting in air-layers. It is being revealed that High percentage of rooting and root characters of air layers of guava can be successfully achieved by exogenous application of IBA in June and July.

Key words: IBA, rooting media, time, air Layering,Guava.

Introduction

Guava (*Psidium guajava* L.), is the poor man's apple and "apple of tropics" belongs to the family Myrtaceae. Guava (*Psidium guajava* L. common guava) is a common tropical fruit cultivated in many tropical and subtropical regions 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. Guavas originated from an area thought to extend from Mexico, Central America, and northern South America. Although related species may also be called guavas, they belong to other species or genera, such as the "pineapple guava" *Accasellowiana*. It has gained considerable prominence owing to its hardy nature, prolific bearing, high vitamin C i.e., high nutri + tive value, easy availability at moderate price with pleasant aroma and good flavour of fruits. The main reasons for its popularity are prolific bearing nature and remunerative yields even without much care justifying its name as Poor man 2s apple (Singh, 2007). Guava is hardy, drought tolerant, high yield potential and diverse use of fruits also helps in developing a good ecological system in addition to improve the rural economy as well as nutritional standard to a greater extent (Rathore, 2001). The genus *Psidium* has about 150 shrubs and *P. guajava* is well-known and grown worldwide (Paull & Bittenbender, 2006). It is being cultivated in India on 2.04 lakh hectares area with an annual production of 22.70 lakh tonnes (Salaria and Salaria, 2013). According to the National Horticulture Board of India, guava ranks fourth among the commercially important fruits mango, banana and citrus so far as arid area and production of major fruits is concerned. India is the leading producer of guava in the world.

Guava is successfully propagated through sexual method and asexual methods such as cutting, grafting, budding and air layering. The seed propagation was wide spread earlier is now restricted to raising of rootstock material. The vegetative propagations by air layering are becoming more and more popular on account of their cheaper cost and easy method. They also have better success obtained. However, greater deal of variation in per cent success is observed in air layering. One of the causes for variation has been observed to be the age of shoots/trees used in air layering. The rooting ability of air layered shoots is decided by several factors that vary

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with the crops, cultivar and biochemical constituents of the clone (*viz.*, carbohydrates, nitrogen, sugars, starch, phenols, auxins levels etc.) and the climatic conditions prevailing in the season (*viz.*, temperature, relative humidity, rain fall etc.) of layering. All these factors should be at optimum level to attain better rooting of a guava layers. The growth parameters of the layers depend on the pre- condition shoots on mother plant, the speed and number of roots formation on layer and post separation environment to which the layer is exposed (Sharma *et al.*, 1975). This might be due to the congenial weather conditions prevailed during these months triggered cell activity resulted in early sprouting, number of sprouts and shoot length. In August month higher accumulation of Carbohydrates and C: N ratio, which readily served as a reservoir of food for new growth reflected in layers. Kunal Kumar and Syamal (2005) observed that the highest number of primary roots was produced using IBA 3,000 ppm treatment followed by NAA 2,000 ppm. High number of roots was recorded with IBA + NAA (1:1) at 2,000 ppm each. Etiolation along with exogenous application of auxin had stimulating effect on producing longer roots. The longer primary roots of 11.30 cm were obtained with 3,000 ppm of IBA followed by NAA at 2,000 ppm, each produced 9.17 cm long primary roots. Etiolation along with auxins treatment had marked influence on rooting of air layers.

Sharma *et al.*, (1991) described the influence of NAA or IBA at 5000, 7500 or 10000 ppm in lanolin paste applied at the time of ringing on 10 July, 25 July or 10 August. A significant increase was found in the percentage of layers rooted (75.55%) and the number, length, diameter and weight of roots. Air layering carried out on 10 July resulted in the-highest percentage success (67.70%) and total root Weight. Among the media, through no significant difference was found in respect to rooting percentage while the coffee husk gave the best result compared to other media used in the study. Rathore (2006) conducted an experiment of guava layering. He found that rooting was 100% in the treatments including compost, loamy soil and cow dung and 60-70% in saw dust. The mean number of primary roots was the highest in compost and lowest in saw dust. Effect of IBA, time of layering and rooting media on air-layers and plantlets survival under different growing nursery conditions inguava. Rymbai and Sathyanarayana, (2010) conducted an experiment in India, to evaluate the response of different rooting media on guava air-layers. Three different concentration of IBA *viz.,* 2000, 3000 and 4000 ppm were used in three time of layering *viz.*, 15th June, 15th July and 15th August with two rooting media *viz.*, sphagnum moss and coco peat. Among the rooting media, moist sphagnum moss produced highest rooting percentage and root characters. The survival of rooted air layers was found to be maximum with the treatment sphagnum moss and polyhouse conditions produced higher survival than open conditions after 45 days of detachment from the mother plants.

Air Layering

Guava propagates on seedling, raised from open pollinated seeds results in considerable variation in the size, shape, form and quality of fruits (Zamir *et al.*, 2003 and Mishra *et al.*, 2007) and evidently take longer time to reach to bearing stage when compared to vegetative propagated materials. There are several vegetative methods for multiplication of the quality stock in fruit trees. Traditional asexual propagation techniques have been hampered due to juvenile phase of longer duration, season reliance, long life span, and increased plant propagation material (Jaiswal and Amin 1992, Usman *et al*., 2014). In the modern times air layering propagation techniques using growth regulators during rainy seasons are being used to achieve more success.

Air layering is the most convenient method of propagation in litchi plants in our country (Bose and Mitra, 1990). In guava, two types of layering is commonly adopted viz., Air layering/ Marcottage and Mound/Stool layering. Among the vegetative methods of guava propagation, air layering with the help of growth substances (IBA, NAA) is a successful method of propagation (Tyagi and Patel, 2004).

Air layering have been found very successful in guava, litchi and many other fruit species, so it is easy and economic means of vegetative propagation. 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). This is a quick, efficient & simple, way to clone guava plants and could be the most inexpensive technique. 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 (Bhagat *et al.*, 1999, Singh and Bhuj, 2000. Tyagi and Patel, 2004, Sarkar and Ghosh, 2006 and Singh *et al.*, 2007).

Sharma *et al.*, 1975 reported that the growth parameters of the layers depends on the pre- condition shoots on mother plant, the speed and number of roots formation on layer and post separation environment to which the layer is exposed. It might be due to the congenial weather conditions that triggered cell activity resulted in early sprouting, number of sprouts and shoot length. The application of growth substances in accumulation of certain chemical substances at the base of cutting, may stimulate the meristem to divide quickly, and form roots. Kakon *et al.,* (2005) reported that growth characteristic like number of shoots and number of leaves was found highest in the guava layers severed by three cuts. The physiological state of branches, type of application, concentration of PGRs, the kind of auxin and media applied are significant aspects to consider when guava plants are propagated by air layering (Urdaneta *et al*., 2009). Sarkar and Ghosh (2006) evaluated the effects of IBA at 1000 and 2000 ppm on the performance of guava *cv.* L-49 in West Bengal, India. They reported IBA at 2000 ppm resulted in the best results in terms of number of primary and secondary roots, rooting success and survival percentage. Kakon *et al.,* (2008) concluded that different concentrations of growth regulators had significant effect on almost all parameters. IBA at 1200 ppm showed the best performance among the treatments in guava mound layering.

Effect of Time on air layering

The climate of the region plays a crucial and significant role in realizing better success rates with this method (Rymbai and Satyanarayana Reddy, 2010). In the present investigation results was found significantly highest in layers prepared August month treated with IBA- 4000 ppm concentration, vigrous growth was reflected in number of sprouts, number of leaves, shoot length and survival percentage during hardening in shade house. Similar findings obtain by Tyagi and Patel (2004), Karunakara (1997) and Rymbai and Reddy (2011) in guava.

Sharma *et al.,* (1978) observed that guava shoots treated with 100 and 200 ppm of IBA had 35 and 31 days respectively for root initiation. While in untreated shoots the root initiation was observed after 45 days. Early and higher rooting was observed with layers done during July compared with layers done during winter months.Sharma *et al.,* (1991) described the influence of NAA or IBA at 5000, 7500 or 10000 ppm in lanolin paste applied at the time of ringing on 10 July, 25 July or 10 August. A significant increase was found in the percentage of layers rooted (75.55%) and the number, length, diameter and weight of roots. Air layering carried out on 10 July resulted in the-highest percentage success (67.70%) and total root Weight.

Kamleshkar Singh and Jain (1996) reported that in guava (*cv.* Allahabad safeda), the highest (78.75%) percent of rooting, number of primary and secondary roots, length of the longest root were obtained when the etiolated shoots were treated with IBA @ 6000 ppm during the month of July. Chaudhari *et al.,* (1994) studied the effects of combinations of IBA (3000-4500 ppm) and NAA (400-750 ppm) in lanolin on stooling in guava under semi-arid conditions in August and found that the highest rooting percentage (100% after 60 days) was obtained with 4500 ppm IBA + 400 ppm NAA. This combination also resulted in the highest rate of survival in nursery beds (80.34% after 90 days). Chandrappa *et al*., (1998) studied the effects of applying IBA and NAA alone or with 1000 ppm of 1, 2, 4 acid (a phenolic compound) on air layering in May-September and reported that rooting was the best in air layers taken in June and treated with 10000 ppm IBA + 1000 ppm 1, 2, 4 acid. Animesh and Ghosh (2006). Air layers prepared during June and July showed maximum rooting success, number of primary and secondary roots and survival percentage in new alluvial zone. Rymbai and Reddy (2011) studied the plantlets of different layering methods under open field nursery for their survival and growth characters. The minimum record in all parameters where obtained in 15th June air layering method, except for maximum number of days (11.00) taken for sprouting. Among nursery conditions, Poly house nursery performed better than open field nursery in all the parameters irrespective of methods of layerings with minimum (8.83) number of days taken for sprouting, maximum survival percentage (90.10), number of leaves (9.58) at 45 days after transplanting (DAT) and (13.08) at 60 DAT.

Rymbai and Reddy (2010) reported that IBA at 4000 ppm + 15th August + wet sphagnum moss recorded maximum rooting percentage (86.00 %) in Guava air layers, while the minimum value was observed in Control. Kumar *et al.,* (2007) carried out the investigation to know the suitable time, optimum concentration of growth regulators and locally available media to get the rooting success in 12 years old guava air layers cv. Allahabad Safeda under high rainfall zone of Kodagu. Study revealed that IBA 10,000 ppm was best among all the treatments as far as rooting is concerned. July was the best month for making the air layers in guava *cv.* Allahabad Safeda.

Singh (1995) stated that air layering is done in the beginning of monsoon *i.e.* June-July and may be continued till September. B. Manga *et al.*, 2017 observed

Good layers survival % in the month of August treated with IBA- 4000 ppm, 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.

Duarte and Sachini (2003) Air layers with mature terminal leaves and 5000 ppm IBA were superior to those with immature leaves. Rooting was 80.0, 91.6, 100.0 and 91.6 per cent in June, August, September and November respectively. Ghosh and Ranjan, (2005) maximum field establishment (100%) was observed in guava air-layers of October in red laterite zone of west Bengal followed by September with 70 percent field establishment. Manna *et al.*, (2001) studied the response of different guava cultivars to air layering. It was observed that among the 12 guava cultivars, Lucknow-49, Kerala and Chittidar gave good response to air layering, as evidenced by high rooting and good field establishment under semi-arid conditions of West Bengal. Apple Colour, Allahabad Safeda, Banarasi and Baruipur responded poor to air layering, while Allahabad (U.P.), Behat Coconut, Seedless and Supreme exhibited moderate responses. The most suitable period for conducting air-layering is from August to February (southern hemisphere). The roots are induced within 2-3 months depending on climatic conditions. Once 50% of the roots are induced, the layers are removed from the parent plant and stored in a 5 liter polyethylene bag until they become strong enough to be transplanted into the garden." (Hartman and Kester, 2002). The regeneration of the roots in the air layering is largely controlled by a series of external and internal factors. It is now known that treatment with etiolation increases the temporary accumulation of endogenous growth substances in the etiolate portion due to some anatomical abnormalities, which promote better root rooting and quality (Dhua and Sen, 1984). Navanatha *et al.*, (1991) obtained 75 percent rooting initially and 58.20 percent final survival with IBA 1000 ppm in Tamarind air layers in the month of May. Singh and Jain (1996) reported that survival of guava rooted layers (75%) was obtained when the etiolated shoots were treated with IBA at 6,000 ppm during the month of July. Chandrappa and Gowda (1998) reported that guava air layers prepared during June month treated with 10,000 ppm of IBA + 1, 2, 4 acid gave maximum of 97.79 percent survival. Duarte and Suchini, 2002 recorded that air layer in litchi with mature terminal leaves and 5000 ppm IBA were superior to those with immature leaves. Rooting was 80.0, 91.6, 100.0 and 91.6 per cent for June, August, September and November, respectively. Ghosh and Ranjan, (2005) The maximum field establishment (100%) was observed in guava air-layers of October month in red laterite zone of west Bengal. Patel *et al.*, (2012) reported that application of IBA 5000 ppm with using sphagnum moss as rooting media produced maximum number of leaves (50.07 and 51.68) in Pomegranate air layers at 45 and 60 DAL respectively, in the month of July. Manga and Jholgiker (2017) found that the highest rooting and the survival rate were found in layers prepared in August were applied with IBA-4000 ppm. The growth of these layers was vigorous, as demonstrated by the maximum number of shoots, the number of leaves and the length of the shoots to 90 days from the separation of the layers of mother plants placed in the shade of the house for hardening in Softwood Grafting in Guava (*Psidium guajava* L.) *cv.* Sardar.

Effect of Auxins on air layering

Several workers have reported successful results by the use of plant growth regulators in stimulating of root primordia in air layering of guava crop (Tyagi and Patel, 2004; Sarkar and Ghosh, 2006 and Singh *et al.*, 2004). The growth regulator treatments which produced better rooting seem to influence the survival percentage also.Auxin particularly IBA, NAA and IAA have reported to induce rooting in many of the species with varied success. However, the response to treatment with different growth substances varies with species to species and with changing physiological and environmental factors. Among the various auxins viz., IBA, IAA, NAA etc. used for in vitro rooting, IBA is the most commonly used auxin. Singh KK (2018).

Cooper (1940) presumed the application of growth substances in accumulation of certain chemical substances at the base of cutting, which stimulate the meristem to divide quickly, and form roots. Burstorm (1942) found that auxin induced acceleration of cell elongation in individual root cell. Elongation of cell is caused by stimulation of the first phase. The second phase of cell elongation can only be retarded by auxin. Thus, an overall acceleration of elongation of cells can be brought about by addition of auxin. If its concentration is so low that the acceleration of the first phase of growth is not completely marked by retardation of the second phase. Siddiqui and Farooq (1996) found that 1.0 mg/l BA was effective in stimulating the formation of axillary shoots in guava.Air layering reported to have yielded good results. Air layering with the help of growth substances stimulating root primordial in air layers of fruit plants (Tyagi and Patel, 2004). Raut (1992) obtained 100 percent rooting and 60.5 percent survival with IBA 5000 ppm in air layers of Guava. Kunal (2005) reported that all growth

regulator treatments enhanced rooting and survival of etiolated air layers compared with the untreated control. IBA highest values for mean number (14.80) and length (11.30 cm) of primary roots per air layer, average number of secondary roots (10.72), percentage of success of air layers (93.34%) and survival of air layers (75.90%), while IBA at 4000 ppm recorded the highest value for diameter of roots (2.30 mm).Intact shoots with leaves may synthesize some unknown auxiliary substances which help in induction of adventitious roots (Singh *et al.,* 2004). Exogenous application of auxin-type growth regulators can speed up the rooting process in air layers (Rahman *et al.,* 2000).

Naithani *et al.,* 2018 reported that the response of IBA at higher concentration might be due to the activity of auxin at cambial may be adequate for callus formation and initiation of root primordia. In addition, exogenous application of auxin could have converted starch into simple sugars, which is required to a greater extent for the production of new cells and for the increased respiratory activity in the regenerating tissues at the time of initiation of new root primordial.

Sadhu *et al*., (1972). Reported that, P-hydroxy benzoic acid alone showed a small increase in the rooting of guava layers but in combination with IBA it showed a fourfold increase in the number of roots. Nanda (1975) observed that the air-layers of guava cv. 'Sardar' gave low percentage of rooting without growth regulator IBA. Singh and Hammer (1956) reported that IBA was an active agent in promoting formation of roots in air-layering. Root initials in stem is apparently dependent upon the native auxin in plant plus auxin synerigist together these lead to synthesis of ribo-nucleic acid (RNA) which is involved initiation of the root primordia (Haising 1971). Roots are much more sensitive to auxin than stem and real stimulation of root elongation may be achieved if low concentrations are used. The application of relative high concentrations of IBA to root not only retards root elongation but a noticeable increase in number of branches roots also Devlin (1974). Mahabir Singh *et al.,* (2001) found that use of IBA was beneficial in enhancing the callus formation, number, length and diameter of both primary and secondary roots and survival of air layered twigs. 20000 ppm of plant growth regulators was found optimum for better rooting success and survival. (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 per cent rooting (Tyagi and Patel, 2004).

Athani *et al*., (2001) studied effect of girdling, growth regulators and etiolating on the rooting of air layers in guava cv. Sardar. Among different treatments the highest values for rooting percentage (90%), number of roots (18.23) and length of longest roots (9.56 cm) were observed upon treatment with 30 days advance girdling + etiolation + IBA, while the values for these parameters were minimum (20%, 6.25 and 4.87 cm, respectively) upon treatment with the control. Rahman *et al.,* (2000) reported that maximum numbers of roots (9.94), root length (10.94 cm) per air layer was recorded in litchi air-layers treated with 2500 ppm of IBA. Singh (2002) studies on the effects of different concentrations of IAA, IBA and NAA in combination with white or black polyethylene film on air-layered guava cv. Allahabad Safeda plants. He found that among the plant growth regulators, IBA was the most effective for the rooting, establishment, survival and vegetative growth of the air layers.

Tyagi and Patel (2004) reported in guava (cv. Sardar) plants propagated by air layering that the combination between IBA and NAA was more effective than IBA or NAA alone, and the higher concentration was more effective than the lower concentration in the enhancement of rooting and growth parameters. Thus, the greatest rooting (90.0%) and establishment (76.58%) were obtained with IBA + NAA at 10 000 ppm. Kumar and Syamal (2005) observed that the highest number of primary roots was produced using IBA 3,000 ppm treatment followed by NAA 2,000 ppm. High number of roots was recorded with IB A + NAA (1 : 1) at 2,000 ppm each. Etiolation along with exogenous application of auxin had stimulating effect on producing longer roots. Sarkar and Ghosh (2006) observed that the effects of IBA at 1000 and 2000 ppm on the performance of guava *cv.* L-49 in West Bengal, India. IBA at 2000 ppm resulted in the best results in terms of number of primary and secondary roots, rooting success and survival percentage. Kakon *et al.,* (2008) studied in guava mound layering as affected by different variety and growth regulators, That different concentrations of growth regulators had significant effect on almost all parameters. IBA at 1200 ppm showed the best performance among the treatments.

Lal *et al.,* (2007) reported that, application of IBA (7500 ppm) gave maximum rooting percentage (96.67%), average number of roots per shoots (46.93) and average root length (8.45 cm) in guava. They also noticed that the treatment with IBA (7500 ppm) gave maximum survival (75%) of guava air-layers after transplanting in the field.

Desale, (2011) observed significantly higher root volume (6.20 ml) in Karonda air layers treated with IBA

5000 ppm, whereas minimum root volume was recorded in treatment control.

Patil *et al.,* (2011) reported that the highest concentration of IBA at 12000 mg/l provided higher success of rooting (91.11 %), highest fresh weight (3.89g) and dry weight (0.98g) of roots per layer as compared to IBA at 4000 and 8000 mg/l. Mankar *et al.,* (2009) found that The layers treated with growth regulator treatment of IBA 3000 ppm followed by IBA 4000 ppm, NAA 3000 ppm and IBA + NAA 5000 ppm gave significantly maximum of 95 percent final survival percentage of guava layers by poly bag method over growth regulator treatment of 1000 ppm concentration of IBA and NAA alone, their combination, NAA 2000 ppm.Rymbai *et al.,* (2010) observed the effect of IBA concentrations (2000, 3000, and 4000 ppm) on rooting, root character and survival percentage of rooted air layers under different growing nursery condition *i.e.*, open and poly house condition The highest percentage of rooting and root character of air layers of guava *cv.* L-49 was successfully achieved by exogenous application of IBA at 4000 ppm. Albany *et al.,* (2004) evaluated air layering as a technique of vegetative propagation of guava with the use of NAA and IBA and a mixture of both using river peat as substrate. Based on the percentage of rooted air layering, number and longitude of primary roots, it was concluded that NAA was the best simulative for the formation of roots in air layers. Patel *et al.,* (2012) reported in Pomegranate that minimum numbers of days taken for root initiation (15.08) with IBA 5000 ppm, while control took highest number of days for root initiation (25.83) in air layers. Chawla *et al.,* (2012) reported that the application of IBA 5000 ppm on litchi air layers gave better results with respect to fresh and dry shoot weight (46.29 g and 28.00g, respectively) in comparison to all other treatments.

Effect of rooting Media on air layering

In dint of better absorption of nutrients and moisture from the growing media created more favourable environment for root and shoot growth resulting in higher survival percentage of air layering in guava. Maximum survival percentage of air layers might be due to better water holding capacity of media as well as more number of primary and secondary roots, number of leaves etc. The increase in yield is attributed mainly to an improvement in root development, an increase in the rate of water and mineral uptake by roots. While, maximum number of leaves might be due to the availability of more mineral nutrients and water due to efficient absorption by vigorous root system. The results are in respect to IBA also in conformity with finding of Rymbai and Reddy (2010) in guava air layering.

The rooting media such as sand, soil, saw dust (Tyagi and Patel, 2004), moss grass (Kumar and Syamal, 2005), poultry manure, Vermi compost and Farmyard manure (Singh *et al.,* 2007) etc., are being used to improve the scope of air layering in guava. Similar results were also obtained by Singh *et al.,* 1996; Karunakara, 1997; Kumar and Syamal, 2005 and Singh *et al.,* 2007 in guava. The higher percentage of survival after transplanting the rooted air-layers can be attributed to the possession of better root characters like higher number and length of roots. The increase in shoots might be due to early initiation of roots, more numbers of roots, root length, numbers of leaves etc., which increased the absorption of nutrients from the rooting medium and thereby increased the shoot length. The results are quite comparable with the results of Patel *et al.,* (1989) aswell as Tyagi and Patel (2004). Maurya *et al.,* (2012) observed that "the air layering are made with soil and dung + sphagnum + 6000 mg IBA / L showed early emergence of the roots (16.33 days), increase in the number of primary roots (17.49), secondary roots (47.73), the maximum root length (10.20 cm), fresh root (3.31g) and dry root weight (0.68g) compared to control Singh *et al.,* (2007) observed that in Air layering of guava *cv.*„ Lucknow-49 treated with IBA concentration of 6000 ppm with soil: sand : poultry manure rooting media produced maximum percentage (76.75%) of survival of 60-days-old-plants grown in poly bags. This combination of IBA with rooting media helped in producing maximum number of primary roots (18.57), secondary roots (23.91), leaves on 60 days (14.36) and length of shoots on 60 days (5.31 cm). IBA 5000 ppm and poultry manure combination was found to be second best for survival of air layering (73.25%).

Reddy *et al.,* (2014) reported maximum fresh and dry weight of shoots (34.10g, 35.96g and 43.53g) at 45, 60, and 75 DAP with the application of IBA 3000 mg/l , poultry manure and sphagnum moss as rooting media on air layers of Fig *cv.* Poona produced. Alloli *et al.,* (2001) reportedthe beneficial effects of fly ash were more pronounced in fig, which produced the highest fresh and dry weight of roots in this media. Fly ash was the most ideal media for fig, while sawdust was the most ideal for pomegranate. Rathore (2006) observed in guava layering that rooting was 100% in the treatments including compost, loamy soil and cow dung and 60-70% in saw dust. The mean number of primary roots was the highest in compost and lowest in saw dust. Sathyanarayana (2010) observed in guava air-layers that among the media, through no significant difference were found in respect to rooting percentage while the coffee husk gave the

best result compared to other media used in the study. Rathore (2006) conducted an experiment of guava layering. He found that rooting was 100% in the treatments including compost, loamy soil and cow dung and 60-70% in saw dust. The mean number of primary roots was the highest in compost and lowest in saw dust.

Effect of interaction between Rooting media × Time × IBA concentration

In the modern era air layering propagation techniques using growth regulators during rainy seasons are being used to achieve more success. The rooting media like sand, soil, saw dust, moss grass (Kumar and Syamal, 2005), poultry manure, Vermi compost and farmyard manure (Singh *et al.,* 2007) etc., are being used to improve the scope of air layering in guava. Prabhar Singh *et al.,* (2007) Air layering of guava with IBA concentration of 6000 ppm with soil: sand: poultry manure rooting media produced maximum percentage (76.75%) of survival of 60 days old plants grown in poly bags. IBA at 5000 ppm and poultry manure combination was found to be the second best (73.25%) with respect to survival of air layers. Singh *et al.,* (2007) found one-year old shoots of guava *cv.„* Lucknow-49 were treated on ringed surface of shoots with IBA concentration (ppm) of 3000, 4000, 5000 and 6000 along with organic media *i.e.* poultry manure, vermi-compost and farm yard manure. Air layering of guava with IBA concentration of 6000 ppm with soil: sand: poultry manure rooting media produced maximum percentage (76.75%) of survival of 60-days-old-plants grown in poly bags. Kakon *et al*., (2005) found that, "the combination of medium rooted IBA helped to produce the maximum number of primary roots (18.57), secondary roots (23.91), leaves at 60 days (14.36) and shoot length at 60 days (5.31 cm) on mound layering in the three varieties of guava. Kumar *et al.,* (2007) carried out the investigation with NAA, IBA treatments and, locally available media (Saw dust, Rice brawn, Coffee husk and Coir pith) to know the suitable time, optimum concentration of growth regulators and locally available media to get the rooting success in 12 years old guava air layers *cv.* Allahabad Safeda under high rainfall zone of Kodagu. It was observed that IBA 10,000 ppm gave best result among all the treatments as far as rooting is concerned. Among the media, the coffee husk gave the best result compared to other media used in the study. July was the best month for making the air layers in guava *cv.* Allahabad Safeda.

Sathyanarayana (2010) conducted an experiment in India, to evaluate the response of different rooting media on guava air-layers. Three different concentration of IBA *viz.,* 2000, 3000 and 4000 ppm were used in three time of layering *viz.,* 15th June, 15th July and 15th August with two rooting media *viz.,* sphagnum moss and coco peat. Among the rooting media, moist sphagnum moss produced highest rooting percentage and root characters. The survival of rooted air layers was found to be maximum with the treatment combination of IBA at 4000 ppm, 15th August and sphagnum moss and polyhouse conditions produced higher survival than open conditions after 45 days of detachment from the mother plants. Patel *et al.,* (2012) recorded maximum survival percentage (88.33 % and 83.33 %) at 15 and 30 DAT in pomegranate air layers treated with IBA 5000 ppm with using sphagnum moss as rooting media in the month of July. Maurya *et al.,* (2012) reported early root initiation (16.33 days) in guava air layers treated with soil + poultry manure + sphagnum mass+ 6000 mgL^{-1} IBA. Rymbai and Reddy (2012) reported that application of IBA 4000 ppm with using coco peat and sphagnum moss as rooting media on air layers of guava was produced maximum number of leaves (6.67 and 13.83) at 45, and 60 DAT. Bhosale *et al.,* (2014) in pomegranate air layering, found that the sphagnum moss with IBA 5000ppm was best combination giving the best rooting, survival and was economical also. Based on this investigation use of sphagnum moss with application IBA 5000ppm may be recommended for better rooting and survival of air layers in pomegranate *cv.* Sindhuri.

Future scope:

As layering does not involve sexual reproduction, newly developed plants become clones of the original plant and exhibits the same characteristics. Additionally, the new plant tends to be stronger and more mature than those propagated by any other technique. Layering process involves wounding the target region to expose the inner stem and optionally applying rooting medium. Layering results in a good-sized plant in a matter of weeks instead of years. Layering is utilized by horticulturists to propagate desirable plants. It has the advantage that the propagated portion continues to receive water and nutrients from the parent plant while it is forming roots.

The newly developed plant has characteristics identical to the mother plant. Larger plants which are readily mature can be produced in faster time. Rooting success is more ensured through layering. Layering is important for plants that form roots slowly, or for propagating large pieces. It is also used in the propagation of bonsai. The juvenile period of a plant can be shortening by air layering. More rapid and stronger root growth reducing the period of propagation. Valuable space and time in attending to rooting trays, etc. With a small number of plants, it can produce more layers with less skill, effort

and equipment. Examples of Important Crops That Have Been Layered are cashew (*Anacardiumoccidentale*), citrus (*Citrus* spp.) and tamarind (*Tamarindusindica*).

Conclusion

Guava is one of the very important fruit crops of India because of its hardy nature, prolific bearing, high vitamin C *i.e.,* high nutritive value, easy availability at moderate price with pleasant aroma and good flavour of fruits. The effect of Time, IBA, different rooting media and combination of these are being studied on the air-layers of the plant. On the basis of the experimental findings, it can be concluded that the rainy season of air layering, the exogenous application of root promoting chemical IBA at higher concentration and rooting mediaindividually and in combination is the best for higher rooting and survival percentage and can be used for mass multiplication of true-to type plants of Sardar Guava through air layering under the sub-tropical condition of Kota Rajasthan. Rooting media, Rainy season and IBA treatments seems to have influence the activation of root primordia and provide carbohydrates, cause considerable increase in the success in promoting roots and improved root characters like number of roots, root length and root weight.

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