ABSTRACT

Guava is also propagated vegetative through inarching, layering, cutting, budding and grafting. But layering and that too air-layering remains the best method of propagation for this crop. The use of plant growth regulators to increase the efficacy of propagation in cutting and layering are now common and moreover, use of growth regulators has opened a new vista for nurserymen for propagating fruit trees. Growth substances accelerate the rooting, produce a large root system and increase the percentage of survival. Growth regulators like IAA, NAA and IBA have been used to stimulate plant growth and specially root formation in layering. IBA has been found to be most effective in producing maximum number of roots with better vigour. For air-layers, the rooting media like sand, soil, peat moss, compost, farm yard manure, coconut pith, sphagnum moss are used.

Key words  IBA, layering, media, nursery, guava

Guava (*Psidium guajava* L.) is one of the most important and commercial fruit crops of tropical and subtropical region of India. It is believed to be introduced in India early in the 17\(^{th}\) century. It belongs to family Myrtaceae and genus *Psidium* which contains about 150 species. This fruit crop is native of tropical America. The fruits are liked by rich and poor equally and are popularly known as the “Apple of Tropics”. In guava, most of the commercial cultivars are diploid (2n = 22), while the seedless cultvar is triploid in nature and a shy bearer. Guava is an important fruit crop of India in area and production after mango, banana and citrus. It occupies an area of 219.7 thousand hectares and production of 25.72 lakh tonnes with productivity 11.7 metric tonnes/ha (Anon., 2010) in India. Its cultivation is common in India, which is concentrated mainly in Uttar Pradesh, Bihar, Madhya Pradesh, Maharashtra and Chhattisgarh. Chhattisgarh covered an area of 13353.25 hectares with an annual production of 102819.71 metric tonnes (Anon., 2010). 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; Tyagi and Patel, 2004; Sarkar and Ghosh, 2006 and Singh *et al*., 2004). 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. It is mostly propagated from seed. However, plants raised from seeds are not true to type and evidently take longer time to reach to bearing stage when compared to vegetative propagated materials. 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). However, the percentage of establishment and survival of rooted layers in open conditions is very poor and not achieving up to an expectation of the demand at cheaper rate with high establishment and survival percentage. Polyhouse technology has been in use for crop production in more than fifty countries all over the world. Application of this technology is more common for vegetable production and in India is a recent phenomenon but gaining important these days. To facilitate better percentage of establishment and survival of rooted layers.

Effect of plant growth regulators on rooting of air layers of guava

Bhujapal, 1972 reported that IBA 1000 ppm to 4000 ppm concentration in marcotting experiment of guava variety Lucknow - 49 obtained best results with IBA 3000 ppm which gave 86.6 per cent rooting and 76.6 per cent survival. Patel *et al*., 1989 found with air layers of guava using IBA at 3000 ppm and wrapping with black polythene
resulted in 100 per cent rooting and maximum number of roots. Ram Chandra et al., 1991 reported that air layers of guava treated with sucrose (5 to 10 %) with or without coconut milk IBA 4000 ppm or 8000 ppm or 4000 ppm IBA + 4000 ppm IAA, the highest number of primary and secondary roots and greatest primary root diameter were obtained with the IBA + IAA treatment. Sharma et al., 1991 reported that in air layering of guava cv. Allahabad Safeda 1000 ppm IBA treatment resulted in the highest percentage of success (75.55%). Patel and Pasaliya, 1995 found that NAA at 9000 ppm applied immediately after ringing gave the highest number of primary and secondary roots and heaviest root fresh and dry weights. Singh et al., 1995 studied the effect of IAA, IBA, NAA, IBA + NAA, IAA + IBA or IAA + IBA + NAA (2500, 5000 or 10000 ppm) and white or black polyethylene wrappers on rooting, growth and survival of air layers of guava cv. Allahabad Safeda. They reported that best plant growth regulator treatment for air layering was IBA + NAA in most respect. Patel et al., 1996 observed that IBA alone was better than IAA alone. The best plant growth regulator for promoting rooting and growth of air layers was 3000 ppm. Singh and Jain, 1996 observed that percentage rooting and survival were highest (78.75 % and 75 % respectively) for etiolated shoots treated with IBA at 6000 ppm in guava air layer.

Athani et al., 1999 observed the response of guava cultivars to air layering. The varieties GW-1, GW-2, CIW-1 and SR-1 exhibited 100 % rooting while lowest percentage of rooting was observed in Sardar (20 %). Longest root length (11.15 cm) was noticed in GW-1 and GR-2 while SR-3 had Tomar et al., 1999 observed in air layers of guava cultivar Gwalior - 27 that survival rates were highest (71.65 %) with 15000 ppm NAA in 1995, whereas, in 1996 survival rates were highest (70.29 %) with the application of 15000 ppm IBA. Singh and Bhuj, 2000 studied the effect of paclobutrazol 250 ppm and 500 ppm with poly wrapper colour (white, black and red) on air layering in guava cv. Sardar and reported that red and blue poly wrappers combined with paclobutrazol 500 ppm produced the best results with regard to the survival and rooting capacity of guava. Athani et al., 2001 observed the highest rooting percentage (90%), number of roots (18.23) and length of longest root (9.56 cm) upon treatment with 30 days advance girdling + etiolation + IBA. The effect of etiolation was more significant than girdling 15 days advance. Singh, 2002 studied that callus formation, rooting, length, diameter and weight of roots, number of new sprouts and leaves per plant and survival of guava air layers were highest with 20000 ppm IBA + black polyethylene film treatment. Tyagi and Patel, 2004 reported that the combination of 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 root growth and growth parameters (shoot length, number of branches and number of leaves). ppm. Kunal Kumar and Syamal, 2005 found that IBA at 3000 ppm recorded the highest number (14.80) and length of primary roots in air layers (11.30 cm), average number of secondary roots (10.72), percentage of success 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).

**Effect of plant growth regulators on rooting of air layers of other fruit crops**

Acharya and Dash, 1972 observed that IBA at 3000 ppm resulted in 84.6 per cent success in marcotting of cashew and also resulted in the largest roots, the greatest number of roots and shortest period of root emergence. Chhonkar and Singh, 1972 reported that IBA treated with 5000 ppm was markedly more effective than NAA in promoting rooting and establishment of mango marcots. Sharfuddin and Hussain, 1973 obtained 100 per cent rooting with IBA at 5000 ppm in litchi layering. Kadman and Slor, 1974 reported that 55 per cent layers rooted with the use of 1 per cent IBA, whereas, only 45 per cent without any treatment in litchi propagation. Chatterjee and Rao, 1978 reported that 55 per cent layers rooted withuse of 1 per cent IBA, whereas only 45 per cent without any treatment in litchi propagation. Chatterjee and Rao, 1978 reported that in air layers of *Ziziphus jujuba*, IBA at 10000 ppm gave the best result in terms of rooting percentage. Patil and Chakrawar, 1979, treated with IBA or NAA each at 500 - 2000 ppm and covered with moss grass and polythene. The highest number of roots per air layer (81.14) and greatest survival (96.67 %) of air layers occurred in variants treated with IBA + NAA each at 1000 ppm. Bearing shoots produced slightly fewer roots than non-bearing shoots. Tomar, 1979 obtained the maximum length of primary roots, number and length of secondary roots in karonda air layers with 10000 ppm of IBA. Chatterjee, 1982 obtained the best rooting (75 %) and survival after one year (55 %) in mango air layers at 10000 ppm IBA. Patel and Singh, 1982 observed that a combination of IBA 20000 ppm + NAA 500 ppm gave the highest rooting (66.6 %) in air layering of mango cv.
Langra. Rajan and Ram, 1983 reported that good rooting was obtained in the difficult to root cv. Langra by applying IBA at 15000 ppm to air layers of mango.

Ram and Majumdar, 1983 noted 97.1 % rooting and 94.3 % survival in stool layering of litchi with IBA at 2500 ppm. Desai and Patil, 1984 reported that NAA + IBA (2500 ppm + 5000 ppm) along with black polythene resulted in the best rooting of jackfruit by air layering. Dhu and Sen, 1984 observed 98.30 per cent rooting in air layers of jackfruit when treated with ferulic acid + 1000 ppm IBA. However, a survival of 88.88 per cent of layers was also obtained with IBA 3000 ppm. Hanamashetti et al., 1984 observed maximum root length (10.6 cm) were obtained with IAA 300 ppm for cashew nut. Palaniswami et al., 1985 reported that IBA at 500 ppm improved rooting and 40 - 50 per cent success was achieved by air layers of one year old shoot of cashewnut during July to September. Valasal Kumari et al. (1985) reported that air layering in cashewnut between February - April and treatment with IBA at 250 ppm or NAA at 500 ppm gave maximum number of rooted layers. Mukherjee et al., 1986 reported maximum rooting (80 - 90%) and maximum survival of air layers in bael by treating the etiolated shoot with IBA 10000 ppm. Hedge and Sulikeri, 1989 studied the effect of IBA at 250 - 1500 ppm on air layers of pomegranate cv. Jyoti. Rooting increased with IBA concentration from 84.38 per cent at 250 ppm to 93.75 per cent at 1500 ppm with 68.75 per cent in control. Chaterjee et al., 1990 reported that etiolation treatment and application of 1000 ppm IBA gave 91.7 per cent rooting success and 90.9 per cent survival of air layers of sapota. Mishra and Singh, 1990 found that highest percentage of rooting was obtained with 5000 ppm IBA (95 % compared with 21.7 % in the control) Navaneetha et al., 1991 observed treated with IBA (1000 ppm) applied in May, the rooting was best (75 %) and subsequent survival was highest. Mishra and Jaiswal, 1992 observed the concentration of IBA significantly increased rooting compared with control, 100 % rooting being obtained with IBA 5000 ppm. Bisen and Barhola, 1995 recorded the highest percentage of rooting (92.5 %), treated with IBA 15000 ppm in air layers of jackfruit. Rath et al., 1996 found that IBA at 7500 ppm applied to hardwood stems produced the most rooted air layers (upto 88 %, 45 days) in jackfruit. Brahmachari et al., 1997 reported the maximum rooting, survival and improvement in root characters by etiolating shoots 30 days before layering and treating with IBA + NAA at 5000 ppm on litchi. Preeti et al., 1997 reported that the best growth and development of roots and highest survival rates (80 %) in jackfruit were obtained with IBA 5000 ppm. Ganapathi et al., 1998 conducted a study for air layering on a 20 year old tree of tamarind treated with 1250, 2500, 5000 or 7500 ppm IBA alone or in combination with NAA. The treatment also produced the maximum number of roots per shoot. Tomar et al., 1999 reported that when the air layers were treated with powder containing 0, 600, 1200, 2400 or 4800 ppm IBA in Kagzi lime, the concentration of 2400 ppm IBA gave more successful result in air layering.

Ali et al., 2000 reported that the treatment with IBA at 5000 ppm can be used for adventitious root formation in air layering of jackfruit in combination with etiolations for a period of 30 days. Chovatia and Singh, 2000 found that application of IBA at 10000 ppm on air layering of custard apple proved significantly superior in percentage of rooted layer and their survival, formation of main and secondary roots. Ray et al., 2001 the effect of IBA on air layering of litchi cv. Purbi and reported that IBA at 5500 ppm gave the highest percentage of rooted air layers (90 %). 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. Utpal et al., 2003 studied the survival of eight cultivars of litchi through air layering. Shoots treated with plant growth regulators showed better survival (90.56 and 80.26 % under NAA + PHB and IBA + PHB, respectively) compared to the control (37.45 %). Kumari Bandana, 2004 observed that 10000 ppm treatment of IBA stimulated maximum percentage of rooting, root growth and development of air layering in jackfruit.

**Effect of rooting media on rooting of air-layers of fruit crops**

Sharfuddin and Hussain, 1973 treated with IAA and IBA at 500 ppm and wrapped with sawdust and plastic film, soil/dung mixture and plastic film and or soil/ dung mixture and gunny cloth. Sawdust and plastic film was the best wrap for untreated marcots, giving 83.33 per cent rooting. It also interacted with the growth compounds in the promotion of earlier rooting. Malik and Maqbool, 1977 used soil, soil/ sand and soil/ farm yard manure
mixtures in litchi to study the effect of cutting or ringing the layers. A 1:1 ratio of soil/sand mixture gave the best results. Also ringing gave better results than cutting. Gowda, 1983 used wet red soil, sand or saw dust as rooting media in ficus to the stripped portion and covered with polyethylene sheet. After 30 days the branches were cut and cutting were transferred to 23 x 30 cm polyethylene bags filled with 1:1:1 red earth : sand : manure. Out of 500 cuttings taken, 455 sprouted successfully. Kuliev and Babaev, 1983 observed propagation of feijoa by cuttings and layering. In 2 year trails cuttings rooted best in well rotted FYM or FYM: river sand 1:1 mixture under mist. Veeraraghavan et al., 1983 examined five different rooting media, the percentage of rooted layers (40.0) was highest in wood shaving and lowest (18.7) in wood shavings enriched with rock phosphate in air-layering of cashew. Grappelli et al., 1985 tested earthworm casting as a rooting media for air layering. Layers rooted better when casting mixture were used. The beneficial effect of earthworm casting was attributed to the presence of growth regulators namely GA3, cytokinins and auxins.

Shetty and Melanta, 1990 investigated rooted air layers of cashew were hardened in polyethylene bags containing eight different plant media. Highest survival (97.5%) was obtained in air layers hardened in sand + red earth + coir dust (1:1). This medium also gave the highest average number of healthy sprouts and leaves successful air layers on transfer to the field and field establishments (95%). Durate and Freundt, 1991 used coconut fibre, perlite, saw dust, synthetic foam, vermiculite, peat moss, sand + sawdust and no media (control) as an air layering medium for Ficus elastica. The best rooting media for root quality was peat moss (>98% rooting). Almeida et al., 1992 comprised the media saw dust, red sand and cattle manure alone or in combination by percentage rooting was highest in saw dust alone (90%) and lowest in cattle manure alone (0%). Hore and Sen, 1994 found that rooting media containing 2:1:1 ratio of garden soil : sand : rotted cowdung manure in air-layering of pomegranate rooted successfully. Nath, 1994 reported that air layers of carambola treated with 5000 ppm IBA and as media soil, leaf mould and compost (2:1:1) gave the highest percentage of rooting (72.4%), number of primary roots (11.0), root length (7.5 cm) and survival of rooted layers (75.6%). Tomar et al., 1999 observed in kagzi lime that treated areas were wrapped in mixture of sand, farmyard manure and soil held in polythene film gives more success with an IBA concentration of 2400 ppm. Alloli et al., 2001. The 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. Kumar et al., 2001 observed in three different rooting media viz. standard gootee mixture, sphagnum moss and saw dust alone and in combination with 500 pm IBA.

**LITERATURE CITED**


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