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Effect of auxin and media for rooting of different fruit crop cuttings: A review

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Abstract
This review includes information on the impact of growth media and auxin concentration on the potential of fruit cuttings to root and shoot. Auxin, a kind of plant hormone, is essential to the rooting process of fruit cuttings and is required for successful propagation. When applied to the basal end of a cutting, auxin particularly Indole butyric acid (IBA) and Naphthalene acetic acid (NAA), increases root and shoot initiation, as well as growth initiation, by stimulating cell elongation, differentiation, and the initiation of adventitious roots. The choice of growing media has a considerable influence on the rooting success of fruit cuttings, influencing their establishment and growth. Different growth mediums, such as perlite, cocopeat, peatmoss, sand, and vermiculite have been evaluated for their effectiveness in promoting root development and rooting characteristics such as root initiation, root length, and overall rooting efficiency, as well as shooting characteristics such as shoot height, shoot diameter, fresh and dry weight of the shoot in fruit cuttings. Water retention capacity, aeration, nutrient availability, pH level, and microbial activity all affect the appropriateness of growth substrate for rooting. This review advances the understanding of the elements that influence the effective rooting and shooting characteristics of fruit cuttings, as well as providing significant insights for improving fruit crop propagation procedures.

Keywords: Auxin, growing media, fruit cuttings, rooting, shooting

Introduction
The use of plant growth regulators will accelerate germination, shorten the germination period, and boost the germination rate. They can also encourage the production of hydrolysing enzymes, including amylase and protease, which can hydrolyze food and could be utilized for the growth of an embryo. Additionally, to achieve a high survival rate, growing mediums and growth regulators are frequently utilized nowadays [1]. Plant growth regulators like auxins play a vital role in the rooting of cuttings as they promote adventitious rooting of the stem cuttings. Hardwood cuttings treated with auxin give better shoot and root parameters because callus and tissue formation and tissue differentiation are enhanced by the application of auxin. Also, the root primordia get activated, and root formation is enhanced when energy is provided after the polysaccharides present in the mature cuttings get hydrolyzed at a rapid rate [2]. If the right mix of plant hormones is applied in the right season, cuttings will multiply rapidly. The most often used plant hormones are indole butyric acid (IBA), indole acetic acid (IAA), and gibberellic acid (GA3). For stem growth and apical dominance, auxin is crucial. IBA is an organic compound that affects plant development in a number of ways, including root initiation and cell expansion. Based on their structural similarities and their effects on plant physiology, there are several recognized classes of plant growth regulators, including auxins, cytokinin's, gibberellins, ethylene, and abscisic acid [3]. One of the most common asexual methods of fruit production is the vegetative mode, which is the simplest and most common method. Any substrate that promotes the growth of roots and shoots is referred to as a growing medium. Perlite, cocopeat, vermiculite, peat moss, and composted materials are some of the many growth mediums utilized. A procedure for producing high-quality planting material for fruit crops may be developed using the interplay between plant growth regulators and the growing medium [4].
The progeny of seedless fruit plants, such as fig, grape, guava, and lemon, can be effectively maintained through asexual propagation, which also produces true-to-type fruit plants with

consistent growth and quality. The use of soilless growth media is rising in popularity as a means of eliminating pests and diseases that are transmitted through the soil. Globally, many soilless media are currently being used as suitable soil substitutes [5]. To promote the consistent emergence, growth, and development of plant material, the selected growing medium must contain adequate nutrients, retain moisture, and provide proper aeration. Soil or soilless media may be used in the growing medium. Perlite, cocopeat, vermiculite, sand, rice husk, vermicompost, and other materials make up the majority of a soilless medium. For optimal growth and development, seedlings are cultivated in a variety of mediums. Various organic and inorganic media, such as sand, hydrogel, sawdust, rice husk, vermiculite, perlite, and cocopeat. It was found that these media are not easily cheaply, and locally available for users [6]. Cocopeat is a by-product of processing coconuts and coir. Because of its appropriate physical and chemical characteristics, it has been suggested as a potential replacement for peat in growth media. Vermiculite, perlite, and cocopeat all contribute to improved seedling growth and easier handling of plants. Cocopeat has natural rooting hormones and antifungal qualities, while vermiculite and perlite increase the media's permeability, airflow, and water holding capacity [7]. Vermicompost is enriched soil produced by the activities of earthworms; it is also a major part of organic farming. Along with the compost, it has wastewater, which contains beneficial nutrients required for plants which are termed 'Teas' [8]. The biotechnological process of vermicompost involves a variety of organic waste materials. Certain species of earthworms are used in the process, which helps to break down the material into vermicompost, a very valuable, high-quality final product [9]. Vermicompost helps in improving media physical properties viz, bulk density, water holding capacity, porosity and also biological properties [10]. Plant growth and yield can be stimulated by vermicompost, among its many other advantageous benefits. Vermicompost has a high potential for sustaining organic based agricultural production as well as being used in horticulture and agriculture fertilizer [11].

Effect of Auxins on different fruit crops

Auxin is a fundamental part of the reconciliation of assorted biotic and abiotic natural signs to plant root improvement. As per the study conducted by many researchers, various rooting behaviour of different fruit crop cuttings that are affected by auxin treatments is discussed.

The influence of plant growth regulators on the rooting of diverse stem cuttings from guava cv. Arka Kiran under mist chamber conditions. Two plant growth regulators, IBA and NAA, were employed at various concentrations. These regulators were applied to single-node cuttings with one leaf, double node cuttings with two leaves, and herbaceous cuttings. The highest rooting percentage (55.10%), the duration for bud sprouting (21.13 days), and the number of leaves (4.83) were observed in single-node cuttings treated with IBA at a concentration of 3000 ppm. Single-node cuttings treated with IBA at 3000 ppm exhibited superior rooting and sprouting performance compared to Naphthalene Acetic Acid (NAA). Among the three stem cuttings, single-node cuttings with one leaf proved to be the most effective for rapid multiplication [12]. Among the roots sprouting, the minimum number of days taken to first sprouts (10.26 days), and average total sprouted cuttings (89.30%), diameter of shoot (6.75 mm), shoot length of cutting (24.70 cm) at 90 DAP, number of leaves per cutting (9.96) respectively, fresh weight of shoot (11.19 g) and dry weight of shoot (5.47 g) at 90 DAP was recorded in treatment IBA 1000 ppm. The maximum rooting percentage of cutting (84.32) at 90 DAPS, the length of root of cutting (10.80 cm, 18.16 cm, and 27.15 cm), the average number of roots per cutting (20.19, 24.53, and 37.52) at 30, 60, and 90 DAP, respectively, the fresh weight of root (1.39 g), dry weight of root (0.76 g), and survival percentage of cutting (90.54%) at 90 DAPS, respectively was recorded under the treatment IBA- 1000 ppm. Therefore, it is concluded that the application of IBA- 1000 ppm shows the best result for all parameters [13]. The results revealed that cuttings treated with IBA at 2000 ppm (T_5) recorded the highest values of all the traits, viz. success percentage (80.72%), least number of days for sprouting (6.85 days), number of sprouts per cutting (4.30), and plant height (47.76 cm), shoot length (23.65 cm), number of leaves (43.52), root length (26.15 cm), fresh root weight (4.50 g), and dry root weight (1.80 g), followed by T_4 (1500 ppm of IBA). Control (T_1) (without IBA treatment) observed the lowest values of the traits like success per cent of cuttings (26.14%), longest days for sprouting (13.50 days), number of sprouts per cutting (1.50), plant height (25.48 cm), shoot length (13.00 cm), number of leaves (22.15), root length (15.80 cm), fresh root weight (1.95 g), and dry root weight (0.85 g). It is suggested that semi-hardwood cutting treated with a 2000 ppm (T_5) concentration of IBA gives the overall best performance for mass multiplication of acid lime [13]. The effect of IBA concentrations (0, 1000, 2000, and 3000 ppm) on the rooting of V-1 mulberry cuttings with varying numbers of buds (one, two, three, and four). The results recorded the highest in three budded cuttings treated with 3000 ppm of IBA with respect to rooting percentage (93.33%), length of longest root (11.83 cm), and fresh weight of roots (1.52 g), which was followed by two budded cuttings treated with 3000 ppm of IBA. Poor rooting percentage (60.00%), length of longest root (5.70 cm), and fresh weight of roots (0.45 g) were recorded in one budded cutting without IBA treatment. Hence, treatment of cuttings with IBA at 3000 ppm has proven best for improving the rooting of mulberry saplings [15]. The maximum callus diameter (32.99 mm), maximum length of longest roots per cutting (20.11), maximum diameter of root (1.11 mm), and maximum rooting percentage (74.03%) were obtained in 1613 C rootstock treated with 100 ppm IAA. The use of auxins like IAA and IBA may be responsible for more roots since these compounds encourage cell proliferation and elongation, which improve root growth and result in better, relatively large shoots [16]. Among rooting aspects like the minimum days required for callus formation and root initiation, the maximum rooting percent and adventitious roots, fresh weight/air layer, and growth aspects like the maximum survivability of the air layer, the maximum mean shoot length, and the maximum mean number of branches and leaves after transplanting the air layers, they noticed that application of IBA at 5000 ppm gave the best results among all treatments [17]. The maximum total length (12.5 cm) of first order roots, highest number of roots (35.52), higher survival percentage (95.25), maximum mean root thickness (1.62mm), and higher root-to-shoot ratio was registered at IBA 5000 ppm (0.067) and NAA 5000ppm (0.04) [18]. Among the chemical treatments, auxin concentrations tested ranged from 1000 to 1500 ppm IBA. However, 1500 ppm IBA induced a significantly greater rooting percentage than the control, but no single auxin, auxin concentration or combination of auxins was clearly superior in every study. The IBA application also enhanced the number of roots developed on each cutting. In this experiment, the maximum length of the longest root (34.49 cm), which is observed with IBA and

polyamine, average root length (26.93 cm), diameter of root (1.85 mm), volume of the root (9.39 ml), fresh weight of root (9.53 g), dry weight of root (4.97 g) was noticed in treatment T_{14} (T_2 + Putrescine 3.0 mm). While the minimum length of the longest root (12.68 cm) was recorded in the control, average root length (9.13 cm), diameter of the root (0.77 mm), volume of root (1.85 ml), fresh weight of root (2.02 g), dry weight of root (0.34 g) was recorded in treatment Tl5 (control). In the present investigation, maximum root: shoot ratio on a fresh weight basis (0.29) was noticed in treatment T_1 (Indole Butyric Acid 1000 ppm) however, minimum root: shoot ratio on a fresh weight basis (0.14) was observed in treatment Tl5 (control), while maximum root: shoot ratio on a dry weight basis (0.19) was noticed in treatment T_5 (T_2 + PHB 1500 ppm), while minimum root: shoot ratio on dry weight basis (0.04) was observed in treatment T_{l5} (control) [19].

Recommended dose of auxin to enhance the root and shoot behaviour of Fruit crops

Crop name	Recommended Concentration	References
Mulberry	IBA @ 3000 ppm	[15]
litchi	IBA @ 5000 ppm	[18]
Guava	IBA @ 3000 ppm	[12]
Grape	IAA @ 100 ppm	[16]
Fig	IBA @ 1500 ppm	[19]
Pomegranate (semi-hard wood)	IBA @ 1000 ppm	[13]
Lemon	IBA @ 5000 ppm	[17]
Acid lime	IBA @ 2000 ppm	[14]

Effect of rooting media on different fruit crops

Rooting medium has a vital role in rooting percentage, ample aeration drainage to make certain quicker cocopeat is used along with other substrates like Soil, Sand and Cocopeat enhanced rooting of cutting and higher exceptional of root development. Even for the advancement of plant growth, the main rudiments such as nitrogen (N), phosphorus (P) and potassium (K) media are most effective. While selecting the appropriate media, the sort of establishing and their characteristics is the most extreme significance for the production of the quality of rooted cuttings.

The experiment revealed that in Karonda from the two seasons, the maximum survives (100.00%), highest plant height (49.04 cm), girth above union (6.36 mm), maximum number of leaves (49.88), number of shoots (7.03), and number of nodes (6.25) was recorded in T_{11}. The fastest absolute growth rate (0.0650 cm/day) and relative growth rate (0.0099 cm/cm/day) was found in T_5. The maximum fresh weight of grafts (76.67 g), longest length of root (38.73 cm), highest number of adventitious roots (27.67), and dry weight of root (10.78 g). It is proved that the size of polybag 10″×14″ with medium containing soil, FYM, and rice husk in 1:1:1 proportion is best for the survival and growth of Karonda grafts under Konkan agro-climatic conditions [20]. The effect of different growing media on the rooting ability of different types of stem cuttings of jamun. Results showed that the minimum number of days (8.37 DAP), was recorded for sprouting initiation in shoot tip cutting planted in Soil rite (75% Irish peat moss and 25% expanded perlite with pH-5.0 to 6.5), the highest sprouting percentage (36.73%) was recorded in Hardwood cuttings planted in Sand and length of longest root (15.43 cm) was found in hardwood cutting planted in soil rite media. Whereas the Hard wood cutting planted in soil rite showed better rooting percentage (44.87%) at 90 DAP [2]. The best way of enhancing the root initiation, growth and survivability of wax apple air layers by using Indole-3-Butyric Acid (IBA) and suitable rooting media. Among the rooting media, vermicompost was the almost effective treatment in promoting the rooting, leaf and shoot growth, chlorophyll accumulation, and survival of air layers. The highest survival rate (100%) of wax apple air layers was recorded in the treatment combination of 2000 mg L-1 IBA and vermicompost medium. As a result, it is concluded that the combination of 2000 mgL-1 IBA with vermicompost medium is the best option for air layering in wax apple fruit trees to produce quality planting materials [21]. Air layering in acid lime is done with the application of respective rooting media around the ringed out portion with help of the hand followed by wrapping portion with polythene film tied with jute rope. Application of Vermicompost + FYM + Sand (1:1:1) yielded the maximum root parameters, such as rooting percentage (94.33%), number of primary roots (34.40), maximum and minimum root length (10.60 cm and 0.95 cm), root fresh and dry weight (0.93 and 0.16 g), survival percentage (82%), plant height (44 cm), number of branches (8.27), and number of leaves (48.20) was significantly recorded best under the treatment combination (T_9) of vermicompost + FYM + sand (1:1:1) as compared to control [1]. The effect of vermicomposting and different organic growing media on the morpho-physiological characteristics of dragon fruit (*Hylocereus costaricensis* L.) under Indo-Gangetic plains of West Bengal. Application of vermicompost along with farm yard manure and the mustard cake had a significant effect on the dragon fruit plant height, number of fruits, fruit weight, length, diameter, edible pulp weight, and number of bracts of dragon fruit plants. the treatments of vermicompost @ 1 kg+ FYM @ 1.5 kg+ Mustard cake @ 500 g and T_4- vermicompost @ 1 kg + farmyard manure @ 1.5 kg was recommended for the improvement of the marketability of dragon fruit [22]. The effect of different growing media on the survivability, root, and shoot growth of dragon fruit cuttings, it can be concluded that the growing media affect the success and growth of cuttings. Vermicompost and soil (1:1) combinations are the best among all the treatments for most of the growth parameters. The application of soil +FYM+ Vermicompost (2:1:1) improves root and shoot growth [23]. The highest sprouting percentage (90%), shoot length (30.83 cm), number of leaves (18.83), root length (13.66 cm), number of roots (49.50), and the most negligible mortality percentage (10%) was found in plants grown in compost. This is due to improved gaseous exchanges, good drainage, the presence of high levels of organic matter, and better water holding capacity, which resulted in an increased number of roots in compost and sand [24]. The responses of Fig cuttings (Ficus carica) to different sowing dates and potting media and observed that the maximum length of root (9.8 cm), maximum shoot thickness (1.4 cm), and maximum number of leaves (4.1 cm) was found in farmyard manure, whereas the minimum was noted in soil, i.e., control. This is because cuttings planted in farmyard manure emerge earliest among other cuttings due to farmyard manure having high porosity and greater availability of moisture and nutrients, which in turn stimulates the physiological activity of fig cuttings and causes their leaves to emerge earlier than in other growing media [11]. The impact of different growing media on rooting and survival percentage of pomegranate cuttings cv. Super Bhagwa under Chhattisgarh plains conditions and reported that sand and cocopeat with a ratio of 1:1 showed significantly higher survival percentage (80.61%), maximum number of roots per cutting (32.44), length of roots per cutting (30.37 cm), diameter of roots per cutting (1.52 mm), fresh weight of roots per cutting (4.15 g), and dry weight of roots per cuttings (1.55 g) in comparison to

other growing media [26]. The minimum number of days required for first sprouting on pomegranate Cv. Bhagwa coco peat, vermiculite, perlite, and 2000 ppm IBA were used to cultivate cuttings recorded in an experiment on pomegranate Cv. Bhagwa Coco peat, Vermiculite, Perlite, and 2000 ppm IBA were used to cultivate cuttings. (11.63). The largest number of days required for initial sprouting (16.23) was reported in cuttings cultivated in Sand, Vermiculite and 1000 ppm IBA [26].

The recommended combination of media to enhance the root and shoot behaviour of fruit crops

Crop name	Recommended doses	References
pomegranate	Sand + cocopeat (1:1)	[25]
Jamun	Soil rite (75% Irish peat moss and 25% expanded perlite)	[2]
Karonda	Soil, FYM and Rice husk in 1:1:1	[20]
Grape	Compost + Sand (1:1)	[24]
Apple	Vermicompost	[21]
Fig	Farm yard manure	[11]
Acid lime	Vermicompost + FYM + Sand (1:1:1)	[1]
Dragon fruits	vermicompost @ 1 kg + FYM @ 1.5 kg + Mustard cake @ 500 g	[23]
Dragon cuttings	Vermicompost and soil (1:1)	[24]
Pomegranate (Hardwood)	Coco peat, Vermiculite, Perlite	[27]

Conclusion

This review paper examines the effect of auxin concentration and different growing media on the rooting and shooting success of fruit cuttings. Different auxin concentrations, particularly IBA and NAA, are regularly shown to increase root initiation and root length in fruit cuttings. A relatively small proportion of growing media is very important for a good start to plant cultivation and can be used for the production of quality plant material while outperforming in terms of root and shoot formation. Importantly, relationships between auxin concentration and growing media underscore the necessity for individualized ways to improve rooting efficiency in various fruit species. Today growing media along with plant growth regulators can be used to develop a protocol for the production of quality planting material for fruit crops through various modes of vegetative propagation. Their application results in the initiation of roots and shoots during the propagation of fruit crops.

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