A review: Macro-propagation of guava (*Psidium guajava*)

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**Abstract**
Guava can be propagated by air-layering, ground layering, inarching, root and shoot cutting and budding. Air-layering is the most popular commercial method of vegetative propagation of guava in India. Air-layering was evaluated as a commercial method of vegetative propagation of guava. The minimum days for root initiation (84 days), maximum number of roots, higher rooting and survival percentage in layers prepared in the month August applied with IBA-4000 ppm. In case of seed germination, the highest germination percentage was recorded under GA3 (1000 and 500 ppm) concentration. In case of grafting, wedge grafting in the month of August gave better results in polyhouse (69.88 %) as well as in open field condition (67.12 %). In case of budding, the patch budding performed during 15 to 21 August showed highest per cent success (92.07%) recorded after 90 days of guava propagation. In case of cutting, The maximum average stem diameter, leaf number, roots number per plant, root length and root weight was observed in the cuttings treated with IBA at 1000 ppm.

**Keywords:** guava, multiplication, layering, cutting, budding

**Introduction**
Guava (*Psidium guajava* L.) belong to family Myrtaceae. Place of origin of guava is tropical America. Guava is propagated through budding (Gupta and Mehrtra, 1985; Kaundal et al., 1987) [14, 29], air layering (Singh and Singh, 1970; Sharma et al., 1978; Manna et al., 2001) [67, 68], stooling (Pathak and Saroj, 1988) [54] and inarching (Mukherjee and Majumder, 1983) [44] these are still not commercially viable due to varying rate of success, absence of tap root system and cumbersome process. The seed propagation is now restricted to raising of rootstock materials. Although guava is hard-to-root, investigations have indicated that it can be successfully propagated from cuttings under mist. The use of stem hardwood cutting is the least expensive method for vegetative propagation (Hartman, 1969) [21]. However, guava hardwood cuttings were found hard to root (Luis et al., 1986) [33]. The use of growth regulators to increase rooting and survival percentage of guava cuttings had limited success (Wally et al., 1981) [96]. Environmental conditions can influence the ability of stem cuttings to grow and root. The most common external factors are light, seasons, temperature, humidity, moisture level of cutting and rooting medium (Hartman et al., 1997) [22], Evans, (1992) [12] and Singh (2018) [76,77] contended that probably the best time to take cuttings from the field is at the beginning of the rainy season. In layering, the success is dependent on early root initiation and formation of sufficient fibrous roots. Singh et al. (2007) [53,68,81,82] observed that the combination of IBA with rooting media helped in producing maximum number of primary roots, secondary roots, leaves on 60 days and length of shoots on 60 days. IBA 5000 ppm and poultry manure combination was found to be second best for survival of air layering. The germination of guava seed was improved by soaking it in tap water before sowing. Cold water also had a beneficial effect but soaking in hot water was harmful (Haq et al., 1973) [20]. Banuprakash et al. (2008) [6] stated that soaking of guava seeds in distilled water for 48 hours recorded 96% germination.

1. Layering
In layering, the success is dependent on early root initiation and formation of sufficient fibrous roots. Regeneration of roots in air-layers is largely controlled by a number of external and internal factors. Etiolation stimulates the rooting at etiolated portion and has resulted in better rooting in a number of fruit plants. It is now a well-known fact that etiolation treatment increases the temporary accumulation of endogenous growth substances in the etiolated portion due to some anatomical abnormality, which promotes better rooting and quality of roots (Dhua and Sen, 1984) [10]. Patel (1985) [51] observed that IBA was better than NAA. Amongst the different concentration, IBA at 3000 ppm gave highest (100%) rooting and 76.6% in air layers of guava. Sharma (1985) [64] showed that the application of IBA 10000 ppm had influenced the rooting of
air layers of guava. 5000 ppm IBA + NAA was found optimum for better success and survival of air-layers, while 10000 ppm resulted in better growth attributes (Singh et al. 1995) [180]. Patel et al. (1989) [252] showed that black polythene film was better than white polythene film for air-layering in guava. The application of IBA particularly 15000 ppm had significantly proved better for rootage as well as survival and subsequent growth of air layerage of guava Kale (1996) [256], Ramteke (1998) [258] reported that the layering on 23 June gave the best results in terms of root and shoot growth and survival percentage. Saroj and Pathak (1998) [262] reported that combined application of IBA +NAA (7500) induced profuse rooting (90 to 100%) in (Psidium chinensis L.).

Pre conditioning treatments such as girdling, Blanching and etiolation of shoots have been shown to induce roots in some difficult to-root fruit plants. Etiolation stimulates the rooting at etiolated portion. Tomar et al. (1999) [260] reported that the rooting success increased with the increasing growth regulators concentration. Survival rates were maximum with 15000 ppm NAA. Shrivatava (2000) [266] reported that the treatment combination (IBA + NAA 7500 each) with sphagnum moss showed the greatest improvement in all the characters like callusing, rooting and survival of air layering of guava. Hammasselwe (2005) [199] finds a number of grafting methods for the vegetative propagation of Psidium guajava in north Cameroon. Preliminary results showed that grafting and air layering were not practical at Kismatari. Terrestrial layering was the best technique for mass production of homogenous plant material to supply research and farmers. Gauthier et al. (1996) reported that auxin naturally or artificially is applied for a requirement for initiation of adventitious roots on stem and indeed it has been showed that the division of first root initial cell is dependent upon either applied or endogenous auxin. Kakon et al. (2005) [255] reported that the highest percentage of survivability (100%) was observed from layers in situ under open condition which was statistically similar to layers in poly bags under open condition. The 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 at 5000 ppm and poultry manure combination was found to be second best for survival of air layering (73.25%) (Chandrakar et al. 2007) [252].

Maurya et al. (2012) [242] reported that the air layers made with soil + poultry manure + sphagnum moss + 6000 mg/l IBA showed early root initiation (16.33 days), highest number of primary roots (17.49), secondary roots (47.73), maximum root length (10.20 cm), fresh root weight (3.31 g) and dry root weight (0.68 g) as compared to control and rest of the treatments. It also recorded maximum survival percentage (90.67), length of shoots (7.93 cm) and number of leaves (18.33) at 60 days of air layers in the poly bag after transferring with highest economics (Net CBR 1:3.59). The root initials in stem, is apparently dependent upon the Native auxin in plant plustauxin synergist together these lead to synthesis of ribo-nucleic acid (RNA) which is involved initiation of the root primordia (Haising, 1971) [188]. Devlin (1974) [9] reported that action of auxin in root is similar to that in stem, but that the concentration of auxin to stem growth is inhibitory to root growth. In other words roots are much more sensitive to auxin then stem and real stimulation of root elongation may be achieved if low concentration are used. The application of relatively high concentration of IBA to root not only retarded root elongation but a noticeable increase in number of branch roots also. Rathore (1982) [60] observed that among concentration of IBA, 15000 proved significantly better in the formation of primary roots and secondary roots, length, diameter, and number of primary and secondary roots in guava air-layers. Manga et al. (2017) [256] reported that the minimum days for root initiation (84 days), maximum number of roots, higher rooting and survival percentage in layers prepared in the month August applied with IBA-4000 ppm. Growth of these layers was vigorous as depicted by maximum number of sprouts, number of leaves and shoot length at 90 days after separation from mother plant layers placed under shade house for hardening. The root initials in stem, is apparently dependent upon the Native auxin in plant plustauxin synergist together these lead to synthesis of ribo-nucleic acid (RNA) which is involved initiation of the root primordia (Haising, 1971) [188]. Baghel et al. (2016) [4], reported that the August month recorded significantly higher values for rooted air layer, number of primary and secondary roots, length of primary and secondary root, fresh and dry weight of root and survival percentage. This study revealed that for realizing higher rooting and success of guava air layers under semi arid tropical ecosystem of Vidarbha region may be performed in the month of August and IBA treatment at the rate of 10,000 ppm.

2. Cutting

Propagation by cuttings has significant advantage, since, in addition to obtaining plants with the same type of tree, will ensure production of economically important tree in just one growing season (Tavares, 1994) [69]. Rooting among the vegetative methods of propagation is undoubtedly the most evolved and expanded method (Manica et al., 2000) [274] but the information regarding the rooting ability of the cuttings in guava is very scarce. Auxin application has been found to ensure production of economically important tree in just one growing season (Tavares, 1994) [69]. Rooting among the vegetative methods of propagation is undoubtedly the most evolved and expanded method (Manica et al., 2000) [274] but the information regarding the rooting ability of the cuttings in guava is very scarce. Auxin application has been found to enhance the histological features like formation of callus and tissue and differentiation of vascular tissue (Mitra and Bose 1954, Singh 2018, Singh et al. 2011, Singh, 2017, Singh, 2013, Singh, 2014, Singh, 2016) [43, 76, 77, 70, 73, 78, 74, 72, 79]. Singh (2017) [75] showed that the 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%) (Chandrakar et al. 2007) [252].

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mg to 112.4 mg dry weight of roots) irrespective of variety, while at 3500 ppm it decreased the different rooting parameters (Debnath and Maiti 1990)  

Kareem (2013) observed that the maximum survival percentage of plants at transplanting was noted with 0.4g concentration. In general IBA 0.4g concentration performed better as compared to NAA for all parameters studied. Experiments have been conducted by various workers on the effect of different concentrations of IBA, NAA treated with different combinations in cuttings on the rooting percentage, number of roots, promoting better shoot characters using different media and observed better performance on the root as well as shoot characteristics (Pandey, 2010; Kareem, 2013; Hafeez et al. 1991; Gautam et al. 2010; Tready, 1983; Rahman et al. 2004; Reddy, 1998; Tavares, 1994; Vale et al. 2008; Wahab 2001; Noor et al. 2004; Padilla-Ramirez et al. 2003; Rahman et al. 1991; Rahman et al. 1988; Maqbool, 1973)

3. Grafting

Inarching is another method of propagating guava: this technique may yield up to 95 per cent success but is more laborious than cutting or layering. Maximum percentage of graft sprouting, number of flushes per sprout were recorded in plants grafted under shade net condition when compared to the plants grafted under poly house condition and also the maximum percentage of graft sprouting, less number of days taken for 50 % of graft sprouting and number of flushes per sprout were also recorded in the plants grafted during January month (Vanaja et al. 2017)  

Sweeti et al. (2016) reported that the maximum bud sprouting percent (44.76%) was recorded in 5th March grafting and graft success per cent (69.08%) and shoot length (14.00 cm) was observed maximum in plants grafted on 20th February recorded after 90 days of grafting. The earlier formation of cambial tissue between stock and scion increased the percentage of graft sprouting and development of new flushes on the sprout (Taiz and Zeiger, 2012)  

Gotur et al. (2017) reported that wedge grafting in the month of August gave better results in polyhouse (69.88 %) as well as in open field condition (67.12 %). The most success of grafts in month of August might be due to optimum temperature and high humidity prevailed during this period which had resulted in successful union of cambium layers of stock and scion, early callus formation and initiation of subsequent growth. Abbas et al. (2013) observed that the maximum success percentage (59.26) was achieved in plants budded by T-grafting followed by T-budding. Significantly high graft success and survival percentage was noticed in 35 per cent shade house (68.80 and 87.19 %, respectively) followed by 50 per cent shade house (58.00 and 79.13 % respectively) (Manga 2017)  

Similar experiments have been carried out by different workers in Psidium guajava on various parameters of grafting and highest number of leaves with minimum time with respect to the various planting time (Mahendra et al. 2015; Singh et al. 2005; Munthaj 2014; Syamal et al. 2012; Rani et al. 2015; Singh et al. 2000; Beera et al. 2013; Nanditha et al. 2017; Singh et al. 2007; Visen et al. 2010; Singh et al. 2011; Singh 2010; Shashi et al. 2012; Gurjar et al. 2012; Gurjar et al. 2012).

4. Budding

Different budding techniques like Forkert, shield, patch, chip, etc. have been tried in guava with different degrees of success. Jaffco (1970) developed green chip method of budding on guava seedling (5mm in diameter). He suggested that this can also be adopted successfully for top working on older trees. Sohnika et al. (2015) reported that the patch budding performed during 15 to 21 August showed highest per cent success (92.07%) recorded after 90 days of guava propagation. Bhatt et al. (2013) reported that the patch budding during mid June showed better response with respect to number of sprouted buds (7.49), survival percentage (73.33%), average length of sprout (50.27 cm), average length of leaves on new growth (6.67 cm), average width of leaves (3.71 cm) and leaf area (53.86 cm²). Patel et al. (2017) reported that the highest budding success, maximum length of sprouts, number of leaves/plant, leaf width and minimum number of days taken for sprouting was recorded in cultivar Allahabad Safeda. While, sprouts girth and leaf length was recorded under cultivar Hybrid-1.

5. Seed Germination

Most of guava plantations in India are seedling origin. Traditionally, it is mostly propagated from seed (Zamir et al., 2003)  

The germination of guava seed was improved by soaking it in tap water before sowing. The highest germination 83.79 and 80.30 percentage was recorded with GA3 (1000ppm) and (500 ppm) respectively which were superior to other treatments. However, seed treatment with Conc. H2SO4 for 5 minutes did not influence germination (Kalyani et al. 2014)  

The germination of guava seeds is uncertain due to hard seed coat (Singh, 1967)  

The pre-sowing soaking improved seed germination of guava seeds up to 60% with GA3 100 ppm in comparison to 46% in untreated seeds (Kumar et al., 1991)  

Pandey and Singh (2000) reported that the maximum percentage of germination (90%) and a reduced time for seedling emergence in comparison to seeds soaked in H2SO4, HCl, and HNO3. Essien (2004) reported that maximum germination percentage was recorded with conc. sulphuric acid (98%) followed by nitric acid (93%) and hydrochloric acid (78%) over control (20%). Manoj et al. (2013) observed that guava seeds scarified with 10% hydrochloric acid for 2 minutes were found superior over control with highest percentage of seed germination, seed vigour index, survival percentage of seedlings. Manoj and Rajesh (2013) found that pre-soaking of guava seeds in 10% hydrochloric acid for 2 minutes resulted in maximum seed germination percentage. Among the different seed treatments, soaking in GA3 3000 ppm for 24 hours resulted in significantly higher seed germination, co-efficient of germination velocity, shoot length, seedling girth, vigour index, maximum number of leaves per seedling, leaf area, fresh weight and dry weight of seedlings (Munthaj 2014).

Conclusions

It may be concluded that guava can be successfully propagated by layering with application of plant growth regulators and time of planting. So increasing the production of guava fruit layering is one of the easy processes for developing the guava plant as soon as possible.

References


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