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Review

Vegetative propagation techniques of fruit crops through cuttings – a review

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ABSTRACT

This review article summarizes the current knowledge on vegetative propagation of fruit crops through stem cuttings, highlighting the key factors influencing rooting success. Successful propagation of fruit crops through stem cuttings depends on multiple factors, including the physiological status of the mother plant, type and length of cutting, planting season, temperature, rooting media and hormonal treatments. Among these, the timing of planting, the choice of rooting media and the application of synthetic auxins such as indole butyric acid (IBA) are particularly critical for rooting success. Various studies have demonstrated that IBA enhances root initiation, increases root number and quality and promotes shoot growth across diverse fruit species. Rooting media such as soil, sand, cocopeat, perlite, vermiculite and vermicompost provide physical support, aeration, water retention and nutrient availability, which significantly influence rooting and shooting parameters. Hardwood cuttings of pomegranate, lemon, fig, phalsa and other fruit crops showed improved sprouting, survival, plant height, shoot and root biomass and root characteristics when treated with appropriate concentrations of IBA and planted in optimal media. Early planting, particularly during February-March, further enhanced rooting due to higher carbohydrate accumulation. Overall, integrating suitable rooting hormones with well-structured media can substantially improve the vegetative propagation of fruit crops, contributing to higher success rates and uniform plant growth.

Keywords: Fruit crops; stem cuttings; rooting media; IBA; sprouting; root growth; shoot growth

INTRODUCTION

The successful multiplication of fruit crops using stem cuttings is contingent upon various factors, including the condition of the mother plant, the type of cutting, the time of operation, temperature, the rooting media and the specific rooting hormones employed (Polat and Caliskan 2009). Among these variables, the time of operation, rooting media and applied hormones are particularly crucial in determining rooting success. While certain fruit cuttings, such as those from pomegranate, can naturally induce roots without exogenous application of auxins (Melgarejo et al 2000), the use of synthetic auxins is widespread to mitigate cutting failure, even though young leaves and shoots produce natural auxins (Kasim et al 2009). The synthetic auxin, indole butyric acid (IBA), is especially important, as studies show it can accelerate rooting success by up to three-fold (Melgarejo et al 2000). IBA functions by stimulating root initiation and increasing both the number and overall quality of roots across various fruit plant cuttings (Upadhyay and Badyal 2007). Furthermore, this synthetic auxin promotes cell enlargement and elongation, which contributes to increased root length, while also inhibiting axillary bud break on the developing shoots.

The ideal plant growing medium must possess several specific characteristics, including chemical resistance, light weight, heat balance, physical stability and must serve as a source of nutrients while remaining free from insect pests and pathogens (Ercisli et al 2003). Additionally, a successful medium should be sufficiently firm and dense to keep cuttings securely in place, yet porous enough to allow excess water to drain and permit adequate aeration. Meeting these requirements helps improve nutrient absorption, water consumption, oxygen maintenance and overall plant growth, utilizing various organic and inorganic substrates. However, there is no single universal or ideal medium for all cuttings, as the specific requirements vary depending on the plant species, the type of cutting used, the season and the propagation system being employed (Hartmann et al 2002). Since no single medium fulfills all these diverse needs, developing different combinations is critical to the rooting process. For pomegranate, rooting media that can be used include sand, cocopeat, perlite, vermiculite and vermicompost.

Sand serves as a chemically inert medium characterized by a neutral pH and lack of nutrients (Alikhani et al 2011). Cocopeat is an organic material that is porous, has medium ion exchange capacity and high water absorption capacity (Schie 1999) providing sufficient aeration to the roots and maintaining a suitable pH and electrical conductivity. Cocopeat can store and supply nutrients to the cuttings over a prolonged period and thus can help make nutrients available to pomegranate cuttings (Raut et al 2015). Cocopeat and perlite possess the ability to interchange elements, especially within the substrate and ensure proper moisture distribution, which supports effective rooting and plant growth (Nourizadeh 2003). Perlite is valued as a substrate in soilless cultivation because it offers excellent features such as high water absorption capacity which increases water use efficiency (Djedidi et al 1999) and it improves aeration in the soil by facilitating gas interchanges within the media due to its porosity. Vermiculite enhances soil aeration which leads to high moisture retention and greater nutrient availability for the roots (Rajkumar et al 2016). Finally, vermicompost is rich in readily available nutrients for plant uptake, including nitrates exchangeable phosphorus, potassium, calcium and magnesium and also offers an increased water retention capacity (Khalighi and Padasht-Dehkaee 2000).

The earlier planted cuttings experienced earlier sprouting because of the higher accumulation of carbohydrates, as their planting succeeded the dormant season compared to cuttings planted later. Specifically, cuttings planted at the end of February demonstrated a higher rooting percentage than those planted at the beginning of October (Hambrick et al 1991). Hardwood cuttings that are 20 cm in length will root more quickly and easily if they are planted during February or March (Sheets et al 2004).

Effect of IBA and time of cutting on rooting and shooting parameters

Number of days taken for sprouting: Indole butyric acid (IBA) at 2,500 ppm in combination with p-hydroxybenzoic acid (1,500 ppm) was reported to induce early sprouting in pomegranate stem cuttings (Ram et al 2005). Similarly, Shukla et al (2010), while studying the effect of IBA, p-hydroxybenzoic acid (PHB) and boron (B) on rooting and shoot growth of hardwood stem cuttings of peach, observed that cuttings treated with IBA (2,000 ppm) + PHB (1,000 ppm) + B (50 ppm) exhibited significantly earlier sprouting (29.54 and 29.20 days) during both years of experimentation. In fig (*Ficus carica*), Bhuva (2013) found that hardwood cuttings treated with IBA (2,000 ppm) resulted in earlier sprouting. In pomegranate, cuttings treated with IBA (4,000 ppm) and planted under open conditions sprouted in the minimum number of days (Swathi 2013). Raut et al (2015), while examining the effect of IBA and different rooting media on pomegranate cuttings, reported that hardwood cuttings treated with IBA (2,500 ppm) showed early sprouting. Further, Hakim et al (2018) studied the influence of biofertilizer and auxin on growth and rooting of pomegranate cuttings and observed that treatment with IBA (1,500 ppm) + NAA (1,500 ppm) + Biomix resulted in early sprouting (8.60 and 7.80 days) in the cultivars Bhagwa and Ruby respectively.

Number of sprouts per cutting: The cuttings of sweet lime (*Citrus limettioides*) treated with IBA (1,500 ppm) + PHB (1,000 ppm) produced the maximum number of sprouts (Kumar et al 2004). In *Ficus hawaii*, Siddiqui and Hussain (2007) evaluated the effect of IBA and different types of cuttings on root initiation and observed that the highest number of shoots per plant (13) was recorded in cuttings treated with IBA (4,000 ppm), while the control showed the minimum. Ratnamala (2013), while studying the influence of auxins and types of cuttings on the propagation of phalsa under open and shade-net conditions, reported that cuttings treated with IBA (200 ppm) produced the maximum number of sprouts per cutting (2.26, 4.34 and 4.85) at 30, 45 and 60 days after planting respectively. In wild fig, the maximum number of sprouts was recorded in stem cuttings planted in July and treated with IBA (6,000 ppm) (Mewar and Naithani 2016). Mehta et al (2018) examined the effect of IBA concentration and planting time on rooting of pomegranate cuttings and found that the highest number of sprouts per cutting (4.66 and 4.00) occurred in cuttings treated with IBA (500 ppm) and planted on 25 January respectively.

Sprouted cuttings: The hardwood cuttings of pomegranate cultivar Ganesh treated with IBA (4,000 ppm) recorded the maximum percentage of sprouted cuttings (Gurjar and Patel 2007). Singh et al (2011), while evaluating the influence of planting time and IBA on rooting and growth of pomegranate cultivar Ganesh, reported that cuttings treated with 100 ppm (slow dip) and 2,000 ppm (quick dip) and planted in January showed a positive effect on sprouting percentage. Parmar (2015), in a study on the efficacy of IBA on rooting of stem cuttings of star gooseberry (*Phyllanthus acidus*), observed that the maximum sprouting percentage was obtained in cuttings treated with IBA (2,000 ppm) applied individually as well as in combination treatments. Singh (2014), investigating the effect of different IBA concentrations on rooting of hardwood cuttings of pomegranate cultivar Ganesh under mist house conditions, recorded the maximum number of sprouted cuttings (7.33) with IBA (5 g/l).

Sprouted cutting survival: The cuttings of pomegranate treated with IBA (2,000 ppm) recorded the highest survival rate (81.33%), followed by NAA (100 ppm) + IBA (2,000 ppm) (Upadhay and Badyal 2007). In grape (*Vitis vinifera* L) cultivar Perlette, Yadav et al (2012) evaluated the response of plant growth regulators on stem cuttings and observed that the highest survival percentage was obtained in hardwood cuttings treated with IBA (1,500 ppm) compared to semi-hardwood cuttings treated with NAA and the control. Bhuva (2013), while studying the effect of plant growth regulators on propagation of fig by hardwood and semi-hardwood cuttings, reported that hardwood cuttings treated with IBA (2,000 ppm) exhibited the highest survival percentage. Raut et al (2015), investigating the influence of IBA and different rooting media on pomegranate cuttings, revealed that hardwood cuttings treated with IBA (2,500 ppm) had the maximum survival percentage. Similarly, Singh et al (2015a) studied the effect of different growing conditions and IBA concentrations on rooting and shooting of hardwood cuttings of phalsa and found that cuttings treated with IBA (2,000 ppm) performed best in terms of survival percentage.

Plant height: The maximum plant height (37.46 cm) in *Ficus hawaii* cuttings was obtained with IBA (4,000 ppm), whereas the minimum height (5.33 cm) was recorded in the control (Siddiqui and Hussain 2007). Kaur (2015), while evaluating the effect of various IBA treatments on rooting and growth performance of hardwood cuttings of peach (*Prunus persica* L Batch), observed that hardwood cuttings of the cultivar Shan-e-Punjab treated with IBA (3,000 ppm) for 1-2 minutes produced the highest plant height.

Stem diameter: The maximum stem diameter was recorded in cuttings treated with IBA (5,000 ppm) + PHB (1,500 ppm) applied as a quick dip treatment (Ram et al 2005). Alam et al (2007), while studying the effect of different IBA concentrations on rooting of kiwi cuttings, observed that cuttings of the cultivars Hayward and Abbott treated with IBA (4,000 ppm) showed improved shoot diameter. Singh et al (2011), investigating the influence of planting time and IBA on rooting and growth of pomegranate cultivar Ganesh, found that cuttings treated with 100 ppm (slow dip) and 2,000 ppm (quick dip) and planted in January exhibited the maximum shoot girth. Singh et al (2016) reported that, among various growing media, hormonal treatments and seasons evaluated for lemon cuttings, the rainy season proved superior to the spring season with respect to average shoot diameter.

Number of leaves: Shukla et al (2010) recorded the highest number of leaves (28.35 and 29.64) in hardwood stem cuttings of peach treated with IBA (2,000 ppm) + PHB (1,000 ppm) + B (50 ppm). In guava, Abbas et al (2013) found that softwood cuttings treated with IBA (1.5%) produced a higher number of leaves (18.46) compared to the control (10.33). Singh (2014), while evaluating different IBA concentrations on rooting of hardwood cuttings of pomegranate cultivar Ganesh under mist house conditions, observed the maximum number of leaves (25.33) with IBA (5 g/l). Hakim et al (2018) studied the effect of biofertilizer and auxin on growth and rooting of pomegranate cuttings and reported that the number of leaves (41.67 and 44.60) was significantly highest in the cultivars Bhagwa and Ruby respectively, under the treatment IBA (1,500 ppm) + NAA (1,500 ppm) + Biomix.

Fresh and dry weight of shoots: The highest fresh and dry biomass of shoots was recorded in hardwood cuttings of fig treated with IBA (2,000 ppm) (Bhuva 2013). Ratnamala (2013), while studying the effect of auxins and types of cuttings on propagation of phalsa under open and shade-net conditions, reported that IBA (200 ppm) resulted in the maximum fresh (18.45 g) and dry (8.49 g) shoot weight. Swathi (2013), evaluating the role of IBA and NAA in inducing rhizogenesis in pomegranate cultivars under open conditions, observed that cuttings treated with IBA (4,000 ppm) produced the highest fresh (9.78 g) and dry (4.44 g) shoot weight. Sariki (2013) found that cuttings of tamarind (*Tamarindus indica* L) planted in June and treated with etiolation combined with IBA (1,000 ppm) recorded the highest fresh and dry shoot biomass. Parmar (2015), while assessing the efficacy of IBA on rooting of stem cuttings of star gooseberry, noted that IBA (2,000 mg/l) applied individually as well as in combination yielded the maximum fresh and dry shoot biomass. Rani (2017) studied the effect of rooting media and IBA treatments on rhizogenesis of terminal cuttings in guava cultivar Taiwan Pink and reported that cuttings treated with IBA (3,000 ppm) and planted in cocopeat produced the highest fresh and dry shoot weight.

Number of roots generated per cutting: The cuttings of sweet lime treated with IBA (1,500 ppm) + PHB (1,000 ppm) recorded the highest number of roots per cutting (Kumar et al 2004). Gurjar and Patel (2007), evaluating the effect of types of rooting media, stem cutting and growth regulators on rooting of pomegranate cultivar Ganesh, observed that hardwood cuttings treated with IBA (4,000 ppm) produced the maximum number of roots per cutting. Alam et al (2007) reported that kiwi cultivars Hayward and Abbott treated with IBA (4,000 ppm) showed the highest number of roots per plant. Siddiqui and Hussain (2007), while studying the effect of IBA concentrations and cutting types on root initiation in *Ficus hawaii*, found that the maximum number of roots per cutting (13) occurred with IBA (4,000 ppm), whereas the minimum (2.1) was recorded in the control. Upadhay and Badyal (2007), evaluating the effect of growth regulators on rooting of pomegranate cuttings, observed that IBA (2,000 ppm) resulted in the highest number of roots per cutting.

The cuttings of pomegranate treated with IBA (500 ppm) + borax (1%) in both semi-hardwood and hardwood categories recorded the maximum rooting and root number (Sharma et al 2009). Shukla et al (2010), while studying the effect of IBA, PHB and B on root and shoot growth of hardwood stem cuttings of peach, observed that the highest number of roots was obtained in cuttings treated with IBA (2,000 ppm) + PHB (1,000 ppm) + B (50 ppm). Yadav et al (2012), evaluating the response of plant growth regulators on stem cuttings of grape cultivar Perlette, reported that hardwood cuttings treated with IBA (1,500 ppm) produced the maximum number of roots per cutting compared to semi-hardwood cuttings treated with NAA and the control.

In guava, Abbas et al (2013) noted that softwood cuttings treated with IBA (1.5%) recorded the highest number of roots (21.70) compared to the control. Ratnamala (2013), in a study on propagation of phalsa under open and shade-net conditions, reported that IBA (200 ppm) resulted in the maximum number of roots per cutting (28.50). Mewar and Naithani (2016) evaluated different IBA concentrations and planting times on stem cuttings of wild fig and found that the maximum number of roots per cutting occurred with IBA (6,000 ppm) applied to cuttings planted in July. Peticila et al (2016), investigating the effect of rooting hormone treatments on propagation of *Actinidia deliciosa* (Hayward) by hardwood cuttings, observed that the maximum number of roots (17.2) was obtained with NAA + IBA (1,000 ppm).

Fresh and dry weight of roots per cutting: Hardwood cuttings of fig treated with IBA (2,000 ppm) recorded the maximum fresh and dry root weight (Bhuva 2013). Sariki (2013), while studying the effect of time, etiolation and IBA concentration on rooting of semi-hardwood cuttings of tamarind, found that cuttings planted in June and treated with etiolation plus IBA (1,000 ppm) exhibited the highest fresh and dry root weight. Ansari (2013), evaluating the influence of collecting time and rooting media on pomegranate cultivar Malas Torsh, observed that the maximum fresh root weight occurred on 21 December. Damar (2013) reported that pomegranate stem cuttings treated with IBA (2,000 ppm) recorded the maximum root fresh weight (2.30 g). Galavi et al (2013), assessing the effect of auxin (IBA) concentrations and planting beds on grape cuttings, found that IBA (4,000 mg/l) resulted in the highest fresh and dry root weight. Singh et al (2015a), studying different growing conditions and IBA levels on hardwood cuttings of phalsa, observed that cuttings treated with IBA (2,000 ppm) produced the maximum fresh and dry root weight. Kumar et al (2017) revealed that pomegranate cultivar Ganesh cuttings treated with IBA (500 ppm) recorded the highest fresh (1.77 g) and dry (1.02 g) root weight.

Root to shoot ratio: Ratnamala (2013) reported that phalsa cuttings treated with IBA (300 ppm) exhibited the maximum root to shoot ratio (0.12). Parmar (2015), while evaluating the efficacy of IBA on rooting of stem cuttings of star gooseberry, found that IBA (2,000 mg/l) applied individually or in combination produced the highest root to shoot ratio. Rani (2017), studying rhizogenesis in terminal cuttings of guava cultivar Taiwan Pink, observed that cuttings planted in cocopeat and treated with IBA (3,000 ppm) recorded the maximum root to shoot ratio.

Root diameter: The maximum root diameter was recorded in hardwood cuttings of pomegranate cultivar Ganesh treated with IBA (4,000 ppm) (Gurjar and Patel 2007). Damar (2013), while examining the effect of growth regulators and biofertilizers on survival of pomegranate cuttings, observed that IBA (2,000 ppm) produced the highest root diameter (1.23 mm). Singh et al (2015a) noted that hardwood cuttings of phalsa treated with IBA (2,000 ppm) exhibited the maximum root diameter. Singh and Tomar (2015), assessing planting time and IBA levels on woody cuttings of phalsa, reported that cuttings planted in mid-June and treated with IBA (2,000 ppm) performed best for root diameter. Singh et al (2016) observed that, among different growing media, hormonal treatments and seasons for lemon cuttings, the rainy season resulted in the highest root diameter compared to the spring season.

Length of the longest root: Siddiqui and Hussain (2007) reported that cuttings treated with IBA (4,000 ppm) produced the highest root length (11.5 cm), while the control recorded the minimum. Sharma et al (2009) found that pomegranate cuttings treated with IBA (500 ppm) + borax (1%) in both semi-hardwood and hardwood types exhibited the maximum root length. Yadav et al (2012), studying grape cultivar Perlette, observed that the longest roots were recorded in hardwood cuttings treated with IBA (2,000 ppm) compared to semi-hardwood cuttings treated with NAA and the control. Swathi (2013) reported that cuttings treated with IBA (4,000 ppm) recorded the maximum root length (27.29 cm) in pomegranate cultivars. Singh et al (2015a) found that hardwood cuttings of phalsa treated with IBA (2,000 ppm) produced the highest root length. Peticila et al (2016) recorded the maximum root length (19.3 cm) in *Actinidia deliciosa* hardwood cuttings treated with NAA + IBA (1,000 ppm). Mewar and Naithani (2016) observed that wild fig cuttings treated with IBA (6,000 ppm) planted in July showed the maximum root length. Jat et al (2017), studying mulberry under subtropical Himalayan conditions, found that cuttings planted on 10 January produced the maximum root length (13.11 cm).

Number of primary roots: The maximum number of primary roots (29.26) was recorded in hardwood cuttings of pomegranate cultivar Ganesh treated with IBA (5,000 ppm) (Singh 2014). Jat et al (2017), in mulberry, observed that the maximum number of primary roots occurred in cuttings planted on 10 January. Hakim et al (2018) reported that the number of primary roots (11.67 and 10.73) was significantly highest in pomegranate cultivars Bhagwa and Ruby, respectively, when treated with IBA (1,500 ppm) + NAA (1,500 ppm) + Biomix.

Effect of rooting media on rooting and shooting parameters

Number of sprouts per cutting: The number of sprouts per cutting was significantly increased in hardwood cuttings of pomegranate cultivar Ganesh planted in soil + sand + leaf mold medium (Gurjar and Patel 2007). In an experiment on the effect of growth regulators and potting media on morphological traits and rooting responses of *Salix* cuttings under nursery conditions, Shira and Kumar (2015) reported that soil:sand (1:1) was the most effective treatment, producing the highest number of sprouts per cutting.

Sprouted cutting: Pomegranate cuttings planted in soil + cocopeat medium recorded the highest sprouting percentage (Raut et al 2015). Singh et al (2015b) observed that maximum sprouting (64.26%) occurred in hardwood stem cuttings of lemon cultivar Pant Lemon-1 grown in soil + sand + cocopeat medium. Kumar et al (2016) reported that among all rooting media, soil + vermicompost in equal ratios resulted in the highest sprouting success (88.33%) in marigold (*Tagetes erecta* L) shoot cuttings.

Sprouted cutting survival: The highest survival (100%) was recorded in leaf-bud cuttings of Assam lemon treated with IBA (3,000 ppm) and planted in sand, whereas untreated cuttings had the lowest rooting (Nath 2000). Kumari (2014) found that pomegranate cv Bhagwa cuttings treated with IBA (4,000 ppm) and planted in coir pith + farmyard manure (FYM) had the highest survival under shade net conditions. Raut et al (2015) reported that soil + cocopeat medium provided the maximum survival percentage of rooted pomegranate cuttings. Singh et al (2016) observed that soil + sand + FYM medium resulted in the highest survival of lemon cuttings, while Singh et al (2018) found that phalsa hardwood cuttings planted in vermicompost had the highest survival (57.77%).

Plant height: Strawberry plants attained maximum height in cocopeat + perlite (4:1) medium (Arun 2013). Ramteke et al (2015) observed that papaya seedlings (cv Coorg Honey Dew) reached maximum height when treated with GA_3 (200 ppm) and grown in soil + FYM (1:1) potting media. Sharma and Godara (2017) reported that strawberry grown in cocopeat + perlite + vermicompost (3:1:1) exhibited maximum plant height, followed by cocopeat + perlite + vermicompost (2:1:1).

Stem diameter: Soil:sand (1:1) medium significantly increased the stem diameter of *Salix* cuttings under nursery conditions compared with control and other treatments (Shira and Kumar 2015).

Number of leaves: Gurjar and Patel (2007) observed that the number of leaves per cutting was highest in hardwood cuttings of pomegranate cv Ganesh planted in soil + sand + leaf mold. Ors and Anapali (2010) found that increasing soil proportion in perlite-based media reduced the number of leaves in strawberry cv Camarosa. Arun (2013) reported that strawberry grown in cocopeat + vermiculite + perlite (3:1:1) had the maximum number of leaves. Singh et al (2016) found that soil + sand + FYM medium resulted in the highest number of leaves in lemon cuttings. Sharma and Godara (2017) observed maximum leaf number in strawberry grown in cocopeat + perlite + vermicompost (3:1:1), followed by cocopeat + perlite + vermicompost (2:1:1).

Fresh and dry weight of shoot: Papaya seedlings recorded the highest fresh (7.72 g) and dry (1.01 g) shoot weight in GA_3 (100 ppm) with soil + sand + vermicompost (1:1:1) medium (Ramteke et al 2015). Raut et al (2015) reported maximum shoot dry matter in pomegranate cuttings grown in soil + cocopeat. Singh et al (2015b) found that lemon cuttings had maximum fresh weight (12.24 g) in soil + sand + cocopeat medium. Shira and Kumar (2015) observed that soil:sand (1:1) medium produced higher shoot dry weight in *Salix* cuttings compared with control and other treatments.

Number of roots per cutting: The highest number of roots (11.33) was observed in MM111 apple clonal rootstock hardwood cuttings treated with IBA (2,500 mg/l) and planted in cocopeat + perlite (Dvin et al 2011). Galavi et al (2013) reported that grape cuttings rooted best in a mixture of agricultural soil and sand with IBA treatment. Kumari (2014) found that pomegranate cv Bhagwa cuttings treated with IBA (4,000 ppm) and planted in coir pith + FYM produced the highest number of roots. Kumar et al (2016) observed that pure vermicompost medium resulted in the maximum number of roots in marigold cuttings.

Fresh and dry weight of roots per cutting: Leaf-bud cuttings of Assam lemon planted in sand after IBA (3,000 ppm) treatment showed the highest root dry weight (Nath 2000). Ors and Anapali (2010) reported that soil addition significantly increased fresh root weight in strawberry cv Camarosa. Ansari (2013) observed that pomegranate cv Malas Torsh cuttings had the highest fresh root weight in vermiculite medium. Galavi et al (2013) reported maximum fresh and dry root weight in grape cuttings grown in agricultural soil + sand medium with IBA treatment.

Root diameter: In pomegranate cv Ganesh, root diameter increased significantly in hardwood cuttings grown in soil + sand + leaf mold (Gurjar and Patel 2007). Ors and Anapali (2010) observed that strawberry roots attained maximum diameter when soil was added to perlite compared with pure perlite control.

Length of the longest root: Dvin et al (2011) reported that the longest roots (9.83 cm) were produced in MM111 apple clonal rootstock hardwood cuttings treated with IBA (1,500 mg/l) and grown in cocopeat + perlite. Kumari (2014) found that pomegranate cv Bhagwa cuttings treated with IBA (4,000 ppm) and planted in coir pith + FYM had the maximum root length. Singh et al (2016) observed that lemon cuttings attained the longest roots in soil + cocopeat medium, while Singh et al (2018) reported maximum root length (8.79 cm) in phalsa hardwood cuttings grown in vermicompost.

CONCLUSION

Vegetative propagation of fruit crops through stem cuttings is highly dependent on careful management of planting time, rooting media and hormone treatments. The use of IBA consistently accelerates root initiation, improves root quality and enhances shoot growth, making it a key tool for increasing propagation efficiency. Selecting appropriate rooting media such as soil, sand, cocopeat, perlite, vermiculite or vermicompost provides the necessary aeration, nutrient supply and moisture retention required for optimal cutting performance. Hardwood cuttings planted in early seasons (February-March) tend to perform better due to higher carbohydrate reserves, resulting in faster sprouting and higher survival rates. The integration of suitable hormonal treatments with properly structured media can maximize root and shoot development, improve plant uniformity and significantly boost the success of fruit crop propagation. This review highlights the current trends and findings in vegetative propagation, providing a comprehensive overview for researchers and horticulturists to improve propagation practices. Future research should explore species-specific combinations of media and hormones to further refine propagation techniques and achieve consistent commercial-scale outcomes.

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