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Performance of Guava Stem Cutting – A Review of Successful Though Non-commercial Propagation Method

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Abstract

Propagation of Guava (*Psidium guajava* L.) can be successfully performed by stem cutting as demonstrated by many researchers time to time. Though, guava is found hard to root, use of root inducing hormone (IBA, IAA, NAA etc.), rejuvenating techniques (fungicide, wounding, Girdling etc.), growth supporting media (silt, Sand, cocopeat, vermicompost, vermiculite etc.) and suitable protected environment (mist house, polyhouse, net house etc.) ease the rooting of cutting. Despite of the fact that propagation through cutting is easiest and most convenient method of vegetative propagation to regenerate numerous planting materials in short duration, wedge grafting is still recommended as commercial method of propagation in Guava. This scenario raises the question on potentiality of stem cutting as viable propagation method. This might be due to complex mechanism behind guava stem cutting propagation which results in inconsistent and highly variable results. Moreover, propagation involves multiple factors which have combined influence on the performance of stem cutting viz., preparation of cutting, preconditioning treatment, season of taking cutting, type of cutting, chemical treatment, growing environment, growing media and container. Therefore, to establish guava stem cutting as viable and commercial propagation technique, in depth study of these factors is vital. This paper briefly discusses the research so far has done with relevance to various factors influencing performance of guava stem cutting while indicating possible future research directions for more encouraging and consistent results.

Keywords: Guava, stem cutting, plant growth regulator, propagation, *Psidium guajava* L.

1. Introduction

Guava (*Psidium guajava* L.) belongs to family myrtaceae, is considered to be one of the exquisite, nutritionally valuable and remunerative crops while holding status of fourth most important fruit crop of India. In world, India is leading producer of guava with largest cultivated area. (Anonymous, 2020) Production of quality planting material for fruit crop of such commercial importance is essential need of hour (Kumar et al., 2022). Although, it is apparent that despite the rising need of horticultural crops, horticulture sector faces acute shortage of planting material and nursery people cannot meet the requirement (Mohapatra, 2013, Yogesh et al., 2023). In such a scenario, there is anurgent need to develop cost effective protocols, which are rapid and can provide uniform, high quality genetically predictable stocks in desired quantities within a short period of time.Guava is readily propagated by seed but inherent heterogeneity of seedling does not favour its commercialization. Furthermore, cultivation of seedling origin plants is one of the major causes behind low productivity of guava in India (Kumar et al., 2007, Prabhu, 2013). Thus, it is obvious that in spite of highest area and production, country is far behind in terms of productivity (Anonymous, 2018). Vegetative propagation of guava is now performed by inarching, air layering, wedge grafting and budding with varying degree of success (Pereira et al., 2017, Kumar et al., 2022, Vanitha et al., 2023). However, expense of maintaining plant, long duration for producing sellable plants and complex stock-scion relationship are making layering, grafting and budding less suitable method for rapid clonal propagation.

In case of cutting,it is well documented that clonal regeneration through cutting is most rapid and least expensive method (Hartman, 1969, Yogesh et al., 2023). Investigations have proved that guava is successfully propagated from stem cuttings with several manipulative treatments viz., wounding, hormonal treatment, growing environment (Siva Prakash et al., 2018, Costa et al., 2019, El-Sharony et al., 2020, Sarjiyah et al., 2021, Vanitha et al., 2023, Yogesh et al., 2023). Although, propagation of guava stem cutting was not so popular method in old days because of its difficult to root nature (Kumar et al., 2022). This limits its commercialization and thus substituting wedge grafting as recommended propagation method for guava in India (Singh, 2012) whereas, on account of cheaper cost and more convenient method with higher success and survival percentage, air layering is becoming more and more popular in India (Kumar et al., 2022). To check out the potentiality of stem cutting, author of this paper had taken a feeler trial on guava stem cutting with different type of stem cutting in different month of year along with treatment of plant growth hormones for consecutive two years in fan and pad green house. Nevertheless, trail resulted in non-considerable result (<10%). Owing to understand mechanism of guava stem cutting more precisely, review has been done of research so far has conducted.While reviewing the rooting success in stem cuttings, highly variable results (7%–70%) are noticeable in guava (Prasad et al., 1988, Yogesh et al., 2023). Such variable results, explain the complexity of propagation through cutting, pointing out the possible reason behind unpopularity of guava stem cutting propagation despite very active research. It is well studied fact that initiation of rooting mainly depends upon formation of adventitious root formation, which is a dynamic series of distinct biochemical, physiological and histological events (Davis and Hartmann, 1988) which are affected by certain internal and external factors influencing rooting of cuttings in guava (Inamine, 1969). Some of these factors are: preparation of cutting, type of cutting, different growing environment and media, time of taking cutting. Thus, there is need to study various associated aspects related to rooting of cutting viz. developmental stage, physiological condition and climatic requirement for higher success rate. Hence, considering the necessity of more factors specific research in relevance to explore potentiality of guava stem cutting, this review discusses here various influential factors affecting guava stem cutting for better understanding of concept and future research directions.

2. Influence of Preparation of Cutting

Developmental status of shoot, optimum cutting length and presence of adequate leaves and bud are the major influencing factors for rooting induction. So, it is necessary to consider these factors while preparing the cutting for planting. In most plants, the cuttings taken from juvenile (young) growth phase often root better than from adult phase as the ability of cuttings to form adventitious roots decrease with the increase in the age of the plant (Audua, 1963). Owing to this, most researchers have collected the apical shoot cuttings at juvenile phase from current season growth (Qadri et al., 2018, Siva Prakash et al., 2018, Sarjiyah et al., 2021, Yogesh et al., 2023). Manohar (1966) revealed that cuttings taken from 1-year old rooted cuttings were the best as compare to normal shoots, water sprouts, root suckers, forced sprouts. He suggested main possible factors responsible for these differences were vigour, juvenility, hormone balance, and food supply. The cutting length of 20–25 cm with four bud and 2–3 leaves was general consideration for preparation of guava stem cutting (Siva Prakash et al., 2018). Although, depending on the length of the internodes, the cutting length can be reduced to ensure that only one node remains within the rooting media (Periera et al., 2017). Promoting effect of leaves and buds is well known as they are the primary source of carbohydrate, auxin synthesis and other root promoting co-factors in the plants (Davis and Hartmann, 1988). However, in some species, the leaves are removed to reduce the loss of water due to transpiration (Sharma, 2012). Vanitha et al. (2023) comparing cuttings namely single-node cutting with one leaf, double node cuttings with two leaves and herbaceous cuttings on rooting induction and found significant difference rooting success. While, Santoro et al. (2010) studied the influence of leaf in the guava rooting and revealed that cutting with a pair of leaves had been superior to the parameters of the fresh and dry root mass while cutting without leaves showed no root formation.This result shows the essentiality of leaves presence for rooting.

3. Influence of Preconditioning Treatment

Various preconditioning treatments had been demonstrated in guava to treat cutting prior planting and prior collection for promoting rooting in guava. These treatments include use of fungicides, etiolation, girdling, wounding, mineral nutrients (Mitra and Pathak, 2018). It is observable that sometimes the rooting of cuttings initiates at better rate but their survival is low because of pathogen infection. Kareem et al. (2013) treated the cutting with copper oxy chloride solution before planting to avoid any fungal infection. While, Sarjiyah et al. (2021) proposed use of Dithane M45 solution for sterilization of cuttings to avoid any fungal attack.

Girdling or ringing is the process which blocks the downward movement of carbohydrates, hormones and other root promoting factors (Sharma, 2012) ultimately helping to initiate the rooting process much early. The findings of Gurudatt et al. (2004) observed that the increase in rooting percentage in lower portion of ringed branch might be due to optimum increase in the endogenous auxin level, phenols, carbohydrates and other bio compounds which stimulate cell division and growth. The treatment of wounding promotes rooting in cuttings by facilitating better moisture absorption and faster division of cell in wounded area (Sharma, 2012). Kareem et al. (2013) prepared the cutting in which the bark on lower portion of the cuttings was injured with knife to facilitate callusing process. El-Sharony et al. (2020) reported that the wounding treatment recorded the highest rooting % in 2 successive seasons (59.27% and 49.19%, respectively).

In contrast to it Santoro et al. (2010) observed that base lesion of herbaceous cutting in the guava not had proportion vantage on rooting. Reddy and Singh (1988) observed results correlated to this. Normally, creating base lesions increase the lignin content in the tissues which has a direct influence on the rooting capacity of cutting (Davis and Hartmann, 1988). This may explain the above results that little influence is probably because of the herbaceous type of cutting nature.

4. Influence of Seasonal Variability

Season of the year has significant influence on rooting of the cutting (Hartmann et al., 2002). Seasonal conditions in different months of the year differs country wise.However, most researchers were using protected structures for propagation eliminating external environmental factors. Thus, it would be better to emphasis on physiological growth phase of plant during particular season and prevalent climatic condition at experiment site to understand influence of seasonal variability. Mostly for best results in broad-leaved evergreen plants, cuttings should be prepared after a flush of growth has been completed and wood is partially matured, particularly during spring to late fall (Sharma, 2012). Tavares et al. (1995) found the highest rooting cutting (51.52%) from cutting collected in February. The greater rooting of the cuttings collected in February may be due to the quality of the branches grown from the winter pruning. Similar encouraging result is observable when sprouted shoots from the trimmed branches of guava during April to Septemberis used,because of favourable growth status of plant (Abdullah et al., 2001). In most plants generally high relative humidity and moderate temperature favours the rooting induction. Rahman et al. (1991) obtained maximum rooting % during 15th June to 30th August which may attribute to improved prevalent climatic conditions, which helped in improving the physiological conditions of the cutting to root. This observation is in close proximity with result of Kareem et al. (2013). For general consideration, favourable months for guava stem cutting can be summarized as shown (Table 1).

Table 1: Summery of month of taking guava stem cutting in India

Month of taking cutting	Reference
January–May	Sinha et al. (1962)
July–October	Rathore et al. (1975)
November–December	Prasad et al. (1988)
July–August	Reddy and Singh (1988)
Spring and Rainy season	Debnath and Maiti (1990)
January	Yogesh et al. (2023)

5. Influence of Type of Cutting

A proper choice of wood for cutting is an essential success factor for rooting of cuttings. Probably formation of adventitious root is under the influence of physiological state of cutting. In guava stem cutting, Kuperberg (1953) carried out pioneer studies. He classified four type of cutting on the basis of age of the guava wood which is described as below:

- "T" - Terminal growth represented by green, succulent tips (flush growth) with swollen apical bud
- "L" - Terminal growth lacking terminal bud, green and succulent at apical end to brown and semi woody at basal end; square in cross section, uppermost set of lateral buds swollen, no apical bud.
- "I" - Intermediate growth, semi woody to woody, brown in colour, ranged from square to round in cross-section; uppermost set of lateral buds swollen, no apical bud.
- "O" – Old growth; brown in colour; woody; in cross-section; uppermost set of lateral buds swollen, no apical bud.

Considering their characterization,the above four cutting can be described as herbaceous cutting, soft wood cutting, semi hardwood cutting and hardwood cutting respectively. Rahman et al. (1988) investigated leafy tip cutting from current season's growth dipped in paclobutrazol and found that leafy tip cuttings giving upto 94.44% rooting after six weeks of planting. Similar trend observed by Santoro et al. (2010) and Vanitha et al. (2023) with notable results (60–85% and 40–50% rooting, respectively) in herbaceous cutting.While in soft wood cuttings, Siva Prakash et al. (2018) found that, softwood cutting treated with IBA recorded early sprouting (19.10 days), highest rooting (74.44%) and highest sprouting (76.66%) at 3 months after planting. The results are in line up with the findings of Milhem et al. (2014), Rani et al. (2015), Kareem et al. (2016), El-Sharony et al. (2018), Qadri et al. (2018), Shahzad (2019) and Bhusari et al. (2023). With regard to response of Semi hardwood cutting, Sardoei (2014) observed positive results with variable success. Mostly hardwood cuttings are avoided in difficult to root plants, but some researchers get good results possibly because of more reserve food material inside hardwood cutting which may have been further utilized for induction of new growth. Prasad et al. (1988) carried an investigation on propagation of hardwood cutting along with bottom heat technique and it shown pronounced effect on rooting (98%). Even, when hardwood cuttings are treated with root promoting hormone like IBA, it results in significant rooting and survival. This is backed with result of Sardoei (2014). Contrast to such positive results, Rahman et al. (1988) observed no rotting in hardwood stem cutting and contended that failure of hardwood cutting was most probably due to drying. Such difficulty in hardwood cutting was also recorded by Webber (1942) and Luis et al. (1986). However, it is noticeable that, several scientists received good results irrespective of type of cutting used. Soni et al. (2016) get encouraging rooting and survival in both soft wood and hard wood types of cutting. Zamir et al. (2017) studied soft wood and semi hardwood cuttings and found that, both rooted well (73.7% and 58.9%, respectively) and survived (15% and 19.8% respectively). It is visible that in most investigations, result of softwood cuttings was more encouraging than other types of cutting even though the cuttings which were selected for the experiment had conform growth, size and age in each type. Moreover, other types of cutting too can be multiplied with the aid of protected environment and plant growth regulator treatment.

6. Influence of Growing Media and Container

Suitable growing media is one of the basic requirements for propagation as its composition helps in producing well branched, slender and flexible roots which ultimately lead to the better survivability of cutting. An ideal growing medium for rooting of stem cutting should hold the cutting properly meanwhile providing adequate moisture and free air passage to the base of the cuttings. Generally, media pH near 7.0 is considered ideal for rooting process in the cuttings (Sharma, 2012). Several researchers have studied in this direction. Gislerod (1983) mentioned that media having low water retaining capacity is best choice in rooting cuttings.Silt as a growing mediafulfil such characteristics as it has adequate porosity, aeration and drainage capacity which helped to produce more adventitious root. Qadri et al. (2018) recommended silt as growing media along with IBA while observing significantly higher number of roots (28.78±3.99), root length (24.95±5.00 cm), number of leaves (4.88±0.53), number of sprouts (3.79±0.64), shoot length (26.86±4.63 cm), sprouts length (19.09±3.05 cm), stem diameter (5.30±0.65 mm), dry weight (139.25±14.92 mg), fresh weight of guava cutting (877.57±27.26 mg) and survival (83.33±16.33%) at 3 months after planting. These results are in correlation with findings of Sardoei (2014). With regard to other media, Cocopeat is proved to be the suitable media for propagation because of its rich nutrient content, high water holding capacity, good drainage and high porosity of coir pith. This perhaps due to the release of phenolic compounds from the coir pith (Lokesha et al., 1988). Dhatrikarani (2019) suggested cocopeat for best vegetative growth of cutting viz., number of leaves cutting^{-1} (4.41 and 4.60 respectively) and leaf area cutting^{-1} (193.66 cm^2 and 203.24 cm^2 respectively). These findings were supported by the results of Costa et al. (2010). Nowadays, majority of hi-tech nurseries which have well access to different plant propagation material, are using different growing media mixtures to get advantage of their respective quality viz., vermiculite and perlite. Despite of usefulness of these media, its availability in remote areas are still of concern. In such circumstances, use of FYM and properly decomposed compost as growing media resolve the issue. Vanitha et al. (2023) used growth media composed of sand, soil and well decomposed FYM in a 2:1:1 ratio for successful rooting induction.

Apart from media, selection of appropriate planting container is important for propagation as it performs a major role in holding a medium for cutting mean while affecting rooting parameters and transplanting. The transplant containers should be large enough to sustain the cuttings for 4–6 months until the resulting plants are ready for field transplanting (Shigeura and Bullock, 1983). Costa et al. (2010) studied the different size polythene bag as container and found that the largest volume (15×21.5 cm^2) container had a higher percentage of live cuttings (61.3%) at 70 days after planting. This might be due to larger volume of the container provided better conditions for storing the guava cuttings. Though, different growing containers of varying length and size were used by researchers in their studies viz. perforated plastic tray (Abdullah et al., 2006, Yogesh et al., 2023), polyethylene bag (Vanitha et al., 2023), nursery bed (Hossain and Kamaluddin, 2005) and plastic tube (Rahman et al., 2004). Though, their investigation was not primarily focused on impact assessment of container.

7. Influence of Chemical Treatments

Various chemical treatments have been demonstrated by many researchers to treat guava stem cuttings before planting to promote rooting. These treatments include mainly plant growth regulator, mineral nutrition and other chemicals. Particularly, plant growth regulators are used extensively to encourage rooting in plants. Auxins like Indole Acetic Acid (IAA), Indole Butyric Acid (IBA) and Naphthalene Acetic Acid (NAA) is widely used as root promoting hormone. Yogesh et al. (2023) evaluated the effect of IBA on survival of guava cutting. The result of the study revealed that the apical cuttings treated with IBA @ 5000 ppm was found better for rooting percentage (69.90%), survival percentage (67.50%), time taken to root (23.75 days), number of roots per cutting (15.15, 16.25, 17.53 and 24.64) and root length (7.33, 9.78, 13.85 and 18.33 cm) respectively at 30, 60, 90 and 120 DAP, fresh root weight (3.93 and 10.15 g), dry root weight (1.13 and 2.18 g) at 60 and 120 DAP, respectively. Vanitha et al. (2023) revealed the highest rooting percentage (55.10%), the duration for bud sprouting (21.13 days), and number of leaves (4.83) were observed in single-node cuttings treated with IBA at a concentration of 3000 ppm concentration under mist condition. This is in accordance with the findings of Pennock and Maldonadd (1963), Prasad et al. (1988), Abdullah et al. (2001), Kareem et al. (2013), Soni et al. (2016), Zamir et al. (2017), Shahzad et al. (2019) and Bhusari et al. (2023) who received promising results when cuttings treated with varying concentration and dipping time of IBA. While, majority of investigation pointing out the lead of IBA in rooting induction, Rathore et al. (1975) demonstrated superiority of IAA at concentration of 2500 ppm quick deep treatment to receive highest survival (62.5%) in as compared to IBA and NAA. Collectively it explains that the role of auxin in above discussed experiments is multidimensional. Improved sprouting parameters may be due to role of auxin in the histological features like formation of callus and tissue and differentiation of vascular tissue (Mitra and Bose, 1958). Longer shoot and root length might be attributed that auxin induced hydrolysis and translocation of carbohydrates and nitrogenous substances in the cellular level at the base of cuttings, resulted in accelerated cell elongation and cell division under favourable environmental condition (Yogesh et al., 2023) ultimately improving weight of fresh and dry weight of root. Higher survivability of rooted cuttings is possibly due to improvement in various parameters viz., a greater number of leaves cutting^{-1}, more number of shoots and roots. Apart from inducing rooting in different type of cuttings, auxin was found to promote rooting irrespective of varieties. Debnath and Maiti (1990) investigated the success of cutting in three different guava varieties viz., Baruipur, Sardar and Harijha. They revealed that IBA at 2500 ppm exhibited the best performance (73.3–83.3% rooting success, 5.82–7.16 primary roots and 101.2–112.4 mg dry weight of roots) in all three varieties.

Apart from auxin, various other alternative chemical treatments were studied to encourage guava stem cutting rooting. Rahman et al. (2004) observed that maximum sprouting cutting^{-1} (71.22%), a greater number of branches (3.44), maximum root-weight (1.46 g), more no. of branches (3.44) and better survival (57.22%) were noted in softwood cutting treated with paclubutrazol (PBZ) at the 1000 ppm solution dipped for 5 m. Qadri et al. (2018) explained that PBZ induced increase in number of roots plant^{-1} and fresh and dry weight might be due to the inhibition of gibberellin production and increase in increased carbohydrate supply to roots resulting from reduced demand for growth above ground. They further advised that PBZ should be used at lower concentration (200 mg l^{-1}) as higher concentration may induce toxic effects on shoot growth and sprouting. El-Sharony et al. (2020) found that the application of IBA accompanied with antioxidants (mixture of 5% citric acid+5% ascorbic acid) significantly increased rooting percentage, root length and number of roots in guava by increasing ethylene content which further act as a trigger for root initiation. Therefore, it is possible to improve rooting through the application of various antioxidants such as citric acid and ascorbic acid. Hence, it is clear from above findings that IBA extensively used as primary root promoting hormonal treatment. However, its availability in remote places is still matter of concern. In such case there is need to examine locally available farm inputs which can be utilized to get better results in place of non-availability of IBA. In this direction, Sarjiyah et al. (2021) successfully used a shallot extract as a natural plant growth hormone source for inducing rooting (91.6%) in guava stem cutting which offer an alternative of IBA at farm level.

Since, it is well known that the immersion time of the cuttings in chemicals depends on the concentration of the solutions,

Table 2: Summary of vegetative propagation of guava stem cutting in India

Variety/cultivar	Type of cutting	Media	Treatment	Reference
Allahabad safeda	-	-	IAA, IBA, Phenyl acetic acid	Sinha et al. (1962)
	Soft wood cutting	-	IAA, IBA, NAA	Rathore et al. (1975)
	Hard wood cutting	Sand (with nutrient solution)	IBA, wounding	Reddy and Singh (1988)
	Hard wood and Semi hard wood cutting	Soil, silt, vermicompost, farm yard manure	IBA	Soni et al. (2016)
Lucknow-49	Hard wood, semi hardwood and soft wood cutting	Sand, soil, farm yard manure	IAA, IBA, NAA	Siva Prakash et al. (2018)
	Soft wood cutting	-	IAA, IBA, PBZ	Bhusari et al. (2023)
	Apical cutting	-	IAA, IBA, NAA	Yogesh et al. (2023)
Arka Kiran	single-node cutting with one leaf, double node cutting with two leaves and herbaceous cutting	Sand, soil, farm yard manure	IBA, NAA	Vanitha et al. (2023)
Baruipur, Sardar and Harijha	Soft wood cutting	Sand	IAA	Debnath and Maiti (1990)
Taiwan Pink	Terminal cutting	coco peat, vermiculite, saw dust	IBA	Dhatrikarani (2019)
-	-	-	NAA and IBA	Shrivastava (1962)
-	Soft wood cutting	Sphagnum moss, grit, Sand	IBA, Etherel, Benzoic acid, Catechol	Manohar (1966)
-	Hard wood cutting	-	IBA	Prasad et al. (1988)

which eventually influence the rooting success. Thus, Costa et al. (2019) specifically studied the effect of different immersing time (5, 10, 15 and 20 s) of cutting in IBA 2000 mg l^{-1}. However, they found no influencing effect in the rhizogenic process of herbaceous cuttings. Despite of significant success of various chemical treatments, yet there is a need to assess treatments at lower concentration for extended immersing time to standardize the chemical treatment more precisely.

8. Influence of Growing Environment

High relative humidity and moderate temperature is requisite to get a higher rooting and survival of cuttings. Thus, use of different type of protected structures for propagation is common nowadays. Kuperberg (1953) in his experiment suggested that when cutting confined to water mist unit, it produced encouraging results up to 80% success in rooting % in guava stem cutting. Yogesh et al. (2023) recorded that mist house growing condition was found effective in increasing the rooting performance of the apical stem cuttings. Vanitha et al. (2023) found encouraging results despite of different types of cuttings, when cutting kept under mist chamber condition. Similar positive results were recorded by Milhem et al. (2014), Costa et al. (2019), Siva Prakash et al. (2018), Sarjiyah et al. (2021). Structures like lathe house and fibreglass house were also tried by Zamir et al. (2017) and Rahman et al. (1991) respectively. Although, for commercialization of guava stem cutting it is desirable that low cost structures should be utilized more for guava propagation. Keeping this in mind, Reddy and Singh (1988) used plastic house for guava stem cutting. Likewise, Soni et al. (2016) tried net house condition with variable success. Investigations thus far reviewed above clearly indicate that the success of guava stem cutting is depends on many inter related influencing factors. Therefore, summary is given (Table 2) for easy understanding of research done so far in India regarding guava stem cutting.

9. Conclusion

Optimum length juvenile soft wood cutting has potential to generate excellent rooting in guava when treated with indole butyric acid along with growth supporting media under protected condition. Although, the information is yet scanty and imperfect in relevance to various associating factors which hurdle commercialization of guava stem cutting. Hence, a detailed study on various influential factors will help in further standardization of this efficient propagation method.

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