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REVIEW ARTICLE

Impact of plant growth regulator in cutting propagation of Jamun (*Syzigium cuminii*): A Review

Dhrubajyoti Banerjee , Vikram Singh*, Vishal Johar, Ritik Thakur and Shravankumar
Department of Horticulture, School of Agriculture,
Lovely Professional University, Phagwara, Punjab, India- 144411
* Corresponding author: vikram.26038@lpu.co.in

ABSTRACT
Jamun (Syzigium cumini L. Skeels) cutting-based vegetative propagation is the quickest, simplest, and most economical method for producing plants that are true to type in a short period of time. In Jamun there are various kinds of propagation methods, like- Cutting, Grafting, Buddingand Layering also but cutting is the most challenging method. The application of PGR is a well- known technique to improve rooting and growth of plant cutting. The effect of PGR on Jamun cutting can vary depending on the type and concentration used, as well as cutting type, time and environmental conditions in addition, some PGRs can have negative effects on Jamun cuttings if used improperly, such as inhibiting root growth or abnormal shoots. In this content showed that the effect of PGR and best time of planting cuttings in Jamun. IBA shows the best results in rootingand shoot cutting that are collected in the month of July-August, given the highest survival percentage. In in-vitro condition the combination of IBA with NAA showed the highly positive result of root and shoot formation. Hence, summarize the current knowledge about the applicationof PGRs on the Jamun cutting and highlights the potential benefits and challenges associated withthis technique.
Keywords: PGR, Jamun, IBA, NAA, Cutting, Grafting, Budding

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INTRODUCTION

Jamun (Syzygium cumini), an indigenous and significant minor crop in India, is a member of the Myrtaceae family[8]. Jamun has recently gained significant commercial importance in dry regions[54]. It is widely grown throughout most of India, from the Indo Gangetic Plains in the North to TamilNadu in the South. An important evergreen tree native to India goes by the names Indian blackberry, Java plum, Jambu, black plum, and Jambul. A new fruit crop for the twenty-first century is S. cumini. Alkaloids, fatty acids, steroids, and tannins are only a few of the many phytochemicals the fruit contains. The fruit's hypoglycemic qualities have earned it the nickname "diabetes warrior." The multipurpose tree known as Jamun has many pharmacological and phytotherapeutic applications [65]. Iron, sugars, minerals, proteins, carbs, and sugars are all present in good amounts in the fruit. In addition to being consumed fresh, fully ripe fruits can be made into beverages like jelly, jam, squash, wine, and vinegar. The fruit creates a very reviving squash and has a sub acidic spicy flavour. Fruit syrup, in small doses, can be used to treatdiarrhea. A slightly under ripe fruit's juice is used to make vinegar, which has digestive, stomachic, carminative, and diuretic properties. Beverages can be made from little fruits that are unsuited forconsumption but are high in acids, tannins, and anthocyanins [56]. Jamun an effective cure for diabetes, heart disease, and liver issues[57]. Several properties of the Jamun, including those that are anti-diabetic, anti-hyperglycemic, anti- leishmanial, antifungal, anti-inflammatory, radio-protective, antibacterial, gastro-protective, antifertility, anorexigenic, antidiarrheal, ulcerogenic, and anti-HIV, have been demonstrated [10] [29] [40] [42] [7] [50] [2] [35].The main sugars in ripe fruits are glucose and fructose; sucrose is utterly lacking the main acid is malicacid (0.59%), with a trace amount of oxalic acid. The tannins and gallic acid in the fruits make them astringent. The blooms in North India constitute a substantial source of honey produced by Apis dorsata[58]. Acetyl oleanolic acid, eugenia-triterpenoidA, and eugenia-tritetrapeniod B are the three triterpenoids said to be

present in the flowers. Together with the flavonoids isoquercitrin, quercetin, kaempferol, and myricetin, Jamun flowers also contain ellagic acid [2]. Jamun fruits provide a decent quantity of calcium, potassium, vitamin C, and B-complex (alanine, arginine, aspergine). Delphinine and petunidin are the two main anthocyanins; malvidine, peonidin, and cyanidin are only found in trace amounts [56]. Dihydrocarvylacetate, geranyl butyrate, and terpinyl valerate are three estersthat are most likely in charge of the fruit's distinctive flavour. Vitamins, tannin, and anthocyaninsare said to have an antioxidant effect [59]. 8.5 percent crude protein, 16.9% crude fibre, 21.72% ash, 0.41% calcium, and 0.17% phosphorus are all present in seeds. Using ground seeds to treat diabetes is a great idea [58] **[56]**. Seeds contain the glycosides jambolin and antimellin, as well as the alkaloid jambosin, which inhibit the diastatic conversion of starch to sugars[45] [60]. The Jamun seed's dried alcoholic extract may be able to lower blood sugar and glycosuria.Plants grown from seeds require a lot of time to bloom and develop fruit, and the fruits they do produce will vary in size and quality. Three weeks and 8%, respectively, are the averagegermination rates for Jamun seeds [49]. Thus, vegetative propagation is the most idealmethod for producing plants that are true to type. The most practical and affordable way to growa fully formed, more robust tree in a lot less time is by cuttings. There is virtually little researchon the rooting of Jamun cuttings. During conducting the current study, which investigated theimpact of plant growth regulators on the ability of several types of Jamun stem cuttings tosuccessfully root, these parameters were taken into account. The greatest number of roots percutting at IBA concentrations of (1000, 2000, 3000, 4000, and 5000 ppm) was also reported. Thereis virtually little research on the rooting of Jamun cuttings. These factors were taken intoconsideration when conducting the current study, which examined the effect of PGRs on the success of different types of Jamun stem cuttings ability to take root.

Sprouting time in cuttings

The number of days required for sprout initiation in Jamun stem cuttings was significantly influenced by the dose of growth regulators, the type of cutting and their interactions [12]. When compared to other propagation methods, shoot-tip cuttings were the earliest (11.46 days), while rootex had the best early sprout initiation (11.20 days). Shoot-tip cutting + rootex had a sprouting initiation minimum of 8.65 days in the interaction, which wascomparable to shoot-tip cutting + IBA 4,000 ppm's 9.50 days and shoot-tip cutting + IBA 4,000 ppm's 9.70 days. In semi-hardwood cutting + IBA 2,000 ppm, the greatest days taken (15.50) required for sprout initiation was noted. The earliest sprouting of cuttings may be caused by the exogenous application of auxin, which hydrolyzes starch into sugars, as well as by the suppressionof down-word translocation of carbohydrates and accumulation of larger levels of endogenous exogenous auxins. This is especially important at the time of the onset of a new root primordial for the growth of new cells and for increased respiratory activity in the regeneration tissue [16]. The other observed similar outcomes for sweet lime[28][34]. Different growing conditions, different cutting types and their interactions all had a substantial impact on the number of days required for sprout initiation in Jamun stem cuttings[11]. Shoot-tip cuttings (9.03 days) sprouted earlier than other methods and Soilrite (10.31 days) initiated sproutsthe earliest of any media. The lowest time required for sprouting initiation in interaction was 8.37days for (Soilrite + Shoot-tip cutting), which was comparable to (Sand + Shoot-tip cutting), (Cocopeat + Shoot-tip cutting), and (Soil + Shoot-tip cutting), which required 8.87, 9.23, and 9.67 days,respectively. While they found that treatment (Soil + Hardwood cutting) had the longest average time for sprout initiation (16.00 days). The prevention of glucose down-word translocation and accumulation of larger levels of endogenous auxins may be the cause of the cutting's earliest sprouting. In comparison to other growing media, soilrite produced sprouts that were thicker, longer, and earlier to sprout thanks to better nutrient availability and absorption. In trifoloiate orange[43] and in citrus [24]both reported results that were similar. The Significant differences were identified in the number of days needed for bud-sprouting depending on propagation strategy and timing[17]. The findings showed that softwood grafting carried out during the second week of June had the shortest numberof days (13.50 days) needed for bud-sprouting. Softwood grafting carried out in the second weeksof August (23.68 days), July (24.03 days), September (25.01 days), and May (25.37 days) were discovered to be comparable to one another. While patch budding carried out during the second week of September showed the greatest number of days for bud-sprouting (99.50 days). Softwoodgrafting carried out in the second week of January, from October to December, as well as patch budding carried out in February through May, from November through December, failed to produce any sprouting. The propagation procedure should be carried out when suitable weather conditions are anticipated and the cambium tissue is in an active stage. A higher temperature promotes the production of calluses, which connect the scion buds to the stock. Such conditions were seen in the current study in June and January, which may be the cause of the early bud sprouting. The outcomes are consistent with [62] research on mango, [53] research on aonla, and research on Jamun[22].

Success percentage of shooting in cutting

Presently growth regulators, cutting type and their combinations all had a noticeable impact on the sprout percentage[12]. As comparison to other types of cuttings, hardwood cuttings had the highest percentage of sprouting (12.68%) and rootex (16.19%) was the best environment for sprouting to occur. In the interaction, the treatment Hardwood cuttings + Rootex had the highest sprouting percentage (29.90%), whereas the treatment Shoot-tip cutting + IBA 2,000 + PHB 750 ppm had the lowest sprouting percentage (2.31%). Increased use of nitrogen, stored carbohydrates, and other factors with the help of growth regulators may explain why more hardwood cuttings are sprouting. Similar results were also reported in litchi [9], in *Ficus*[52] and in sweet lime[28]. The average number of sprouts percutting showed that a substantial relationship between the type of cuttings, the growing media, andtheir combinations[11]. During 30, 60, and 90 days are following planting, soilrite and hardwood cuttings produced the most sprouts in compared to other cutting kinds and growing media (8.67, 6.67, and 4.67, respectively). The interaction's Soilrite + hardwood cutting had the highest numberof sprouts per cutting (9.03, 7.03, and 5.03). At 30, 60, and 90 days after planting, the Soilrite + shoot-tip cutting had the fewest sprouts per cutting (6.90, 4.63, and 2.67, respectively), whereas no sprouts appeared in the soil + shoot-tip cutting, coco peat + shoot-tip cutting or sand + shoot- tip cutting. The larger number of sprouts per cutting at 30 and 60 DAP may be explained by the fact that cuttings taken from Jamun were discovered to have the greatest nutrients and that the cuttings made had exploited these stored nutrients for successful vegetative growth. Given the more challenging growing conditions for sprouts at 90 DAP compared to 30 DAP, there were noticeably fewer sprouts per cutting. In comparison to other types of cutting, hardwood cuttings were preferred because they had more stored photosynthates. Similar results were observed in Ficus[52], trifoliate orange[43], and citrus by[24].

Number of shoots per cutting

In the current study, Growth regulators, cutting technique, and their combinations all had a substantial impact on the average number of sprouts per cutting[12]. The maximum number of sprouts were produced by hardwood cuttings (9.79, 8.29, and 5.11) and rootex (9.49, 8.49, and 5.90) when compared to other types of cuttings and PGRs 30, 60, and 90 days after planting, respectively. Hardwood cuttings + Rootex had the most sproutsper cutting (12.05, 10.05, and 6.10) during the interaction. At 30, 60, and 90 days following planting, Shoot-tip cutting + IBA 2,000 ppm, Shoot-tip cutting + IBA 3,000 + PHB 750 ppm, andShoot-tip cutting + IBA 2,000 ppm were reported as the minimum number of sprouts per cutting,respectively. The findings showed that the number of branches per plant varied with time and propagation techniques, with softwood grafting and patchbudding producing the most (5.12) and least (2.19) shoots[42]. When it came to the length of time it took for Jamun to sprout, the effect of propagation time was equally important; between August and November, shoot counts ranged from the highest (4.11), to the lowest (3.57). The interaction between time and propagation methods also affected the number of shoots in Jamun, with softwoodgrafting and patch budding displaying the largest and lowest numbers of shoots in August and July, respectively (6.13 and 1.93, respectively). The outcome could be attributed to excellent monsoon weather circumstances, which aided in quicker growths that benefited the rootstock and scion shoot[47]. This might have happened as a result of superior physiological processes including photosynthesis and lower respiration, as well as greater time formeristamatic cells to proliferate. Similar outcomes in mango were attained in guava [47], and in mango, [31]. Growing media, cutting type, and their combinations all significantly influenced thepercentage of rooted cuttings in the current study[11]. Comparatively speaking, soilrite (23.32) and hardwood cuttings (34.85) had higher percentages of rooted cuttings. Overall, compared to other types of cuttings, hardwood cuttings showed the highest proportion of rooted, and soilrite was thebest growing medium for this result. Soilrite medium outperformed other media because they were porous, which allowed for more root growth and made it easier to encourage longer shoots in cuttings. The Soilrite + Hardwood cutting had the highest rooting rate in the interaction (44.87%),while the Soilrite + Shoot-tip cutting had the lowest rooting percentage (5.63%). These results arein agreement with citrus [24].

Number of leaves per cutting

In the current study, Growth regulators, cutting technique, and their mixtures all had a substantial impact on the typical number of leaves per cutting[12]. Hardwood cuttings (4.76, 6.73, and 7.72) and rootex (5.29, 7.46, and 8.19) had the most leaves at 30, 60, and 90 days after planting, compared to other types of cuttings and PGRs. The interaction's maximum recorded number of leaves per cutting (5.68, 8.15, and 9.15) was obtained from hardwood cuttings + Rootex. However, the minimal number of leaves per cutting of Shoot-tip cutting + IBA 3,000 + PHB 750 ppm, Shoot-tip cutting + IBA 2,000 + PHB 750 ppm,and Shoot-tip cutting + IBA 2,000 + PHB 750 ppm, respectively, were recorded 30, 60, and 90 days after planting. The growth in

the number of leaves may be influenced by both exogenous andendogenous auxin. Because Rootex had remained adhered to the cut end of the cuttings for a verylong time, they had more leaves per cutting. in sweet lime[28], and in pomegranate[27] all reported results that were comparable. In the current study, cutting type, growing media, and their combinations all had a substantial impact on the average number of leaves per cutting[11]. The maximum number of leaves were discovered in rootex (3.69, 5.66, and 7.16) and hardwood cuttings (4.04, 6.12, and 7.51), as well as semi-hard and hardwood cuttings, after 30, 60, and 90 days following planting, respectively. Sand + Semi-hardwood cutting in the interactionhad the most leaves per cutting (4.63, 6.70, and 8.01). Soilrite + Shoot-tip cutting had the fewest sprouts per cutting at 30, 60, and 90 days after planting (6.90, 4.63, and 2.67, respectively). Because semi-hardwood cuttings had greater food reserves at 60 and 90 DAP, they generated moreleaves. The media's nutrient-favored root growth, which produces more leaves per cutting, may have contributed to the rise in leaf count at 60 and 90 DAP. Due to greater root zone aeration andnutrient delivery for the cuttings, cuttings sown in sand and soilrite sprouted at a higher percentage.These results concur with those of other researchers in the guava[69], in the Dalbergia [6], and in the tea[70]. The findings showed a considerable variability in the number of leaves onthe scion depending on the propagation method and period[17]. According to data, the largest numberof leaves on the scion were recorded during softwood grafting in the second week of May (7.87),and it was discovered to be comparable to softwood grafting in the second weeks of August (7.15), September (6.81) and patch budding in the second week of January (6.81). While softwood grafting performed in the second week of July had the fewest leaves on record (3.31). This may bedue to the fact that the grafting technique was completed in the summer and early monsoon seasons, when temperature, humidity, and soil moisture conditions were excellent and had a favourable effect on the number of leaves on the scion. One of the elements that encourage cell growth and proliferation is water. These results support that softwood grafting was the best method of propagation for growing the most mangotrees with leaves[44].

Survival percentage

In patch budding, the highest survival rate (39.50%)was noted between August 1 and 15 **[32]**. In Jamun, where patch budding occurred between August 1 and 15, the largest survival percentage (90.11%) was noted, the interaction of time and propagationmethods has an impact on survival percentage as well. The conclusions of this study and those of are both in agreement **[8]**. In terms of the relationship between time andmeans of propagation, it had a substantial impact on the Jamun's survival rate. After 90 days from propagation, patch budding was associated with the highest survival percentage (90.11%) between1–15 August and the lowest (8.07%) between 1–15 December. The ideal conditions for mending and establishing the continuity of cambium and vascular tissues in July and August, together withthe fast sap flow in the stock and scion, may have contributed to the increased success rates in these months. Fast healing, enhanced sprouting, and graft/bud growth via simple swelling of budsmay have been the results of relative humidity or moisture protection for the cells in the cambial zone of the graft union. The findings of in guava [26] and inJamun[8] are supported by the current results. The same was also mentioned in Jamun [36]. The investigation's findings demonstrated that semi-hard wood cutting and softwood grafting had the highest and lowest survival percentages, respectively (92.24% and 42.48%). The maximum (70.17) and minimum (63.18) of the influenceof propagation time on the taken to survival percentage of Jamun were observed in August and November[42]. The time and mode of propagation in Jamun had an interaction effect that affected thesurvival percentage, with greatest (94.72) and minimum (40.01) values seen in softwood graftingand semi-hard wood cutting in August and November. The high meristamatic activity in the scion,which results in sufficient glucose and other food material being present in both the scion and rootstock, may be responsible for the survival percentage. The mild temperature (28 to 32 °C) andrelative humidity (74 to 78%) could be to blame for this. in Jamun[41], in Jamun[15], and in wood apple[25] all validated this finding. [31]. Growth regulators, cutting type, and their combinations all had a noticeable impact on the percentage of rooted cuttings in the current study[12].In comparison to other cuttings, the percentage of rooted cuttings was higher in hardwood cuttings(27.71) and cuttings treated with rootex (20.90). Overall, compared to other types of cuttings, hardwood cuttings had the largest percentage of roots developing, and rootex was the best growthregulator for this outcome. It might be the result of the quick hydrolysis of stored polysaccharides in stem cuttings into physiologically active sugars, which fuel meristematic tissues and activate the primodia of the roots to start the development of additional roots in stem cuttings. In the interaction, the treatment (Hardwood cuttings + Rootex) had the highest rooting percentage (35.40%), whereas the treatment (Shoot-tip cutting + G5 IBA 3,000 + PHB 750 ppm) had the lowest rooting percentage (8.05%). These findings were consistent with those of [23] in the citrumello plant, in the pomegranate plant[30], in the sheanut tree[4], and in the pomegranate[39]. To show more shooting and rooting qualities in Jamun, Rootex and hardwood cutting performed better together. The

results will help standardise an efficient method for cultivating Jamun from cuttings. The statistics, patch budding had the highest success rate (40.82%) of all techniques of propagation during the 1- 15th of August, and it had the lowest success rate (0.73%) during the same period, which corresponds to cleft grafting's 35.10% success rate[32]. The interaction between time and propagation techniques had a considerable impact on the percentage success of Jamun. After 90 days of propagation, patch budding showed the highest percentage success (94.54%) from 1–15 August and the lowest percentage (2.19%) from 1–15 December. The data also make it very evident that no propagation strategies worked during the months of Januaryand February. The larger bark and cambium tissues used in patch budding operations may be the reason why it has a higher success rate than other approaches. The results of in Jamun[38] and in guava[33] support the highest success in patch budding.This could also be as a result of the ideal humidity and temperature for success. In the budding carried out in May, December, January, and February, it was noted that the successful bud-take percentage was at a minimum or below average. It's possible that immature bud wood and low sapflow are to blame for the low bud take % during this time. The current findings are consistent withthose of who studied guava[47]. The same was also reported in Jamun [46] [59].

Effect on Stem thickness (cm)

Information on how propagation time and method affected stem thickness revealed a considerable increase in the stem thickness of propagated Jamun[32]. At a stem thickness of 0.75 cm after 120 days of growth, cleft grafting was clearly better to patch budding (0.74cm). Both of these could be compared to one another. T budding generatedstems with a bare minimum of (0.65cm). It was shown that the best propagation times occurred between August 1 and 15, when shoot diameters reached a maximum of 1.21 cm and a minimum of 0.13 cm. The growth stimuli may be caused by the endogenous gibberellin levels, which appearto be associated to stimulations of increased cell division and cell enlargement. It's possible that this was caused by the stock's quick growth, which thickened the stems. Both [22]and [15]observed similar outcomes in Jamun. The results of the thickest shoot was formed by cleft grafting grape cv. Tas-A- Ganesh as scion on August 15th, agree with these findings on the greatest stem thickness in cleft grafted plants[64]. The same was also reported by in guava[68] and in Jamun[1].

Plant Protection

The main pests of the Jamun crop include fruit borer (*Meridarchis reprobata*), leaf miner (Acrocercops syngramma and Acrocercops phaeospora), leaf roller (*Polychorosiscellifera*), leaf webbers (Argyroploce aprobola and Argyroploce mormopa), fruit fly (Bactrocera correctus), white flies, and leaf eating caterpillars (Corea subtilis) ([56]) [60]. Spraying Dimethoate 30 EC (2ml/l) at fortnightly intervals can control leaf-eating caterpillars, Jamun leaf miners, fruit borer, and bark-eating caterpillars, whilst spraying Chlorpyriphos 20 EC (2ml/l) at 15-day intervals can manage Jamun leaf rollers and leaf webbers. Maintaining sanitary conditions in the orchard can help control white flies. To do this, pick up anyaffected fruits and bury them deeply in the ground. Additionally, a hole should be dug under eachtree to kill any pupae that may be hibernating in the soil as well as the maggots that are inside the affected fruits. Additionally beneficial for controlling this pest are pheromone traps ([62]). The primary ailment in Jamun is anthracnose. Fruit rot and leaf spot are caused by the fungus. Small, dispersed spots of light brown or reddish brown are visible on affected leaves. Fruitswith lesions display tiny, water-soaked, cirrhotic, and depressed lesions. Fruits shrivel and decay.Dithane Z-78 @0.2% can be sprayed to treat this condition. Spraying dimethoate/malathion will suppress leaf-eating caterpillars[15]. All components are damagedby white fly, and even fruits become wormy. Fruits dropped or damaged should be gathered and burned. If spraying is necessary during blooming, only endosulfan, a safe pesticide for honey bees,should be used. Glomerella causes leaf spot and fruit spot, which Indofil Z.78 (2 grammes per litre) can prevent ([67]).

Effect on fresh weight of cuttings

The average fresh weight of the cuttings in the current study was significantly influenced by growth regulators, cutting type, and their combinations[12]. Hardwood cuttings and rootex had the highest fresh weight of cuttings (17.90g) and 19.69g, respectively, when compared to other types of cuttings and PGRs 30, 60, and 90 days after planting. Hardwood cuts provide more fresh weight than other types of cutting due of their biggerdiameter. In the interaction, the treatment Hardwood cuttings + Rootex recorded the highest freshweight at 90 DAP with 21.47g, which was on par with Hardwood cuttings + IBA 4,000 ppm's

20.70 g. In contrast, the treatment Shoot-tip cutting + IBA 3,000 + PHB 750 ppm recorded the lowest fresh weight with 13.42g. The findings of in pomegranate [39], in citrumello[23], and in dragon fruit[3] were in agreement with these findings. Hardwood cuttings (13.30g) and soilrite (9.96g) had the greatest fresh weight of cuttings ever recorded compared to other types of cuttings and media[11]. Due of their bigger diameter compared to other types of cuttings, hardwood cuttings produced more fresh weight. Because

this media offered an effective supply of nutrients, cuttingsplanted in soilrite and sand also produced greater fresh weight on average than cuttings planted inother media. In comparison to the treatment (Sand + Shoot-tip cutting), the treatment (Soilrite + Hardwood cutting) registered the highest fresh weight at 90 DAP with 13.86g. Similar results havebeen found for tea, pomegranate, and jatropha. ([5], [70]and [20]).

Effect on dry weight of cutting

Growth regulators, cutting style, and their combinations all had a noticeable impact on the average dry weight of the cuttings in the current study[12]. In comparison to other types of cuttings and PGRs, hardwood cuttings and rootex had the highest dry weights of cuttings at 30, 60, and 90 days after planting, respectively (11.83g and 11.34g, respectively because to the wider cuts, the hardwood had the highest average dry weight during the contact. Hardwood cuttings + Rootex recorded the highest dry weight at 90 DAP, followed by Hardwood cuttings + 4,000 ppm with 12.36 g, and Shoot-tip cutting + 3,000 ppm + PHB 750 ppm with 6.71 g. These results were in accordance with that of in pomegranate[27], [51]in guava and in dragon fruit[3]. In comparison to other types of cuttings and media, semi-hardwood cuttings(7.51g) and soilrite (9.96g) had the highest dry weight of cuttings[11]. The hardwood had the highest average dry weight because to the larger diameter of the cuttings, which also produced a higher average dry weight than other media due to the efficient fertilizer delivery given by coco peat andsoilrite. The treatment (Sand + Semi-hardwood cutting) had the highest dry weight of cuttings at 90 DAP, which was 8.01 g, whereas the treatment (Soilrite + Shoot-tip cutting) had the lowest dryweight, which was 6.03 g. With regard to Jamun, neem, and nilgiri, [37], [71], in acid lime, and [3], in dragon fruit, these findings are in agreement.

Effect on number of primary and secondary root

In the current study, The type of cuttings, the growingmedium, and their combinations all had a substantial impact on the average number of primary and secondary roots[11]. In comparison to other types of cuttings and media, soilrite (41.75), and hardwood cuttings (48.41), had a higher number of main and secondary roots. In terms of interaction, the Sand + Hardwood cutting had the most main and secondary roots per cutting with57.77, followed by the Soilrite + Hardwood cutting with 49.98, while the Soilrite + Shoot-tip cutting had the fewest roots with 32.97. The hardwood had the maximum number of primary andsecondary roots because the dry matter of the cuttings was higher. Cuttings put in sand and soilritemedia produced an average of more primary roots than those planted in other media because thesemedia provided an effective supply of nutrients. These results are in agreement with those from [30] and in guava and citrus[24], respectively. According to the current study, Growth regulators, cutting type, and their mixturesall had a substantial impact on the average number of primary and secondary roots[12]. The hardwoodcuttings (50.18) and Rootex (55.35) treated cuttings had more primary and secondary roots than the other cuttings. In the interaction, the treatment (Hardwood cuttings + Rootex) had the most primary and secondary roots per cutting (57.60), which was similar to the treatment (Hardwood cuttings + IBA 4,000 ppm) with 56.88, whereas the treatment (Shoot-tip cutting+ IBA 2,000 ppm)had the fewest roots (roughly 36.25). Because of their increased dry matter content, the hardwoodcuttings had more main and secondary roots. These findings were consistent with those of pant lemon[55], for litchi[9], and for Shea nut tree[4].

Effect on shoot length

The current study found that the type of cuttings employed, the growing medium, and their combinations had a substantial impact on the average shoot length[11]. After 30, 60, and 90 days after planting, respectively, soilrite (2.49, 3.69, and 4.98 cm) and hardwood cuts (3.07, 4.46, and 6.19 cm) had the longest shoot lengths in contrast to othercutting kinds and growing media. After 30, 60, and 90 days after planting, the maximum branch length in the interaction was measured (3.75 cm for soilrite + hardwood cutting, 4.87 cm for soilrite + hardwood cutting, and 6.40 cm for sand + hardwood cutting, respectively). Soilrite + Shoot-tip cutting had the fewest sprouts per cutting at 30, 60, and 90 days after planting (6.90, 4.63, and 2.67, respectively). Sand and soilrite medium performed better than other media at promoting longer shoot length in cuttings because they are porous. Because hardwood cuttings produced longer main roots and more effective nutrient uptake, they were superior to other cutting kinds. in citrus[24] and in pant lemon[55] both reported findings that were similar. Growth regulators, cutting types, and their combinations all had a noticeable impact on the average shoot length in the current study[12]. In comparison to other types of cuttings and PGRs, hardwood cuttings had the highest shoot length (4.66, 5.93, and 5.11 cm) and rootex (6.25, 7.62, and 7.93 cm) at 30, 60, and 90 days after planting,respectively. The maximum shoot length in the interaction was measured at 30, 60, and 90 days after planting (6.45 cm for semi-hardwood cutting + Rootex, 8.15 cm for hardwood cuttings + Rootex, and 8.54 cm with hardwood cuttings + Rootex). the shortest shoot at 30, 60, and 90 daysafter planting (2.15 cm for shoot-tip cutting plus 2,000 ppm, 3.85 cm for hardwood cuttings plus 2,000 ppm, and 4.95 cm for hardwood cuttings plus 2,000 ppm, respectively). In comparison to 30days, the development of primary roots at 60 and 90 DAP

resulted in longer shoots and better uptake of nutrients like nitrogen from the medium for vegetative growth. These findings were consistent with those of and in dragon fruit[66] [3]and pomegranate, respectively.

Effect on length of longest root

The length of the longest root in the current study wasconsiderably influenced by growing media, cutting type and their combinations[12]. The plants with soilrite treatment and hardwood cuttings often had the longest primary roots. It might be because well-drained media also encouraged better root development through root penetration, while soilrite media significantly favoured the length of the longest root due to auxin compound assimilation and transfer in rooted cuttings. The longest roots were those from soilrite (12.78 cm)and hardwood cuttings (12.66 cm). The Soil + Hardwood cutting had roots that were, on average, 15.43 cm long, while the Soil + Semi-Hardwood cutting had roots that were, on average, 9.16 cmlong. These results are in agreement with those of on citrus[24] and on Jamun[37], neem, and nilgiri. In the current study, Growth regulators, cutting type, and their mixtures all had a substantial impact on the average number of primary and secondary roots[12]. The hardwood cuttings (50.18) and rootex (55.35) treated cuttings had more primary and secondary roots than the other cuttings. In the interaction, the treatment (Hardwood cuttings + Rootex) had the most primary and secondary roots per cutting(57.60), which was similar to the treatment (Hardwood cuttings + IBA 4,000 ppm) with 56.88, whereas the treatment (Shoot-tip cutting+ IBA 2,000 ppm) had the fewest roots (roughly 36.25). Because of their increased dry matter content, the hardwood cuttings had more main and secondaryroots. These findings were consistent with those for pant lemon[55] [9], for litchi, and for Shea nut tree[4].

Leaf area (cm^2)

Analysis of the data revealed that, among varioustimes and techniques of propagation, softwood grafting and semihard wood cutting recorded the highest (30.04 cm2) and lowest (24.90 cm2) leaf areas [42]. When it came to the leaf area of Jamun, the propagation time had a considerable impact as well; the highest value (28.16) and lowest value(25.15) were noted in the months of August and October, respectively. The number of days required for bud sprouting was influenced by both time and the techniques employed to propagate Jamun, with maximum (32.88) and minimum (22.62) values reported for softwood grafting and semihard wood cutting in August and October. The reason for this could be the favorable climaticcircumstances that led to the biggest leaf area and higher leaf growth. The same outcomes were reported in Jamun[41], in guava**[**47] and [21] Jamun [63].

Carbohydrate content (%) in cutting

The results of the carbohydrate are shown for various propagation times and methods; the highest (6.13%) and lowest (5.72%) carbohydrate levels were found in hardwood cutting and whip and tongue grafting, respectively[42]. With regard tothe carbohydrate content of Jamun, the effect of propagation time was also important; the maximum (6.08%) and minimum (5.60%) were noted in the months of July and September. The amount of carbohydrates present in Jamun was similarly influenced by the interaction of time and propagation methods, with maximum (6.57%) and minimum (5.28%) amounts being observed in softwood grafting and patch budding in August and October, respectively. It can be due to the shoot's immaturity stage, and as shoot age rises, shoot maturity reduces carbohydrate content. A number of additional components that were necessary for a successful transplant were in short supply at the time and contributed to the poor result. The loss in graft take was partially caused bythe reduction in carbohydrates. This observation corroborated researched on avocados [31].

CONCLUSION

Based on the results of the experiment, August was shown to be the best month for shoot tip cutting to propagate Jamun. Farmers often favor seedlings that exhibit because there is not a standardized technique of propagation. As a result, standardizing the shoot tip cutting method of propagation will enable farmers to more easily replicate real planting material on a wide scale. Testing high-quality shoot tip cuttings planting material also increases yield, productivity, and farmer income.

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