International Journal of Botany Studies
www.botanyjournals.com
ISSN: 2455-541X
Received: 15-03-2022, Accepted: 31-03-2022, Published: 16-04-2022
Volume 7, Issue 4, 2022, Page No. 97-102

The impact of IBA and various growing media on pomegranate (*Punica granatum* L.) hardwood cuttings: A review

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Abstract
Pomegranate, a fruit crop belongs to Punicaceae family, scientific name is (*Punica granatum* L.). Pomegranate cultivation is increasing day by day as it is grown in nearly all of India's states. Production of Pomegranate is in large quantity in India. It is propagated done by air layering, hardwood cuttings and softwood cuttings. Hardwood cutting propagation is the most effective and convenient method. Cuttings take less time than other methods of propagation. In cuttings shooting and rooting are the important factors. Auxins are used for the efficient growth of roots, IBA and NAA are widely used auxins. Growing media, in addition to PGRs, play a pivotal function in cutting growth. Different growing media like Coco-peat, Vermiculite, Perlite, Sphagnum-moss, FYM, Vermicompost and Soil. The best way to grow the cuttings at commercial level is growing them with the help of PGR'S and suitable growing media such as vermiculite and coco peat, Vermiculite with Perlite and a mixture of Coco peat with vermiculite in same quantity. The quick dip method of varying IBA concentrations and spring planting are regarded to be best for fast and cost-effective pomegranate cutting development. As a result, the primary aim of the present review is to gather/compile information on the impact of various IBA treatments on the usage of various growth media for pomegranate cuttings over the years, as well as latest studies.

Keywords: auxin, IBA, NAA, growing media, coco-peat, perlite, FYM

Introduction
The pomegranate (Punica granatum L.) is a member of the Punicaceae family, which consists of just one genus Punica and two species: *P. granatum* and *P. protopunica*. Pomegranate is one of the most popular table fruits. It is a commercially and nutritionally significant species of the world's subtropical and tropical climates because of its wonderful edible fruits and medicinal and decorative applications. Pomegranate is thought to be indigenous to Iran. It is widely grown in arid parts of Southeast Asia, tropical Africa, Malaysia, India, and the East Indies (Pawar and Pushparaj, 2020) [18].
India produces the most pomegranates in the world. Pomegranate production in India spanned over 209,000 hectares, yielding 2442 thousand Tonnes with a productivity of 6.91 tonnes per hectare (Anonymous, 2017) [2]. Maharashtra, Karnataka, Andhra Pradesh, Madhya Pradesh, Gujarat, Uttar Pradesh, Jharkhand, Himachal Pradesh, Haryana, Jammu and Kashmir, Punjab, and West Bengal are among the states that cultivate pomegranates. Seeds are used to propagate the pomegranate, but seedlings are unsatisfactory. Fruits are unevenly sized and yields are low on seeded plants. Cutting and layering are the most frequent ways for propagating pomegranates. Pomegranates are commonly grown through air layering, hard-wood cuttings, and semi-hard wood cuttings because stem cuttings are the easiest, most successful, and convenient means of propagation (Sharma *et al.*, 2009) [24]. Pomegranate cuttings are the most efficient and cost-effective approach to quickly generate fully formed and stronger plants. Rooting of pomegranate cuttings is influenced by a variety of parameters, including the parent plant's physiological state, cutting type, cutting season, rooting media, and the usage of rooting hormones (Polat and Caliskan, 2009) [19].
Auxin is widely thought to play a function in the initiation and development of adventitious roots. This is the only class of chemicals (natural or synthetic) that consistently improves root formation in cuttings (Damar *et al*, 2014; Singh *et al*, 2011) [4, 26]. The success of stem cutting multiplication of fruits crops is determined by a number of factors, including the mother plant's condition, the part of the tree from which the cuttings are made, the age of the tree from which the cuttings are collected, the planting date, rainfall, humidity, and rooting media, as well as care before and after planting (Frey *et al*, 2006) [6]. According to Ghosh *et al*., 1988 IBA has great effect than NAA at rooting, with a maximum rooting concentration of 5,000ppm. Now a day's different hormone are using for as the root growth in pomegranate cuttings along with hormones other materials like Honey, Turmeric and Aloe vera are also widely using for root growth promotion.

The rooting media is one of the most essential components in effective cutting rooting and the survival of rooted plants. Soil, Sand, Sphagnum moss, Perlite, Vermiculite, FYM Peat, Shredded bark, Leaf mould, Sawdust, Pumice, and Rice straw all contribute to the success of rooted cuttings. In addition to traditional garden soils variety of media like Perlite, vermiculite, and Coco peat improves rooting in cuttings. Perlite has a unique capillary activity that makes it an ideal growth medium. It's perfect for boosting aeration and drainage within the container because of its homogeneity and lightweight (Rajkumar *et al*., 2016 and Paradiso and de Pascale, 2008). Pomegranate hardwood cuttings generated the maximum proportion of roots when planted in a mix of sand and vermiculite, and the lowest percentage when planted in sand alone (Ansari, 2013). Planting pomegranate hardwood cuttings in a mixture of soil, sand, and leaf mould led in a substantially greater probability of rooted cutting survival (Gurjar and Patel, 2007) [10]. To achieve the desired results, proper selection of rooting media should be prioritized.

Growth Hormone

Auxin is a phytohormone that has been shown to be associated in the process of root growth rooting and plays a vital role in root development (Tiberia *et al*., 2011) [31]. OuYang *et al*., 2015 [15] stated that IBA is one of the most widely used and effective auxins for promoting root growth for cuttings, besides from IAA and NAA. The IBA concentration required for root initiation depends on type of cuttings that we have taken and at what time the cuttings planted and also various other rooting materials are used. Mostly the efficiency of root is influenced by length of the cuttings, diameter and the interconnection between length and diameter of the cuttings. Seiar, 2017 [23] worked on pomegranates and observed that NAA 1000ppm and IBA 1500ppm and NAA 1500ppm and IBA 1500ppm resulted in much earlier sprouting completion among the various doses of growth regulators used (25.00 days and 26.00 days, respectively), whereas Control had the highest number of days required for the last sprout to appear (36.00 days). The use of growth regulators resulted in a significant increase in the percentage of seeds sprouting. The highest percentages of sprouting were seen in NAA 1500ppm and IBA 1500ppm and NAA 1000ppm and IBA 1500ppm (68.00 percent and 67.10 percent, respectively). The Control had the fewest number of sprouted cuttings (26.40) and the lowest sprouting percentage (44.00%). Cuttings generally treated with NAA 1500ppm and IBA 1500ppm had the greatest rooting percentage (60.40%), followed by NAA 1000ppm and IBA 1500ppm (57.60%) and IBA 1500ppm +NAA 1000ppm (53.10%). Cuttings treated with NAA 500ppm and IBA 500ppm had the least rooting percentage (40.10), followed by un - treated cuttings (40.50 percent).

Saroj *et al*., 2008 and Shinde, 2012 reported that using IBA 2500ppm as a rooting media in Hardwood cuttings planted in soil + coco peat resulted in greater shoot development in terms of sprout length and number, root count, and sprouting percent. Abdul *et al*., 2018 examined the effects of auxin and bio fertilizers on the growth and rooting of Ruby and Bhagwa pomegranate cuttings. The use of IBA 1500ppm + NAA 1500ppm + Bio mix resulted in fast cutting sprouting (8.60 and 7.80 days), a rise in the numbers of sprouted cuttings (18.33 and 17.67 days), and an improvement in the length of the longest shoot in both Bhagwa and Ruby. (39.73 and 41.53 cm). Sharma *et al*., 2009 [24] reported in his experiment that IBA 500ppm + Borax treatment at 1% resulted in In semi-hard wood and hardwood cuttings, max rooting was 64.99 percent and 78.33 percent, respectively. IBA at 200ppm, 300ppm, and 5000ppm was applied to both types of cuttings also had the same effect on root development. However, when compared to this treatment, NAA 200ppm, IBA 300ppm + Borax 2percent, and IBA 4000ppm treatments did not vary significantly in terms of assisting root formation in semi hard wood cuttings. Because the IBA 500ppm + Borax 1% treatment induced root initiation more efficiently than a single hormonal administration to either type of cuttings.

Mehta *et al*., 2018 studied the effects of concentration of IBA and season of planting on the cutting roots of pomegranate (*Punica granatum*). Scientists looked at three different cutting planting dates. (December 25th, January 10th, and January 25th) and treated with (500ppm, 1000ppm) IBA. The planting on January 25th produced the most sprouts per cutting (4.00), leaves on new shoots (10.89), and percentage of rooted cuttings (10.89). (71.11percent). The mixture of 200ppm Indole Butyric Acid (IBA) and Naphthalene Acetic Acid (NAA) showed maximum percentage of rooted cuttings, the most roots per each cutting, the longest roots, and the fastest rooting time. Aside from the stem leaf features and everything else, another mixture (NAA 300ppm and IBA 300ppm) taken place in lesser days for root development and a smaller percentage of cuttings rooted (Panda, 2014) [16]. According to Singh (2014) [28], varying concentrations of IBA had a substantial influence on the development attributes of *Punica granatum* L. hardwood cuttings in his experiment. The maximum number of sprouting cuttings was found at a concentration of less than 5g/l (7.33) was recorded followed by 4g/l of IBA. In control, the smallest number of sprouted cuttings (4.33) was recorded and the highest percentage of rooted cuttings was found in the 5g/l concentration of IBA (73.33%) followed by the 4g/l concentration of IBA. Under control, the lowest percentage of rooted cuttings (43.33%) was recorded.

Singh *et al*., 2021 [29] seen that the treatment I3 mentioned the longest length of roots (21.56 cm), followed by I2 (18.47 cm), and I1 revealed the shortest length of roots (21.56 cm) (13.43 cm). An increase in IBA concentrations was found to increase root production per rooted cutting. However, as IBA concentrations rise above 3000ppm (I3), the number of roots produced per rooted cutting decreases. I3 revealed the highest number of roots (23.33) per rooted cutting compared to I2 (18.22), and I1 revealed the lowest number of roots (12.17) per rooted cutting. I3 induced the highest rooting percentage (78.13 percent) compared to I2 (73.48 percent), and I1 induced the lowest rooting percentage (64.48 percent).

Singh *et al*., 2020 [18] experiment also showed that the highest percentages of rooting were found in 3000ppm IBA T1 (64.10 percent), while the lowest were found in T8 (distilled water) (36.11 percent). Treatment T1 (3000ppm) IBA (59.55 percent) had the highest percentage of rooting survival, while treatment T8 pure water had the lowest (45.46 percent). Treatment T1 3000ppm IBA (12.28) roots produced the maximum roots per cutting, whereas treatment T8 pure water had the lowest roots per cutting (6.41). Treatment T1 300ppm IBA (8.79) had the largest length of the longest root per cutting, whereas treatment T8 distilled water had the shortest (3.49) and also showed that treatment T1 3000ppm IBA had the highest number of days taken for initial sprouting (10.83), whereas treatment T8 distilled water had the lowest (17.83). Cuttings treated with a higher concentration of IBA (3000ppm) and distilled water took less time to sprout than those treated with a lower concentration of IBA (100ppm) and distilled water. Treatment T1 3000ppm IBA possessed the largest number of shoots per cutting (3.82) and the lowest number (2.15) in treatment T8 distilled water. The longest shoot length per cutting (cm) was largest (9.28) in T1 3000ppm IBA-treated cuttings and the shortest (4.58) in T8 pure water-treated cuttings. The various growth regulators have a considerable effect on the amount of days it took for cuttings to sprout and to reach 50% sprouting, but IBA 2000ppm induced the earliest sprouting (Damar *et al*., 2014) [4].

Rooting Media

The rooting medium, which serves as a reservoir for nutrients and moisture, has shown to be the most essential part impacting quality of the sprout in nursery. It is a necessary component of improved seedling output. It has a direct influence on the on the root system's growth, development, impact, and functionality The best rooting media is one that is loose and simple to operate and able to retain a lot of water. Rooting media holds the cutting in place, preserves moisture for newly produced roots, promotes respiration, and keeps the temperature at the right level for root initiation (Kumar *et al*., 2021).

In order to propagate successfully, it is necessary to use growing media. One of the most significant requirements for effective roots and shooting form cutting is a proper growth medium. A good rooting medium should hold the cuttings in place during the rooting phase, supply moisture, allow for exchange, and let adequate light in (Eed *et al*., 2015). Tofanelli *et al*., 2003 discovered that when six rooting substrates, including sand, carbonized rice husk, vermiculite, sand + carbonized rice husk, sand + vermiculite, and carbonized rice husk + vermiculite, were tested for rooting in peach hardwood cuttings, vermiculite had the highest rooting percentage.

Netam *et al*., 2020 studies reported that in comparison to other growing media, treatment T8 - sand + coco peat (1:1) (80.61 percent) had the highest pomegranate survival percentage (80.61 percent). However, it was comparable to T3 – coco peat treatment (77.67 percent). The pomegranate survival percentage was found to be considerably lower following treatment T0 – control (47.24percent). Better water retaining capacity and nutrition availability may have contributed to the increase in survival.

The ideal growth medium for root and shoot development in Pomegranate stem cuttings was identified by Rajkumar *et al*., 2017. The cutting was dipped in 2500ppm IBA (3- Indole butyric acid) for 5 seconds before being placed in one of five rooting substrates in 1:1 (v/v) combinations: sand, vermiculite, Perlite, coco peat, or garden soil (control). Rooting percent (82.33), number of roots per cutting (32.67), and fresh and dried weight of roots (0.61 and 2.08) mg shoots per cutting (80.33), and they discovered that Vermiculite and Perlite 1:1 (v/v) outperformed Coco peat and Vermiculite (76.0 per cent). The largest root length (23.67 cm) was recorded in Coco peat and Perlite, accompanied by 23.0 cm in Vermiculite and Perlite, and the least root length (17.0 cm) in control, according to the root length means. This showed that environmental soil medium has a significant influence on fresh root weight per cutting. The highest fresh root weight (2.08 g) was attained in Perlite and Vermiculite, followed by 2.03 g in Coco peat and Vermiculite, and the least fresh root weight (1.57 g) was observed in control, according to the means of root fresh weight per plant, as shown in Table-1.

Gurjar and Patel (2001) [9] studied the impacts of several rooting media treatments, stem cutting types, and growth regulators on Pomegranate *cv*. Ganesh rooting and growth. With hard wood cuttings planted in soil + sand + leaf mould medium, the percentage of cutting success, real number of sprouts per cutting, total length of sprout, number of leaves and roots per cutting, diameter and length of root, and survival % of rooted cutting were all considerably increased. After hard wood cuttings were treated with IBA 4000ppm, the peak values of these root and shoot attributes were significantly higher. Furthermore, soft wood cutting had a greater response when treated with IBA at 2000ppm. Ghani *et al*., 2019 [7] result showed that in the T6 treatment combination of sand + soil + FYM, the number of days it took to start sprouting, the least days it took to start sprouting, and the days it took to reach 50% sprouting (17.66) and (19.96) were all significantly impacted by rooting media and their combinations.

Manila *et al*., 2017 reported that the T5 (vermiculite) treatment possessed the largest proportion of rooted cuttings (76.67%) of all the treatments. Under control, the lowest percentage of rooted cutting (26.67 percent) was recorded. Under the treatments T3 (sand+ FYM), T5 (vermiculite), and T8 (Sand+ Vermiculite), the most number of sprouts per cutting (2.33) was recorded, while the least number of sprouts per cutting (1.33) was recorded under control and that the shooting response of pomegranate (*Punica granatum*) *cv*. "Kandhari" stem cuttings grown in various media T5 (vermiculite) treatment resulted in the highest percentage of sprouted cuttings (76.67%). Under control, the lowest percentage of sprouted cuttings (26.67%) was recorded and rooting response of pomegranate (*Punica granatum*) *cv*. "Kandhari" stem cuttings grown in various media and found that Vermiculite gave the maximum roots in hardwood as decomposing medium (76.67 percent) produced the

good results, whereas the lowest rooting percentage was achieved in soil (26.67 percent). Vermiculite has the largest proportion of main roots (36.33 percent), while the lowest was found in soil (16.67 percent)

Tanwar *et al*., 2020 [30] found that on pomegranate cv. Bhagwa, the proportion of rooted cuttings increased significantly when cuttings were grown in a mixture of Coco peat + Vermiculite + Perlite + 2000ppm IBA (T13) (97.78%), accompanied by T16 (95.56%), and cuttings cultivated in sand as a control (T1) seemed to have the lowest proportion of rooted cuttings (89.22 percent). The IBA and rooting media had the greatest influence on the number of roots per cutting (41.50) in Coco peat, Vermiculite, Perlite, and 2000ppm IBA were used to cultivate the cuttings. (T13), while the least (17.33) in sand (T1) as shown in Table-2. Their experiment also showed that cuttings grown in a mixture of Coco peat + Vermiculite + Perlite + 2000ppm of IBA, the minimum number of days required for first sprouting was recorded (11.63). In cuttings grown in Sand + Vermiculite + 1000ppm IBA, the maximum number of days required for first sprouting (16.23) was observed (T8).

Table 1: Various media effect on the rooting and performance of Pomegranate (*Punica granatum* L.) *cv*. 'Phule Arakta' cuttings

Growing media	Rooting Percentage	Total number of roots per cutting	Root length in centimeters	Survival Percentage
Sand	69.33	26.33	19.00	67.33
Vermiculite	79.33	28.67	20.00	77.33
Perlite	78.33	28.00	18.00	71.67
Coco peat	72.00	29.00	21.00	67.00
Sand + Coco peat	72.00	28.00	21.00	70.00
Sand + Perlite	75.33	29.67	22.33	73.33
Sand + Vermiculite	79.00	33.00	23.67	77.00
Vermiculite + Coco peat	81.00	30.00	22.00	79.00
Perlite +Vermiculite	82.33	32.67	23.00	80.33
Perlite+ Coco peat	78.00	32.67	23.67	76.00
Control (Garden soil)	62.00	24.67	17.00	60.00
General Mean	75.33	29.33	20.97	72.64

-Rajkumar *et al*., 2017

Table 2: IBA and rooting media effect on root parameters of Pomegranate *cv*. Bhagwa

Treatments	Rooting (Percent)	Survival (Percent)	Total number of roots/ cutting	Longest root length / cutting (cm)	Root fresh weight (g)
T1-Sand (control)	89.22	77.33	17.33	15.56	1.32
T2 -Sand + IBA 1000 ppm	91.89	75.56	20.11	17.86	1.58
T3- Sand + IBA 1500 ppm	94.44	78.55	22.78	19.75	1.58
T4- Sand + IBA 2000 ppm	94.11	83.07	23.69	15.46	1.78
T5- Sand + Vermicompost + IBA 1000 ppm	89.44	79.67	24.11	19.73	1.61
T6- Sand + Vermicompost + IBA 1500 ppm	95.11	79.67	23.71	19.79	1.86
T7 - Sand + Vermicompost + IBA 2000 ppm	90.89	85.22	25.44	20.5	1.93
T8 - Sand + Vermiculite + IBA 1000 ppm	96.67	80.82	23.45	21.25	2.02
T9- Sand + Vermiculite + IBA 1500 ppm	89.56	82.57	34.58	20.85	1.98
T10- Sand + Vermiculite + IBA 2000 ppm	89.89	82.56	37.1	21.65	2.03
T11- Coco peat + Perlite + Vermiculite + IBA 1000 ppm	95.56	87.78	39.19	27.76	2.12
T12 - Coco peat + Perlite + Vermiculite + IBA 1500 ppm	90.67	88.89	40.2	29.75	2.2
T13- Coco peat + Perlite + Vermiculite + IBA 2000 ppm	97.78	93.78	41.5	32.03	2.25
T14- Sand + Perlite + Vermiculite + IBA 1000 ppm	91.11	85.56	34.41	22.57	2.15
T15- Sand + Perlite + Vermiculite + IBA 1500 ppm	92.22	83.33	36.46	24.88	2.21
T16- Sand + Perlite + Vermiculite + IBA 2000 ppm	95.56	87.78	37.45	25.58	2.18

-Tanwar *et al*., 2020

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