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Influence of different plant growth regulators on regeneration of hardwood stem cuttings of plum (*Prunus salicina* L.) cultivar Kala Amritsari

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ABSTRACT

The present investigation, entitled 'Influence of different plant growth regulators on regeneration of hardwood stem cuttings of Plum (Prunus salicina L.) cultivar Kala Amritsari', was conducted at Punjab Agricultural University, Regional Research Station, Gurdaspur (Punjab) during the years 2023-24 and 2024-25. Pencil thickness hardwood stem cuttings of 20-25 cm in length, having more than 5 buds, were prepared from uniformly vigorous, healthy, and insect-pest & disease- free one-year-old branches of Kala Amritsari plum plants during the middle of December. The basal portion of these cuttings was dipped in different doses of plant rooting hormones, i.e., Indole-3-butyric acid(IBA)(2000,3000 &4000ppm); Indole-3-acetic acid(1000,2000&3000 ppm)(IAA), and Naphthalene acetic acid(NAA)(500,1000,1500ppm) for 2minutes and an untreated control. A unit of 100 cuttings comprised of one replication, hence a total of about 300 cuttings were used in each treatment, with three replications, and also in the control(untreated).These cuttings were planted at a distance of 20x30cm, planted in a Completely Randomized Block Design on the well-prepared raised nursery beds incorporated with a mixture of sand, soil, and farmyard manure by following recommended cultural practices and plant protection measures. The results of the experiment indicated that IBA 4000ppm was found to be best in terms of early sprouting (3.05 days), sprouting percentage (96.53), survival percentage(95.75), number of sprouts(22.75), number of shoots(17.62), shoot length(35.21cm), shoot girth(1.05cm), fresh weight of shoot(30.52 gm), dry weight of shoot(18.26gm), number of leaves(205.12), leaf length(10.75cm), leaf breadth (5.56cm), rooting percentage(95.42), number of primary roots(35.15), number of secondary roots(68.53), length of primary roots(30.24cm), length of secondary roots(23.16cm), diameter of primary root(0.56cm)fresh weight of root (2.16gm), dry weight of root(1.12gm), plant height(70.18cm) and success percentage(97.15).

Keywords: *Cuttings, Plum, Kala Amritsari, Rooting, and Survival.*

1. Introduction

Plum is an important stone fruit of the Rosaceae family, grown under temperate and sub-tropical areas of the world, characterized by a firm flesh when unripe, becoming softer to melting at maturity. They can be consumed fresh but are most often processed, mostly into prunes or distilled drinks [43]. The most common species is *Prunus domestica* Lindl. called European plum and *Prunus salicina* Lindl. known as Japanese plum. In India, plum is used mainly for table purposes and commercially for manufacturing jam, chutney, squashes, appetizers, and fermented beverages. On the other hand, due to the presence of phytochemicals, fruits have beneficial effects on health, therefore used in traditional Chinese medicine [13]. Although the cultivation of plum under Indian conditions is not very old but it is gaining considerable popularity and occupying an important position as a commercial crop because of its great acceptance to the consumer either as its fresh form or its various products. China is the leading plum-producing country in the world [19]. In north India, high-quality plum is being grown in the hilly areas of Himachal Pradesh, Jammu and Kashmir, Uttarakhand, and Uttar Pradesh.

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In the plains, low chilling requiring plum cultivars are cultivated throughout Punjab, Haryana, and in some parts of Uttar Pradesh and Rajasthan. In Punjab, plum is grown in an area of 546 hectares with production of 17732 metric tonnes [2]. The districts of Gurdaspur, Amritsar, Ferozepur and Patiala of Punjab are well known for its cultivation. Subtropical Japanese plums (*Prunus salicina* L.) are generally cultivated in the plains of north-western India. There are several varieties of Japanese plums, amongst which 'Satluj Purple' is the low chilling commercial variety grown in Punjab. Due to its early ripening behaviour, low chill requirement, better size, and excellent colour and quality it has become popular among the fruit growers of this region. It fetches a high price in the region due to its early availability, i.e., in the month of May, when there is little competition from other fruits in the market. Satluj Purple plum is quite popularised among orchardists because of its yield potential and high economic returns. It is also profitably used as a filler tree to get early income in the orchards of mango, litchi, and pear, which come into bearing late [22].The plants of the Kala Amritsari plum are transplanted in the orchard of Satluj Purple as a pollinizer. Pollinizer plants are planted alternately in every alternate row of Satluj Purple plum for effective pollination and improving fruit set in the orchard.Propagation of Kala Amritsari plum through stem cuttings is the most convenient, simple, easy, rapid, and least expensive method of propagation. There are several factors known to affect the rooting in woody species, such as substrate, wounding of cuttings, air environment, genotype, season, and plant growth regulators. Among these factors, application of synthetic growth regulators to the stem cuttings may be very effective in promoting faster and better root formation in plum species [5]. Plant growth regulators, usually auxins such as Indole-3-acetic Acid (IAA), Indole -3-butyric Acid (IBA), Naphthalene acetic acid (NAA), and 2,4- Dichlorophenoxyacetic acid (2,4-D) have been reported to promote rooting in cuttings of the most of the plant species and their concentration varies from plant to plant and type of the cuttings used. Auxin induces root formation by breaking root apical dominance induced by cytokinin [7]. There exists a lot of contradiction with regard to the optimum concentration of growth regulator treatments on plum cuttings. Keeping in view the advantages of propagation through cuttings, the present studies were undertaken with the objective of faster multiplication of true-to-type plants through stem cuttings of Kala Amritsari plum with the application of optimum use of rooting hormone to meet the demand of pollinizer plants in the increasing area under plum orchard in the state.

2. Materials and Methods

The present investigation entitled 'Influence of different plant growth regulators on regeneration of hardwood stem cuttings of Plum (*Prunus salicina* L.) cultivar Kala Amritsari' was conducted during the years 2023-24 and 2024- 2025 at Punjab Agricultural University, Regional Research Station, Gurdaspur(Punjab) in sub-mountainous regions of Punjab which is situated between 32°3′ N latitude, 75°22′ E longitude and has an altitude of about 257 m from mean sea level having humid subtropical and dry winter climate. The cuttings of about pencil thickness of 20-25 cm in length, having more than 5 buds, were prepared from uniformly vigorous, healthy, and insect-pest & disease-free one-year-old branches of Kala Amritsari plum plants during the middle of December. A slanting cut was given at the upper side, and a slight slanting cut was also given at the lower end to provide a large surface area to encourage rooting in cuttings. The cuttings were treated with the respective concentrations of different growth regulators by the quick dip method. The experiment was laid out in a Completely Randomized Block Design with ten treatments, which were replicated thrice. These cuttings were dipped in different doses of plant rooting hormones, *viz.* Indole-3-butyric acid (IBA) (2000,3000&4000ppm); Indole-3-acetic acid (IAA)(1000,2000&3000ppm); Naphthalene acetic acid (NAA)(500,1000,1500ppm) for 2 minutes and untreated control. A unit of 100 cuttings comprised of one replication, hence a total of about 300 cuttings were used in each treatment, with three replications, and also in the control(untreated). These cuttings were planted on the well-prepared nursery beds incorporated with a mixture of sand, soil, and farmyard manure, and well drenched with Chloropyriphos 30EC to protect the cuttings from termite attack. The cuttings were planted at a distance of 20x30cm in a completely randomized design on the raised nursery beds in the field on the same day after being treated with growth regulators. The holes for planting the cuttings were made in the beds with the help of an iron rod so as to avoid any damage to the cuttings. While planting, about 2/3rd portion of the cuttings were buried in the soil, leaving 1/3rd portion exposed to the environment. The data on days taken to sprouting, sprouting percentage, survival percentage, number of sprouts, number of shoots, shoot length, shoot girth, fresh weight of shoot, dry weight of shoot, number of leaves, leaf length, leaf breadth, rooting percentage, number of primary roots, number of secondary roots, length of primary roots, length of secondary roots, diameter of primary root, fresh weight of root, dry weight of root, plant height and success percentage were recorded. Experimental data were statistically analyzed by using SPSS software. The level of significance for different variables was tested at 5% value of significance.

3. Result and Discussion

3.1 Days taken to sprouting

The significant difference was observed between the number of days taken for sprouting in cuttings treated with different concentrations of growth regulators. Plum hardwood cuttings treated with IBA 4000ppm significantly took the minimum number of days (3.25) to sprouting, but the control treatment took the maximum number of days(15.32) to sprouting (Table 1). Similarly, Acid Lime cultivar PKM1cuttings treated with 2000 ppm IBA recorded the least number of days for sprouting with the maximum number of sprouts per cutting [41]. Similar results were reported in Grape cuttings treated with 3000 ppm IBA [29]. It was noticed that high accumulation of carbohydrates results in higher callus formation in the cuttings, and with an optimum dose of auxin, resulting highest percentage of sprouted cuttings. Translocation of carbohydrates and accumulation of auxin inside of cuttings for the completion of the physiological process plays an important role in the sprouting of cuttings. The early and increased sprouting might be due to the auxin, which enhanced the hydrolysis of reserve food material and regulated the endogenous auxin level through enhancement of IBA oxidase enzyme activity. Also, the external application of auxins led to the promoted growth and produced more favourable conditions for the sprouting of dormant buds on the cuttings [15]. Enhanced IBA concentration in the cell might have increased the cell division, resulting in quick callus formation in the hardwood cuttings of grape, as reported by[37]. This might be due to the presence of endogenous auxins in cuttings might have brought early breakage of bud dormancy and resulted in early bud sprouting[17].The result also indicated that 2500ppm IBA to Fig hardwood cuttings was found to be best in terms of early sprouting[31]. The results of the experiment also signify that 2000ppm IBA was influential in invigorating the shoot and root traits of stem cuttings of Sweet Lime cuttings and resulted in the earliest sprouting as reported by [20].

3.2 Sprouting and survival percentage

From Table 1 and Table 2, it has been observed that hardwood stem cuttings of plum treated with 4000ppm of IBA showed significantly maximum sprouting (96.53) and survival (95.75) percentage as compared to the rest of the treatments. The minimum sprouting(36.52) andsurvival (38.50) of stem cuttings were observed in the control.Similarly, maximum sprouting and survival percentagewere recorded in Sweet Orange cutting treated with 3000 ppm IBA[25]. Similarly, Grape rootstock cuttings treated with IBA 2000 ppmhad maximum mean survival percentage and sprouting percentage as reported by [12].A higher chance of survival was also observed in Peach rootstock cutting treated with IBA[27]. It is also noted that application of 2000 ppm IBA to the basal segment of semi-hardwood cutting of Pomegranate cultivar Kandhari showed the highest sprouting [14].Likewise, softwood cutting of Guava cultivar Lucknow-49 treated with IBA 4000 ppm exhibited better rooting and sprouting performance as compared to NAA and IAA treatments[38].This might be attributed to cell division stimulated by the auxin at sprout union initiation[45].

Hydrolysis and translocation of carbohydrates and nitrogenous substances result in accelerated cell growth and division, which might be triggered by the use of auxins. It also tends to promote the histological features like formation of callus and tissues, and then further differentiation of vascular tissues [50](Singh 2017). The possible explanation to this lies in better development of the root system with good quality root and shoot parameters enabling the rooted cuttings to make better growth under field conditions after plantation and there by accounting for the highest field survivability[47] (Sharma et al., 2009).Similarly, Acid Lime cultivar PKM1cuttings treated with 2000ppm IBA recorded the highest number of sprouts per cutting [41]. It is also reported that Fig hardwood cuttings treated with 2500 ppm IBA were found to be best in terms of highest sprouting and survival percentages[31]. Similarly,[20] observed that 2000 ppm IBA treatment to Sweet Lime resulted maximum number of sprouts, sprouting, and survival percentages.[55] Also noted the highest survival of rooted cuttings of Pomegranate with 2000ppm IBA treatment.

3.3 Number of sprouts

It is evident from the data that the growth regulators significantly increased the number of sprouts in plum cuttings.The hardwood cuttings of plum treated with 4000 ppm IBA recorded the highest number of sprouts (22.75), whereas the lowest number of sprouts was recorded in the control treatment(8.28)(Table 1). This might be due to the action of IBA, increased concentration and activity of IBA, which caused hydrolysis and translocation of carbohydrates and nitrogenous substances in the cellular level at the base of cuttings and resulted in accelerated cell elongation and cell division under favourable environmental conditions.The greater number of sprouts formed with the growth regulators might be due to the vigorous root system which increased nutrient uptake under the combined influence of IBA application. It affected the cell division in the vascular cambium, cell expansion and control of differentiation into different types of cambial resulting in increase in number of sprouts[9] . Similarly maximum number of sprouts per stem cutting of Sweet Orange was recorded 3000 ppm IBA treatment [25]. Likewise the highest number of sprouts per stem cuttings of Acid Lime cultivar PKM1 were noticed in 2000 ppm IBA treatment and the lowest number of sprouts was found in control treatment as reported by [41]. Similarly the 2000 ppm IBAtreated grape rootstock cuttings had maximum mean sprouting percentage whereas, minimum mean sprouting percentage was noticed in control[12]. It is also reported that 2000 ppm IBA treatment to stem cuttings of Sweet Lime had the maximum number of sprouts, number of shoots, average shoot length and shoot girth [20].[55]Also reported the maximum sprouts in pomegranate cuttings treated with 2000ppm IBA.

3.4 Number of shoots, shoot length, and shoot girth

It was depicted in Table1 that the maximum number of shoots(17.62), average shoot length(35.21cm), and shoot girth (1.05cm) of plum cuttings were recorded with the application of IBA 4000 ppm as compared to the rest of the treatments. Similarly, the highest number of stems per bougainvillea cutting and the longest shoot length were noted under 3000ppm IBA[44]. Similarly, 7000 ppm IBA treatment to dragon fruit stem cuttings showed better results in terms of maximum shoot growth, individual shoot length, and number of new shoots per cutting [1].

The maximum shoot length, number of nodes per shoot, internodal length, number of buds per shoot and stem diameter were reported in 6000ppm IBA treated hardwood cutting of the Grapes cultivar Pusa Navrang[3]. The maximum shoot girth observed in cuttings, might be attributed to a larger number of roots, which significantly improves the cell activity and translocation of synthesized food material and nutrients, thereby resulting in the production of more shoots with significant stem girth.The more number of shoot formation with the growth regulators might be due to the vigorous root system which increased nutrient uptake, that affected the cell division in the vascular cambium, cell expansion and control of differentiation into different types of cambial, which in turn increased the number of shoots[9] The emergence of longest shoots on cuttings treated with IBA may be attributed to the well develop root system in such cuttings which might have enhanced the nutrient uptake and photosynthate production, which provides required energy for cell division and cell elongation that resulted in maximum shoot length [46].Likewise the application of 2000 ppm IBA to the basal segment of semi hardwood cutting of Pomegranate cultivar Kandhari showed the best results in term of number of shoot per cuttings, shoot length and diameter [14]. It is also indicated that 2500ppm IBA to the Fig hardwood cuttings was found to be best in terms of shoot length, shoot diameter and number of shoots [31]. Similarly, 2000ppm IBA treatment to the stem cuttings of Sweet Lime resulted in highest length of sprout, diameter of sprout, shoot length and shoot girth [20].[55] also reported that pomegranate cuttings treated with 2000ppm IBA showed the maximum number of shoots and length of shoot per cutting.

3.5 Fresh weight and dry weight of shoot

The cuttings treated with IBA 4000 ppm attained maximum fresh (30.52gm) and dry (18.26gm) weight of shoots. While minimum fresh (16.15gm) and dry (7.56gm) weight was recorded in untreated plum cuttings (Table1). Similarly,[32]noted that the plum cuttings treated with 2000 ppm IBA attained maximum fresh and dry weight of shoots. It could be due to increase in leaf area through cell division, leaf chlorophyll, more starch, sugars and C/N ratio which resulted in shoot elongation with maximum fresh and dry weight of shoots [42]. Likewise, Pomegranate cultivar Kandhari stem cuttings treated with 2000ppm IBA resulted into highest value of fresh and dry weight of shoots[14].Similarly maximum shoot length, number of nodes per shoot, internodal length, number of buds per shoot, stem diameter, stem fresh weight and stem dry weight were reported in 6000ppm IBA- treated hardwood cutting of Grapes cultivar Pusa Navrang[3]. It is also noted that 2500 ppm IBA to Fig hardwood cuttings was found to be best in terms of fresh weight and dry weight of shoots [31].

3.6 Number of leaves and leaf area

It is evident from the data shown in Table 1 that the growth regulator treatments significantly increased the number of leaves in plum cuttings. It was depicted that the maximum number of leaves(205.12) and leaf area in terms of length(10.75cm) and breadth(5.56cm) were recorded with the application of 4000 ppm IBA.This increase in leaf number with the use of auxins might be due to the vigorous rooting induced by the auxins, which enables the cuttings to absorb more nutrients and thereby produce more leaves and leaf area[53]. The leaf area has a direct relation with the number of leaves as well as shoot growth.

This significant increment in average leaf area might be attributed to the fact that IBA delays the leaf abscission, which increases the partitioning of photo-assimilates towards the leaves, which favoured the leaf area [46]. [18] reported that the cuttings treated with increased concentrations of IBA produced more roots, which increased nutrient uptake and aerial growth of the plants resulting in the highest leaf area. [28] also reported that the maximum number of leaves and average leaf area were recorded in cuttings of Firethorn shrub treated with 6000 ppm IBA, while the minimum number of leaves per cutting and average leaf area were observed in the control. This may be due to the fact that IBA produced healthier, longer roots and hence absorbed more nutrients and water content, which has resulted in a higher number of leaves produced by the cutting. The increase in the number of leaves per cutting might be due to the reason that the plant might divert maximum assimilate quantities to the leaf buds, since the leaves are one of the production sites of natural auxins in them, besides being very important for vital processes like photosynthesis and respiration [58]. Similarly,[16] reported that the maximum number of leaves, leaf area, leaf length and leaf weight was obtained from IBA treatments to strawberry plants as compared to control. It is also noted that the application of 2000 ppm IBA to the basal segment of semi hardwood cutting of Pomegranate cultivar Kandhari produced highest number of leaves and leaf area [14]. Similarly [3] observed that the maximum number of leaves and leaf area were noted in 6000 ppm IBA-treated hardwood cutting of the Grapes cultivar Pusa Navrang. Likewise, [31]observed that2500ppm IBA to Fig hardwood cuttings was found to be best in terms of number of leaves, leaf size in terms of length and width. It is also noted by[20] that 2000 ppm IBA treatment to stem cuttings of Sweet Lime resulted in the highest number, length,and width of leaves.[55] also reported maximum leaves and fresh weight of shoot in pomegranate cuttings treated with 2000ppm IBA.

3.7 Percent rooting

The perusal of data Table 2 revealed that the highest percentage(95.12) of rooted cuttings was found in 4000 ppm IBA-treated cuttings, with the lowest percentage(40.28) in the control. The better rooting in cuttings treated with auxin might be due to the enhancement in hydrolysis activity, which favours the formation of high carbohydrate and low nitrogen, and leads to the increment in root formation [6].Similarly,[38] observed the highest rooting percentage in softwood cuttings of Guava treated with 4000 ppm IBA. It is also found that 2000 ppm IBA stimulated rooting in hardwood cuttings in plum rootstocks [11] and Kala Amritsari plum[32].Similarly, 1500 ppm IBA treatment had the highest rooting percentage of Santa Rosa plum cuttings and the minimum was in the control treatment [24]. Likewise stem cuttings of Pomegranate cultivar Bhagwa treated with 1000 ppm IBA recorded the highest percentage of rooting as compared to the control[21].Exogenous application of auxin breaks starch in to simple sugars, which is needed to a greater extent for the production of new cells and for increased respiratory activity in the regeneration tissue at the time of initiation of new root primordia [54]. The presence of leaves on cuttings also could have helped in the initiation of roots [33]. [57] reported that IBA has enhanced the rooting by increasing of internal auxins. [20] also noted that 2000 ppm IBA treatment to stem cuttings of Sweet Lime resulted in the maximum number of roots. Similarly,[55] noted the highest percentage of rooted cuttings of Pomegranate treated with 2000ppm IBA. [34] Also noted that *Synsepalum dulcificum*(miracle fruit) stem cuttings treated with 400ppm IBA showed maximum rooting percentage.

3.8 Number of primary roots,number of secondary roots, length of primary roots, length of secondary roots, and diameter of primary root

From Table 2, it has been observed that the significantly higher number of primary roots(35.15), secondary roots(68.53), primary root length(30.24cm), secondary root length(23.16cm) and primary root diameter(0.56cm)were observed in the hardwood cuttings of plum treated with 4000ppm IBA. Indole-3-butyric acid encourages cell elongation, which helps in increasing the root length. Increased cultivation and carbohydrate accumulation could explain the rise in root girth. Increased root weight was due to an increase in the number of roots and the largest root girth and length. IBA aided in the mobilization of stored food, meristematic cell elongation, and cambial initials differentiated into root primordia. Because the cuttings already contained some endogenous auxin, treating these with IBA increased the auxin concentration in the cutting [4]. Likewise, 2000 ppm IBA treatment to the basal segment of semi-hardwood cutting of Pomegranate cultivar Kandhari showed the best result in terms of rooting percentage and length of roots[14]. Similarly number of roots, root girth, root length of Shan-i-Punjab cutting was found to be highest in 3000ppm IBA treatment[49]. [26] also noted that Guava stem cuttings were treated with IBA produced thicker roots. It could be because IBA stimulated callus development and root growth by increasing cell wall flexibility and cell division.Cuttings of *Rosa hybrida* rootstock that have sprouted discovered increased root length in IBA-treated plants due to increased glucose hydrolysis, protein synthesis, cell expansion and cell division mediated by auxins [35]. The per cent of root cutting increased, possibly due to the usage of the appropriate hormone level. The IBA concentrations resulted in high carbohydrate and low nitrogen levels, resulting in higher root formation[30] . Indole-3-butyric acid enhanced the number of roots, length of root and roots fresh and dry weight in grape cuttings[10]. Similarly it was revealed that hardwood cuttings of peach treated with 2400 ppm IBA enhanced root number, root girth and root length[36]. Likewise clone of *Prunus domestica* treated with 2000ppm IBA gave the best results in terms of root number and average root length[56] . It is also noted that 2500 ppm IBA treatment to Fig hardwood cuttings was found to be best in terms of number and length of roots[31].[51] also reported that 2000ppm IBA treatment to semi-hardwood cuttings to Phalsa cultivar Thar Pragati showed highest number of primary and secondary roots. Similarly IBA treated pomegranate hardwood cuttings showed highest number of roots and root length while the minimum was found under control treatment[59]. Likewise semi hardwood cutting of Pomegranate cultivar Kandhari treated with 2000ppm IBA had highest number of roots and length of roots[14].[20] also reported that 2000 ppm IBA treated stem cuttings of Sweet Lime produced highest number of roots, length of roots and diameter of roots.[55] also observed the highest number of roots , length of root and fresh weight of rooting Pomegranate cultivar Bhagva cuttings treated with 2000ppm IBA.

3.9 Fresh and dry weight of roots

Different concentrations of IBA recorded significant effect on root fresh and dry weight .

Maximum root fresh (2.56gm) and dry (1.12gm) weights were recorded in treatment 4000ppm IBA. While, the lowest root fresh (0.65gm) and dry (0.21gm) weight observed in control treatment (Table2). This might be due to the strong root system, which returns enhanced nutrient absorption and increases fresh and dry weight of roots. The increase in root weight might be due to the reserved food materials in the cuttings, the translocation of reserved carbohydrates may have also helped in better root growth and weight [48]. Others have reported similar findings that 1000 ppm IBA to stem cuttings of Pomegranate cultivar Bhagwa proved to be the best in terms of fresh and dry weight of roots [21]. Likewise semi harwood cuttings of Sweet Orange treated with 3000 ppm IBA yielded the highest fresh and dry weight of roots [25]. Similarly the results revealed that cuttings treated with 3000 ppm IBA recorded the highest values of root fresh weight and dry weight of Guava cultivar Lucknow-49 through softwood cuttings [40]. The results also revealed that stem cuttings of Pomegranate cultivar Bhagwa treated with 2500 ppm IBA recorded the highest values of fresh weight and dry weight of root [39].Likewise semi hardwood cutting of Pomegranate cultivar Kandhari treated with 2000 IBA showed the best result for fresh and dry weight of roots [14] . Similarly, Fig hardwood cuttings treated with 2500 ppm IBA was found to be best in terms of fresh and dry weight of roots[31].[20]also observed that 2000 ppm IBA treated stem cuttings of Sweet Lime resulted in highest fresh and dry weight of roots.

3.10 Plant height

From the Table1, it has been noted that the maximum plant height (70.18cm) was recorded in cuttings treated with 4000ppm IBA and minimum plant height (32.52cm) was noted in control treatment (Table1). Similarly, [41] observed that in the Acid Lime cultivar PKM1 stem cuttings had highest plant height with 2000 ppm IBA treatment and lowest plant height was noticed in the control. [50]reported that IBA is the active inhibitor of axillary bud break on developing shoots and it stimulates the shoot initiation. Likewise hardwood cuttings of Pomegranate treated with 2000ppm IBA showed the highest plant height after survival [55].[23] Also, reported hardwood cuttings of Peach cultivar Shan-i-Punjab treated with 3000ppm of IBA had the highest plant height. It is suggested that IBA may serve as a physiologically active form of auxin in contributing to stem elongation in intact plants, leading to plant growth and producing taller and healthier plants[60].

3.11Percent success of cuttings

The highest percentage of success(97.15) of hardwood cuttings of plum was noticed with 4000 ppm IBA treatment, which was significantly superior to all other concentrations of IBA and control. Whereas, the minimum cent of success (41.52) of cutting was recorded in the control (Table2). This may be because IBA regulates several elements of a plant's growth and development, including cell division, elongation and differentiation. These processes result in the production of a large number of roots and shoots, which enhance the quality and survival of the plants [8]. This might be explained by a more developed root system with high-quality root and shoot characteristics, which would allow the rooted cuttings to grow more effectively in the field after planting and account for the maximum field survival [47]. Likewise, the highest percentage of success of pomegranate hardwood cuttings was observed in 2500ppmIBA treatment and the minimum percentage of success of cutting was recorded in the control [59] and [39]. Similarly, Acid Lime cultivar PKM1cuttings treated with 2000 ppm IBA recorded the highest values of percentage success [41]. Likewise semi-hardwood cutting of Sweet Orange treated with 3000 ppm IBA resulted in the highest number of roots and root length [25].

Table 1. Effect of different growth regulators on shoot and leaf parameters of Kala Amritsari plum

Treatments	Days taken to first sprout	Number of sprouts	Sprouting (%)	Plant height (cm)	Number of shoots	Shoot length (cm)	Shoot diameter (mm)	Number of leaves	Leaf length (cm)	Leaf breadth (cm)	Fresh weight of shoot (gm)	Dry weight of shoot (gm)
IBA2000ppm	6.05	16.48	75.11	58.36	12.21	22.34	0.67	172.54	9.52	4.36	23.76	13.71
IBA 3000ppm	4.52	18.42	81.25	65.24	13.52	27.32	0.75	190.42	10.1	4.72	25.82	15.45
IBA 4000ppm	3.05	22.75	96.52	70.18	17.62	35.21	1.05	205.12	10.75	5.56	30.52	18.26
IAA 1000ppm	8.1	13.54	67.55	50.61	10.56	15.25	0.6	146.38	7.92	3.41	21.48	12.04
IAA 2000ppm	6.65	15.53	72.1	55.24	11.52	19.35	0.65	163.62	9.02	4.02	23.05	13.05
IAA 3000ppm	5.11	17.62	78.16	60.05	12.85	25.1	0.7	182.11	9.76	4.6	25.16	14.58
NAA 500ppm	9.11	11.36	60.23	44.38	9.05	13.15	0.55	125.55	7.13	3.03	19.65	10.36
NAA1000ppm	8.58	12.25	65.12	47.53	10.12	14.18	0.58	134.58	7.46	3.25	20.52	11.5
NAA1500ppm	7.25	14.06	70.5	52.18	11.05	17.52	0.62	155.34	8.35	3.65	22.56	12.56
Control	15.32	8.28	36.52	32.52	5.23	10.25	0.41	92.16	5.56	2.54	16.15	7.52
SE(m)	**0.29**	**0.80**	**1.07**	**1.0**	**0.75**	**0.81**	**0.01**	**1.16**	**0.33**	**0.35**	**0.72**	**0.72**
CD(5%)	**0.87**	**2.38**	**3.18**	**2.97**	**2.22**	**2.39**	**0.04**	**3.40**	**0.98**	**1.04**	**2.14**	**2.13**

Table 2. Effect of growth regulators on the root parameters, survival and success of Kala Amritsari plum

Treatments	Rooting (%)	Number of primary root	Number of secondary root	Primary root length (cm)	Secondary root length (cm)	Primary root diameter (mm)	Fresh weight of root (gm)	Dry weight of root (gm)	Survival (%)	Success (%)
IBA2000ppm	80.41	22.05	46.61	22.24	14.36	0.32	1.6	0.76	82.38	84.32
IBA 3000ppm	85.16	27.12	58.38	25.15	18.25	0.38	1.81	0.96	90.26	90.52
IBA 4000ppm	95.42	35.15	68.53	30.24	23.16	0.56	2.56	1.12	95.75	97.15
IAA 1000ppm	71.45	15.52	30.41	19.36	10.21	0.25	1.3	0.46	72.21	72.38
IAA 2000ppm	77.08	19.52	40.45	21.52	12.23	0.29	1.52	0.67	80.11	80.14
IAA 3000ppm	82.1	24.36	52.21	23.52	16.18	0.35	1.72	0.85	85.21	88.25
NAA 500ppm	65.23	11.54	24.72	17.54	8.63	0.2	1.05	0.31	65.54	68.6
NAA1000ppm	68.54	13.21	27.15	18.56	9.45	0.22	1.16	0.38	68.36	70.62
NAA 1500ppm	74.32	16.63	35.55	20.35	11.5	0.27	1.41	0.54	78.42	76.18
Control	40.28	8.15	16.28	14.51	5.42	0.12	0.65	0.21	38.52	41.52
SE(m)	**0.75**	**1.05**	**1.39**	**0.60**	**0.67**	**0.01**	**0.05**	**0.04**	**1.07**	**1.17**
CD(5%)	**2.23**	**3.11**	**4.14**	**1.79**	**1.98**	**0.04**	**0.14**	**0.12**	**3.17**	**3.48**

Conclusion

It is concluded from the results obtained from the present study that the basal portion of hardwood cuttings of Kala Amritsar plum treated with 4000 Indole-3-butyric acid (IBA) in the month of December proved to be more effective in terms of various root and physiological growth parameters, with minimum days taken for sprouting with maximum rooting, survival, and success percentage. This treatment was found to be effective for faster multiplication of nursery plants of the Plum cultivar Kala Amritsari.

Future Thrust

Future thrusts for Kala Amritsari plum propagation involve optimizing the application of auxins (IAA, IBA, NAA) through a combination of quick dip and slow dip techniques, exploring new auxin combinations with plant growth regulators like GA_3, and potentially integrating bacterial IAA for enhanced root development. Research should focus on precise concentration determination for IAA, IBA, and NAA in different combinations, and also exploring different media types to improve sprouting, rooting, survival, and subsequent plant growth.

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Conflict of Interest Statement

The author declare that they have no competing interests

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