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Krishan Kumar Singh
Department of Horticulture, School of Agriculture Sciences, Career Point University Kota, Rajasthan, India

Correspondence
Krishan Kumar Singh
Department of Horticulture, School of Agriculture Sciences, Career Point University Kota, Rajasthan, India

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

Krishan Kumar Singh

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 GA_3 (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 Mehrotra, 1985; Kaundal *et al*., 1987) [14, 29], air layering (Singh and Singh, 1970; Sharma *et al*., 1978; Manna *et al*., 2001) [67, 63], 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) [80]. Patel *et al*. (1989) [52] 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) [26]. Ramteke (1998) [58] 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) [62] 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) [90] reported that the rooting success increased with the increasing growth regulators concentration. Survival rates were maximum with 15000 ppm NAA. Shrivatava (2000) [66] 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. Hammaselwe (2005) [19] 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 homogeneous plant material to supply research and farmers. Gauther *et al.* (1996) reported that auxin naturally or artificially applied is 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) [25] 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 bag 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) [82].

Maurya *et al*. (2012) [42] 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) [18]. 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 achived 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 *at el*. (2017) [36] 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) [18]. Baghel *at el*. (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) [89]. Rooting among the vegetative methods of propagation is undoubtedly the most evolved and expanded method (Manica *et al*., 2000) [37] 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%). Abdullah *et al.* (2006) reported that the cuttings of guava gave 60 % rooting and 70.9 % survival percentage in the non-mist propagator when treated with 4000 ppm concentration of IBA. Tready (1983) [91] observed that rooting percentage could be increased from 0 to 30.5 percent in hardwood cuttings of guava treated with 500 ppm IBA. He further stated that IBA enhanced rooting in case of two-year old cuttings. Khattak *et al*. (1983) [30] tried IBA at different concentration in semi hardwood cuttings of guava and achieved 4% rooting in cuttings of guava with the treatment of 6000 ppm of IBA. Kareem *et al*. (2016) [2] observed that the IBA (4000ppm) showed maximum results in terms of sprouting percent, number of roots per cutting, average root length respectively. In absence of indole-3-butyric acid treatment, cuttings had not rooted. 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 (Kamboj *et al*. 2017) [27]. The stem cuttings can give good rooting and survival, when cuttings are taken in July (Singh *et al*., 2017) [70].

IBA at 2500 ppm exhibited the best performance (73.3 to 83.3% rooting success, 5.82 to 7.16 primary roots and 101.2

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) [8]. Kareem (2013) [28] 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) [50, 28].

3. Grafting

Inarching is a 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) [93]. Sweeti *et al*. (2016) [86] 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) [88]. Gotur *et al*. (2017) [46] 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) [1] 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) [36]. 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) [23] 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) [85] 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) [7] was 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 (50.27cm), average length of leaves on new growth (6.67 cm), average width of leaves (3.71 cm) and leaf area (53.86 cm^2). 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) [97]. 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.H_2So_4 for 5 minutes did not influence germination (Kalyani *et al*. 2014) [37]. The germination of guava seeds is uncertain due to hard seed coat (Singh, 1967) [83]. The pre-sowing soaking improved seed germination of guava seeds up to 60% with GA_3 100 ppm in comparison to 46% in untreated seeds (Kumar *et al*., 1991) [31]. Pandey and Singh (2000) [49] reported that the maximum percentage of germination (90%) and a reduced time for seedling emergence in comparison to seeds soaked in H_2SO_4, HCl, and HNO_3. Essien (2004) [11] 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) [39] 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) [40] 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) [45].

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

1. Abbas MM, Javed MA, Ishfaq M, Alvi MA. Grafting techniques in guava (*Psidium guajava* L). Journal of Agricultural Research. 2013; 51(4):465-471.
2. Abdul Kareem, Abdul Manan, Shafqat Saeed, Shoaib Ur Rehman, Umbreen Shahzad, Muhammad Nafees. Effect of different concentrations of IBA on rooting of Guava *Psidium guajava* L. in low tunnel under shady situation. Journal of Agriculture and Environment for International Development - JAEID. 2016; 110(2):197-203.

3. Abdul Kareem, Muhammad Jafar Jaskani, Bilquees Fatima and Bushra Sadia. Clonal Multiplication of Guava through Softwood Cuttings Under Mist Conditions. Pak. J Agri. Sci. 2013; 50(1):23-27.
4. Baghel, Murlimanohar, Raut UA, Ramteke Vikas. Effect of IBA Concentrations and Time of Air- layering in Guava cv. L-49. Research Journal of Agricultural Sciences. 2016; **7**(1):117-120.
5. Beera K, Yadav AL, Akhilendra V. Effect of grafting time and environment on the graft success of guava (*Psidium guajava* L.) under wedge grafting. Trends in Bio Sci. 2013; 6:770-772.
6. Bhanuprakash K, Yogeesha HS, Vasugi C, Arun MN, Naik LB. Effect of pre-soaking treatments and temperature on seed germination of guava (*Psidium guajava* L.) Seed Science and Technology. 2008; 36(3):792-94.
7. Bhatt BB, Tomar YK, Rawat SS. Effect of time and methods of budding in multiplication of guava cv. Allahabad Safeda under valley conditions of Garhwal Himalaya. *Progressive Horticulture.* 2013; 45(2):278-280.
8. Debnath GC, Maiti SC. Effect of growth regulators on rooting of soft wood cuttings of guava (*Psidium guajava* L.) under mist. *Haryana Journal of Horticultural Sciences*. 1990; 19(1-2):79-85.
9. Devlin RM. Plant physiology. Affi. East-West press Pvt. Ltd. Dehli, 1974, 317 and 381.
10. Dhua RS, Sen SK. Role of etiolation, auxinic and non-auxinic chemicals on root initiation of air-layers of jackfruit (*Artocarpus heterophyllus* Lam.). Indian J Hort. 1984; 41(1&2):116-119.
11. Essien EP. Breaking of seed coat dormancy in guava. Tropical Science. 2004; 44(1):40-42.
12. Evans J. Plantation Forestry in the Tropics. 2nd Ed. Pergamon Press, Oxford – London, N.Y., Paris, 1992, 236.
13. Gautam NN, Singh K, Singh B, Seal S, Goel A, Goel VL.. Studies on clonal multiplication of guava (*Psidium guajava* L.) through cutting under controlled conditions. Australian Journal of Crop Science, Lismore. 2010; 4(9):666.
14. Gupta MR, Mehrotra NK. Propagation studies in guava (*Psidium guajava* L.) cv. Allahabad Safeda. J Res. PAU, Ludhiana. 1985; 22:267-69.
15. Gurjar P, Singh R. Performance of wedge grafting in anola at polyhouse and open field conditions. Environment and Ecology. 2012; 30(3):531–6.
16. Gurjar PS, Singh R, Maskar SB, Singh N, Choubey R. Propagation of guava by wedge grafting under polyhouse and open field conditions. *Plant Archives*. 2012; 2(12):827–32.
17. Hafeez UR, Khan MA, Khokhar KM, Laghari MH. Effect of season on rooting ability of tip cuttings of guava (*Psidium guajava*) treated with paclobutrazol. Indian Journal of Agricultural Science. 1991; 61(6):404-406.
18. 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.
19. Hammasselbe A. Vegetative multiplication of guava (*Psdium guajava* L.) in the sudansahelian climate of north Cameroon. Tropicultura. 2005; 23:2-105-109.
20. Haq F, Khan MS, Faridullah I. Germination trial on guava seed. Pakistan J Agriculture Research. 1973; 11:121.
21. Hartmann HT. Some physiological factors involved in propagations by hardwood cuttings. Proc. Int. Pl. Prop. Soc., 1969; 19:108.
22. Hartmann HT, Kester DE, Davies FT, Geneve RL. Plant propagation principles and practices. Prentice hall ENG. Cliffs, New Jersey, 1997, 276-391.
23. Jaffe A. Plant Propagator 1970; 16:6.
24. Jat DK, Singh KK, Mehta SK, Rana DK. Effect of Growing Conditions and Time of Planting on the Rooting in Stem Cutting of Mulberry (*Morus alba* L.) Under Sub Tropical Valley Condition of Himalaya Region. *The Bioscan*. 2017; 11(1):511-514.
25. Kakon AJ, Rahim MA, Alam MS. Effect of steps of cutting on the survivability and growth of two varieties of guava air-layers. Journal of Subtropical Agricultural Research and Development. 2005; 3(1):34-38.
26. Kale, vijay. Effect of different concentration of IBA and NAA on rootage and growth of air-layering of guava (*psdium guajava* L.). var. Gwalior-27 unpublished thesis submitted to J.N.K.V.V. Jabalpur for MSc. (Ag) Dgree, 1996.
27. Kamboj S, Singh K, Singh, Gandhi N. Effect of Indole Butyric Acid on Rooting and Vegetative Parameters of Pomegranate *(Punica granatum* L.) Cuttings. International Conference on Recent Innovative in Science, Agriculture and Management.Guru Kashi University, Bathinda Punjab India, 2017.
28. Kareem A, Jaskani MJ, Fatima B, Sadia B. Clonal multiplication of guava through softwood cuttings under mist conditions. Pakistan Journal of Agricultural Science, Faisaladab 2013; 50:23-27.
29. Kaundal GS, Gill SS, Minhas PP. Budding techniques in clonal propagation of guava. Punjab Hort. J. 1987; 27:208-11.
30. Khattak MS, Inayatullah M, Khan S. Propagation of guava from semi hard wood cuttings. Frontier J Agri. Res. B. 1983; (1):81-92.
31. Kumar CS, Palaniswamy V, Jayaraj T, Arumugam R. Studies on certain seed technological aspects in guava (*Psidium guajava* L.). South Indian Horticulture. 1991; 39:315-16.
32. Kumar K, Swamy GSK, Kanamadi VC, Gangadharappa PM, Prasad kumar, Jagadeesha RC *et al.* Effect of pre-curing of scion on softwood grafting success in guava. Karnataka J Agri. Sci. 2012; 25(2):289-290.
33. Luis AS, Raul S, Rodrigo TJC. Vegetative propagation of guava by different types of cuttings. *Hort. Sci.*, 1986; 21:663.
34. Kalyani M, Bharad SG, Parameshwar Polu. Effect of Growth Regulators on Seed Germination in Guava. International Journal on Biological Sciences. 2014; 5(2):81-91.
35. Mahendra J, Yogesh S, Singh SS, Mishra SP. To Study the suitable period of wedge grafting in guava under different condition of Chitrakoot Region. American Int. J of Research in Formal, Appl. Natural Sci. 2015; 9(1):30-32.
36. Manga B, Jholgiker P. Studies on Performance of Softwood Grafting in Guava (*Psidium guajava* L.) cv. Sardar as Influenced by Different Shade Intensity. Int. J Curr. Microbiol. App. Sci. 2017; 6(6):2792-2795.
37. Manica I. Propagation In: Manica I. Icuma Im, Junqueira Ntv, Salvador Jo, Moreira A., Malavolta E. 2000. Eds. tropical fruit-6: guava. oporto alegre: five continents. cap. 2002; 5:85-111.

38. Manna A, Mathew B, Ghosh SN. Air layering in guava cultivars. Journal of Interacademicia, Nadia. India. 2004; 2:278-281.
39. Manoj B, Rajesh K. Studies on seed germination and subsequent seedling growth of guava (*Psidium guajava* L.). Indian Journal of Agricultural Research. 2013; 47(4):347-52.
40. Manoj B, Rajesh K, Mishra DS. Effect of pre-sowing treatments on seed germination of guava (*Psidium guajava* L.) under Tarai region of Uttarakhand. *Progressive Horticulture*. 2013; 45(2):63-68.
41. Maqbool M, Khan DA. Propagation of fruit plants, studies on the propagation of guava by stem cuttings. Pak. J Agri. 1973; 4:177-193.
42. Maurya RK, Ray NR, Chavda JC, Chauhan VB, Patil AK. Evaluation of different organic mediaand water holding materials with IBA on rooting and survival of layering in guava (*Psdium guajava* L.)cv. Allahabad Safeda. Asian Journal of Horticulture. 2012; **7**(1):44-47.
43. Mitra GC, Bose N. Rooting and histological responses of detached leaves to B- Indolebutyric acid with special reference to *Boerhavia diffusa* Linn. Phytomorphology 1954; 7:370.
44. Mukherjee SK, Majumder PK. Vegetative propagation of tropical and subtropical fruit crops. ICAR, New Delhi, 1983.
45. Munthaj. Studies on improvement of seed germination and season of wedge grafting in guava (*Psidium guajava* L.). M.Sc Thesis. Horticultural College and Research Institute, Dr. Y.S.R. Horticultural University. Anantharajupet, Dr. Y.S.R. Kadapa district, Andhra Pradesh, 2014
46. Mutteppa Gotur, Sharma DK, Chawla SL, Joshi CJ, Navya K. Performance of Wedge Grafting in Guava (*Psidium guajava* L.) Under Different Growing Conditions. Plant Archives. 2017; 17(2):1283-1287.
47. Nanditha GC, Patil DR, Patil SN, Venkateshalu, Gandolkar K. Study the Effect of Different Growing Conditions and Varieties on Graft-Take, Leaves and Scion Diameter in Guava (*Psidium guajava* L.). Int. J Pure App. Biosci. 2017; 5(4):601-606.
48. Noor R, Tehsinullah Nabi G, Jan T. Effect of different growth regulators and types of cuttings on rooting of guava (*Psidium guajava* L.). Quar. Sci. Vis. 2004; 1:3-4.
49. Pandey D, Singh HP. Effect of seed pre-treatment on promotion of germination in guava (*Psidium guajava* L.). Annals of Agricultural Research. 2000; 21(2):279-81.
50. Pandey SK, Bisen A. Effect of mechanical treatments on rooting in cuttings of guava, lemon and pomegranate. Journal of Horticulture and Forestry, Nairobi. 2010; 2(5):95-98.
51. Patel K. To study the effect of growth regulators and wrappers on air-layering of guava (*Psdium guajava* L.).M.Sc. (Ag.) Thesis, J.N.K.V.V., College of Agriculture, Jabalpur (M.P.), 1985.
52. Patel RB, Patel MP. Effect of growth regulators and polythene wrappers on rooting of air-layering of guava. *Bhartiya Krishi Anusandhan Patrika*. 1989; 4(3):145-148.
53. Patel RK, Yadav DS, Singh A, Yadav RM. Performance of Patch budding on different cultivars/hybrids of Guava under mid hills of Meghalaya. *Acta Hortic*, 2007; 735:189-192.
54. Pathak RK, Saroj PL. Studies on the propagation of guava species by stool layering. Fruit Res Workshop, Subtropical and Temperate Fruits, RAU, Pusa, Bihar. Rathore, 1988.
55. Rahman HU, Khan MA, Khokhar KM, Laghari HM, Rahman H. Effect of season on rooting tip cuttings of guava treated with paclobutrazol. Ind. J Agric. Sci. 1991; 61:404-406.
56. Rahman HU, Khan MA, Niazi ZM, Laghari HM, Rahman H. Rooting of different types of guava stem cuttings using growth regulator. Pak. J Agric. Res. 1988; 9:363-365.
57. Rahman N, Nabi TG, Taslim J. Effect of different growth regulators and types of cuttings on rooting of guava *Psidium guajava* L. Quar. Sci. Vis. 2004; 91:3-4.
58. Ramteke NH, Verma RM, Damke MM, Patil VS, Panchbhai DM. Studies on propagation in guava *(Psdium guajav*a L.) under Akola conditions. PKV Research Journal. 1998; 22(2):180-182.
59. Rani S, Sharma A, Wali VK, Bakshi P, Ahmed S. The standardization of method and time of propagation in guava (*Psidium guajava*). Indian Journal of Agricultural Sciences. 2015; 85(9):38-45.
60. Rathore TR. Studies on the effect of different rooting media and various concentration of IBA on rooting, growth and survival of air-layering of guava. M.Sc. (Ag.) Thesis, J.N.K.V.V., College of Agriculture, Jabalpur (M.P.), 1982.
61. Reddy KM, Singh RN. Efficacy of plastic house propagation of guava through cuttings. Ind. J Agri. Sci. 1998; 58:81-82.
62. Saroj PL, Pathak RK. Propagation of *Psdium* species through stooling. Indian J Hort. 1998; 55(3):183-189.
63. Sharma KK, Jawanda JS, Gill SS. Propagation of guava by mound layering. Punjab Hort. J. 1978; 18:65-67.
64. Sharma RS. Studies on effect of different concentration of NAA and IBA with three date of operation on rootage and growth of air-layers of guava (*Psdium guajava* L.) var.Sardar guava. M.Sc. (Ag.) Thesis, J.N.K.V.V., College of agriculture, Jabalpur (M.P.), 1985.
65. Shashi K, Gangadharappa PM, Prasad KR, Jagadeesh SL. Effect of pre-curing of scion on softwood grafting success in guava. Karnataka J Agric. Sci. 2012; 25(2):289-290.
66. Shrivastva PK. Effect growth regulators in combination and different rooting media on rooting and survival of air layers of guava (*psdium guajava* L.). var. G-27. unpublished thesis submitted to J.N.K.V.V. Jabalpur for the degree of MSc. (Ag), 2000.
67. Singh BP, Singh IJ. Studies on the effect of source and plant growth regulators on the performance of air layers of guava (*Psidium guajava* L.). J Res. PAU. 1970; 12:23-25.
68. Singh G, Gupta S, Mishra R, Singh A. Technique For Rapid Multiplication of Guava (*Psidium guajava* L.). Acta Hortic. 2007; 735:177-183
69. Singh G, Gupta S, Mishra R, Singh GP. Wedge grafting in guava – A novel vegetative propagation technique, Pub. CISH, Lucknow, 2005, 12.
70. Singh G, Pandey S, Singh K. Vegetative propagation of guava through wedge grafting. *Progressive Horticulture* 2011; 43(2):203-10.
71. Singh G, Singh AK, Verma A. Economic evaluation of crop regulation treatments in guava (*Psidium guajava* L.). Indian J Agric. Sci. 2000; 70:226-30.
72. Singh KK. Effect of IBA Concentrations on the Rooting of Pomegranate (*Punica Granatum* L.) cv. Ganesh Hardwood Cuttings under Mist House Condition. Plant Archives 2014; 14(2):1111-1114.
73. Singh KK, Rawat JMS, Tomar YK. Influence of IBA on Rooting Potential of Torch Glory Bougainvillea glabra

During Winter Season. Journal of Horticultural Science & Ornamental Plants 2011; 3(2):162-165.
74. Singh KK, Choudhary T, Kumar P. Effect of IBA concentrations on growth and rooting of *Citrus limon* cv. Pant Lemon cuttings. Hort Flora Research Spectrum 2013; 2(3):268-270.
75. Singh KK. Vegetative Propagation of Pomegranate (*Punica granatum* L.) through Cutting- A Review. Int. J Curr. Microbiol. App. Sci. 2017; 6(10):4887-4893.
76. Singh KK. Propagation of citrus species through cutting: A review. Journal of Medicinal Plants Studies. 2018; 6(1):167-172.
77. Singh KK. A review: Multiplication of Bougainvillea species through cutting. International Journal of Chemical Studies. 2018; 6(2):1961-1965.
78. Singh KK, Rawat JMS, Tomar YK. Influence of IBA on Rooting Potential of Torch Glory *Bougainvillea glabra* During Winter Season. Journal of Horticultural Science & Ornamental Plants 2011; 3(2):162-165.
79. Singh S, Singh KK. Effect of various concentrations of IBA and types of stem cuttings on the performance of rooting in Sweet Orange (*Citrus sinensis* l. Osbeck) cv. Malta under mist. The Bioscan. 2016; 11(2):903-906.
80. Singh MB, Sharma BK, Yadav HS. Response of plant growth regulators and layering date on air-layering of Jackfruit. Advanced in plant Sciences. 1995; 8:130-133.
81. Singh P, Chandrakar J, Singh AK, Jain V, Agrawal S. Effect on rooting in Guava cv. Lucknow-49 through PGR and organic media under chhatishgarh condition. *Acta Horiculture* 2007; 735:197-200.
82. 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 Hortic*. 2007; 735:197-200.
83. Singh R. Fruits, National Book Trust of India, New Delhi, 1967, 87-88.
84. Singh VA, Singh JN, Surendra P. Standardization of wedge grafting in guava under North Indian plains. Indian. J Hort. 2010; 67:111-114.
85. Sohnika Rani P, Akash A, Sharma VK, Wali Bakshi P, Shahnawaz A. The standardization of method and time of propagation in guava (*Psidium guajava*). Indian J Agric. Sci. 2015; 85(9):1162-1169.
86. Sweeti C, Bisen BP, Pandey SK. Effect of Different Season and Deblading on Wedge Grafting in Guava (*Psidium guajava* L.) Cv. Lucknow-49. International Journal of Agriculture Sciences. 2016; 8(57):3151-3153.
87. Syamal MM, Katiya R, Mamta J. Performance of wedge grafting in guava under different growing conditions. Indian J. Hort. 2012; 69(3):424-427.
88. Taiz L, Zeiger E. Text book of plant physiology. Fifth edition. Published by sinauer associate Inc publishers. Sunderland. Massachusetts. USA. 2012, 546-580.
89. Tavares MSW. Propagation of guava *Psidium guajava* L. through cuttings. Thesis MA-Faculty of Agronomy "EliseuMaciel", Universidade Federal de Pelotas, Pelotas, 1994, 66.
90. Tomar KS, Gurjar BS, Tomar RSS. Response of different concentrations of IBA and NAA on rootage and growth of air-layers of guava (*Psdium guajava* L.)cv. Gwalior-27. *Advances in plant Science*. 1999; 12(2):535-538
91. Tready MT. Effect of IBA on the kiwi fruit and guava hard wood cuttings. Plant Propagation. 1983; 28(4):7-10.
92. Vale MR, Chalfun NNJ, Mendonca V, Miranda CS, Coelho GVA. Indole butyric acid and sucrose on the rooting cuttings of guava cultivar Paluma. Caat. Natal/. Brazil 2008; 213:69-74.
93. Vanaja L, Swami DV, Prasanna Kumar B, Subbaramamma P. Effect of Grafting Time on Growth and Success Rate of Guava (*Psidium guajava* L.) Wedge Grafts Grown under Shade Net and Poly House Conditions. Int. J Curr. Microbiol. App. Sci. 2017; 6(10):771-779.
94. Visen A, Singh JN, Singh SP. Standardization of wedge grafting in guava under North Indian plains. Indian Journal of Horticulture. 2010; 67(4):111–4.
95. Wahab F, Nabi G, Nawab A, Muslim S. Rooting response of semi-hardwood cuttings of guava *Psidium guajava* L. to various concentrations of different auxins. J Bio. Sci. 2001; 14:1984-1987.
96. Wally YA, El-Hamady MM, Boulos ST, Abu-Amara NM. Rooting experiments on guava using hardwood stem cuttings. Egypt J Hort. 1981; 8:77-86.
97. Zamir R, Khattak GSS, Mohammad T, Ali N. In vitro mutagenesis in guava (*Psidium guajava* L.). Pakistan J Bot. 2003; 35(5):825-828.