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Influence of Growth Regulators on the Regeneration and Survival of Plum cv. Kala Amritsari through Stem Cuttings

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***Abstract* – The present investigation entitled "Influence of growth regulators on the regeneration and survival of plum cv. Kala Amritsari through stem cuttings" was carried out in well maintained nursery and in laboratory of Department of Horticulture, Khalsa College, Amritsar during 2016-17. The experiment comprised of ten treatments of IBA and PHB including control, replicated thrice in randomized block design. Uniform sized 40 cuttings per replication were treated with respective concentrations of growth regulators by slow dip (24 hours) and quick dip (2 minutes) method and then planted on beds of size of 1m×1m, with 20 cuttings per bed. Results of the study showed that IBA @ 2000ppm quick dip was found to be significant in improving the shoot and root characters in cuttings with maximum shoot length (16.87 cm), average shoot girth (0.46cm), shoot number (4.22), fresh weight of shoots (6.82), dry weight of shoots (1.43g), leaf number (154.28), average leaf area (305.79 cm2), root number (44.90), average root length (10.88cm), length of longest root (13.5cm), fresh weight of roots (1.52g), dry weight of roots (1.09). While the cuttings treated with slow dip of IBA 150 ppm (T3) exhibited maximum survival percentage (77.00 %), percentage of rooted cuttings (74.33 %) and sprouting percentage (75.17 %). The treatment T3 was also found to be at par with treatment T6 (IBA 2000 ppm) with 70.67 survival percentage, 64.17 per cent of rooted cuttings and 70.67 sprouting percentage.**

***Keywords* – Plum Cuttings, IBA, PHB, Survival.**

I. Introduction

Plum is an important stone fruit of Rosaceae family, grown under temperate and sub-tropical areas of the world. It is quite popularised among orchardists because of its yield potential and high economic returns. It is also profitably used as a filler tree in the orchards of mango, litchi and pear which come into bearing late [13]. However, some low chilling plum cultivars are well adapted to the sub-tropical climate of India and are successfully grown in the states of U.P., Punjab and Haryana where local cultivars are prominent in different regions viz. Titron in U.P. and Kala Amritsari in Punjab [8]. The total area under Japanese plum in Punjab is 225 ha with an annual production of 4022 mT [2]. Plums are commercially propagated by grafting on seedling rootstocks of peach, plum and apricot in the hills [1]. Whereas in Punjab, peach seedlings and Kabul Green Gage are the commonly used rootstocks. But, this method is laborious and time consuming, so the propagation of subtropical plum can also be carried out successfully by means of stem cuttings. However, stem cuttings is one of the easiest and economical method of propagation, but many woody plants are often difficult to root and this difficulty is still one of the major obstacles to economical propagation. There are several factors known to affect the rooting in woody species such as substrate, wounding of cuttings, air environment, genotype and season and plant growth regulators. Among these factors, application of synthetic growth regulators to the stem cuttings may be very effective in promoting root formation in plum species [4]. Effect of indole butyric acid on root formation from different types of cuttings were reported in several prune species such as GF677 (Peach × Almond hybrid), plum and Japanese plum. Application of IBA at the rate of 3000 ppm for 1-2 min took significantly the minimum number of days to sprouting with the highest sprouting percentage, survival percentage, average number of roots, length of main root, root girth, root weight, plant height, plant girth, number of branches, number of leaves and leaf area [14]. Now-a-days the use of phenolic compounds to enhance the rooting of difficult to root plants is not an uncommon practice. PHB (p-hydroxybenzoic acid), a non-auxin compound, has the capacity to synergize the root promoting action of endogenous auxins [17]. Therefore, keeping the above factors in view, the present study was planned to check the performance of growth regulators (IBA and PHB) in plum cuttings for having true-to-type plants.

II. Materials and Methods

The experiment was carried out in the nursery of Department of Horticulture, Khalsa College Amritsar, Punjab, India during the year 2016-17 to examine the "Influence of growth regulators on the regeneration and survival of plum cv. Kala Amritsari through stem cuttings". The cuttings were taken from healthy and malady free shoots. The cuttings of about pencil thickness and 15-20 cm in length having more than 3 buds prepared from uniformly vigorous, healthy and disease free previous season's branches during 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 the rooting in cuttings. The cuttings were treated with the respective concentrations of different growth regulators by soaking method (quick dip and slow dip).The experiment was laid out in Randomized Block Design with ten treatments which replicated thrice. The treatments were comprised of IBA {@ 50, 100 and 150 ppm (slow dip) and 1000, 1500 and 2000 ppm (quick dip)}, PHB {@ 500, 1000 and 1500 ppm (quick dip)} and control. A unit of 40 cuttings comprised of one replication, hence total of about 120 cuttings were used in each treatment including control and 1200 cuttings were planted for conducting the present experiment. The treated cuttings were planted on the beds prepared for this purpose by incorporating a mixture of sand, soil and farmyard manure. The soil was prepared well and drenched with chlorpyriphos solution to avoid the attack of termites. The cuttings were planted on the raised beds in the field on the same day after treating with growth regulators. There were 20 cuttings planted on each bed by keeping distance of 20×20 cm. The holes for planting the cuttings were made in the beds with the help of iron rod so as to avoid any damage to cuttings. While planting, about 2/3rd portion of the cuttings were buried in the soil, leaving 1/3rd portion exposed to the environment.

III. Results and Discussion

A. *Sprouting Percentage*

The data presented in Table I depicted that there is significant difference between sprouting percentage of cuttings treated with different concentrations of growth regulators. The significant sprouting percentage was found in the cuttings that were dipped in respective IBA concentrations for twenty four hours than all the other treatments. Maximum sprouting percentage (75.17 %) was recorded in cuttings treated with treatment T_3 (IBA 150 ppm slow dip) which was also found to be at par with treatments T_2 (IBA 100 ppm slow dip) and T_6 (IBA 2000 ppm quick dip) with sprouting percentage of 69.17 and 65.08 per cent respectively. Both the former treatments were found to be statistically superior to rest of the treatments. It might be due to the increased level of auxin which results in earlier completion of physiological processes in rooting and sprouting of cuttings. The present findings are in accordance with [12] in plum and [9] in Ericaceae plants.

B. *Percentage of Rooted Cuttings*

The perusal of data Table I revealed that the highest percentage of rooted cuttings (74.33%) was found in IBA 150 ppm slow dip treated cuttings (T_3) and was closely followed by treatment T_6 with 64.17 percent of rooted cuttings. 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 [5]. Minimum percentage of rooted cuttings (12.17 %) was observed under treatment T_9 wherein the cuttings were treated with PHB 1500 ppm by quick dip method. The present results are in line with [24] in fig.

C. *Survival Percentage*

The data presented in Table I revealed that the application of IBA significantly improved the survival percentage of cuttings as compared to PHB. It has been found that the plum cuttings treated with slow dip of 150 ppm IBA registered significantly higher survival percentage (77.00 %) in comparison all the other treatments. The above treatment was also found to be closely followed by the treatments T_2 and T_6 with survival percentage of 70.50 and 70.67 per cent. The superiority of treated cuttings regarding the survival can be attributed to the better start and subsequent root growth, which in turn, might have been facilitated with better absorption of nutrients and moisture from soil because of higher number of healthy roots [22]. Whereas, the minimum survival percentage (19.50 %) was recorded in the cuttings treated with quick dip of PHB 1500 ppm. The present findings are similar to the findings of [12].

D. *Average shoot length*

The data presented in Table I indicated that the average shoot length of cuttings has significantly increased with the application of IBA as compared to PHB and control. Maximum average shoot length (16.87 cm) was recorded in the cuttings that were quick dipped in 2000 ppm IBA (T_6) and was also closely followed by the treatments T_1, T_2, T_3, T_4 and T_5 with average shoot length of 14.37, 15.59, 16.71, 14.03 and 15.51 cm respectively. 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 [25]. However, minimum average shoot length (7.14 cm) was observed under treatment T_9 (PHB 1500ppm quick dip). The above findings are in accordance with the [25] in alstonia, [31] in pomegranate, [3] in lime.

E. *Average Shoot Girth*

The data relating to average shoot girth as influenced by different concentrations and duration of dipping of IBA and PHB showed significant effect of various concentrations of auxins on the average shoot girth in plum cuttings. Maximum shoot girth (0.46 mm) was observed in cuttings under treatment T_6 (IBA 2000 ppm 2 mins), which was further closely followed by treatments T_2 (0.45 mm), T_3 (0.45 mm) and T_5 (0.43 mm). The maximum shoot girth observed in cuttings, might be attributed to more number of roots which significantly improve the cell activity and translocation synthesized food material and nutrients thereby resulting in production of more shoots with significant stem girth [7]. The minimum shoot girth (0.29 mm) was observed under PHB 1500 ppm (T_9) and was found to significantly inferior to all the other treatments including control. These findings are in accordance with [26] in phalsa and [11] in fig.

F. *Number of Shoots Per Cutting*

The presented data in Table I showed that the number of shoots per cutting were not significantly affected by the use of growth regulators. However, the maximum number of shoots (4.22) were found in cuttings treated with IBA 2000 ppm (quick dip) while the minimum number of shoots (2.66) was formed under the treatment T_9 (PHB 1500 ppm).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 [7]. The research findings of [11] in fig and [6] in pomegranate are in support with the present findings.

G. *Fresh and Dry Weight of Shoots*

The cuttings treated with IBA 2000 ppm quick dip (T_6) attained maximum fresh (6.82 g) and dry (1.43 g) weight of shoots. While minimum fresh (2.93g) and dry (0.37 g) weight was recorded in plum cuttings treated with treatment T_9. It could be due to increase in leaf area which leads to the elongation of stems and formation of leaf area through cell division, leaf chlorophyll, more starch, sugars and C/N ratio which resulted in maximum fresh and dry weight of shoots

[23]. These findings are in line with [29] in rhipsalis, [18] in pomegranate and [21] in kiwifruit.

H. *Number of Leaves Per Cutting*

It is evident from the data that the growth regulators significantly increased the number of leaves in plum cuttings. Significant number of leaves (154.28) were noted in cuttings under treatment T_6 (IBA 2000 ppm quick dip). 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 producing more leaves [29]. The minimum number of leaves per cutting (67.13) was recorded under treatment T_9 (PHB 1500 ppm quick dip) and was also found to be at par with treatments T_8 (PHB 1000 ppm quick dip) and T_{10} (Control) with leaf number of 69.00 and 70.11 per cutting respectively. Similar findings have been reported in [16] that also registered significant increase in number of leaves in *Arabidopsis* due to the auxin treatment.

I. *Average Leaf Area*

The leaf area has the direct relation with the number of leaves as well as shoot growth. From the data, it has been observed that the average leaf area was significantly improved with the use of IBA @ 2000 ppm (quick dip) with the average leaf area of 305.79 cm^2. This significant increment in average leaf area might be attributed to the fact that IBA delays the leaf abscission which increased the partitioning of photo-assimilates towards the leaves which favoured the leaf area [25]. Refrence [11] reported that the cuttings treated with increased concentrations of IBA produced more roots which increased nutrient uptake and aerial growth of the plants resulted in highest leaf area. However, the minimum average leaf area (99.78cm^2) was observed under treatment T_9, which was found to be closely followed by treatments T_{10}, T_8 and T_7 with average leaf area of 102.70 cm^2, 105.85 cm^2 and 125.13 cm^2 respectively. These findings are in line with [16] in *Arabidopsis*, [11] in fig and [8] in pomegranate.

J. *Average Root Length Per Cutting*

The presented data revealed that the treatment T_6 proved to be superior in promoting the average root length in cuttings, with maximum average length of roots i.e. 10.88 cm. Evidence suggests that auxin might have increased rooting and ensured length of roots by increasing the translocation of metabolites to the growing apices [10] and also enhanced the histological features like formation of callus and tissues and differentiation of vascular tissues [19]. Whereas, the minimum average root length (4.21cm) was observed under control. These findings are in support with [6] in pomegranate and [11] in fig.

K. *Length of Longest Root*

Significant effect of various concentrations of growth regulators and their soaking duration has been noticed on the length of longest root. Maximum root length (13.50 cm) was found in cuttings treated with IBA 2000 ppm quick dip (T_6) and was also found to be at par with treatments T_3 (12.90 cm) and T_5 (12.30 cm). While the minimum root length observed in T_9 (PHB 1500 ppm), which was statistically inferior to all the other treatments. These findings are agreed with the earlier findings of [20] in Grapes and [28] in *Thuja compecta* with respect to length of root per cutting. The increase in length of roots in cuttings treated with growth regulators may be due to the enhanced hydrolysis of carbohydrates, accumulation of metabolites at the site of application of auxins and also cell enlargement and cell division is induced by the auxins [30].

L. *Number of Roots Per Cutting*

The investigation revealed that cuttings with higher auxin concentration produced more number of roots. The cuttings treated with quick dip of IBA 2000 ppm (T_6) had maximum number of roots (44.90) and was also found to be significant over all the other treatments. This increase in number of roots pertains to the fact that the auxin promotes the differentiation of cambial initials into root primordia and increase the mobilization of reserve food material to sites of root initiation thereby giving higher number of roots per cutting [15]. The minimum number of roots (10.19) was observed under control and was closely followed by treatment T_9 with 15.70 number of roots per cutting. These findings are agreed with the [28] and [11] in fig.

M. *Fresh and Dry Weight of Roots*

The presented data depicted that growth regulators significantly improved the fresh as well as dry weight of roots of plum cuttings *cv.* Kala Amritsari. The cuttings treated with IBA 2000 ppm quick dip registered maximum fresh (1.52 g) and dry (1.09 g) weight of roots and was also found to be significant to all the other treatments. However, minimum fresh (0.39g) and dry (0.13 g) weight of roots recorded under treatment T_9. This increase may be attributed to the higher metabolic reserves for root initiation and its growth as well as higher rooting potential of such cuttings, that leads to the increase in fresh and dry weight of roots [27]. The present results are in positive correlation with [27] in phalsa and [32] in apple.

IV. CONCLUSION

It is concluded that the application of IBA @ 2000 ppm by quick dip method proved to be best for promoting rooting in cuttings, sprouting percentage and ultimate survival of rooted cuttings of plum *cv.* Kala Amritsari.

Table I. Influence of growth regulators on sprouting, rooting, survival and various shoot characters of plum cuttings cv. Kala Amritsari.

Treatments	Sprouting percentage (%)	Rooting percentage (%)	Survival percentage (%)	Average shoot length (cm)	Average shoot girth (mm)	Number of shoots per cutting	Fresh weight of shoots (g)	Dry weight of shoots(g)
T_1 (IBA 50ppm)Slow dip	62.50	54.17	63.17	14.37	0.42	3.55	1.73	0.55
T_2(IBA 100ppm)Slow dip	69.17	60.83	70.50	15.59	0.45	3.66	1.81	1.06
T_3(IBA 150ppm)Slow dip	75.17	74.33	77.00	16.71	0.45	4.11	2.02	1.05
T_4 (IBA 1000ppm) Quick dip	60.00	51.83	63.33	14.03	0.42	3.78	1.83	0.83
T_5 (IBA 1500ppm) Quick dip	60.00	58.67	66.83	15.51	0.43	4.11	2.20	1.20

Treatments	Sprouting percentage (%)	Rooting percentage (%)	Survival percentage (%)	Average shoot length (cm)	Average shoot girth (mm)	Number of shoots per cutting	Fresh weight of shoots (g)	Dry weight of shoots(g)
T_6 (IBA 2000ppm) Quick dip	65.08	67.17	70.67	16.87	0.46	4.22	2.60	1.43
T_7 (PHB 500ppm)Quick dip	40.00	29.83	40.17	13.05	0.36	3.48	1.60	0.75
T_8 (PHB1000ppm) Quick dip	18.33	14.83	31.17	09.11	0.31	3.11	1.51	0.55
T_9 (PHB 1500ppm) Quick dip	16.66	12.17	19.50	07.14	0.29	2.66	1.43	0.39
T_{10} Control	35.83	36.67	48.83	13.26	0.38	3.44	1.53	0.75
C.D. (p = 0.05)	**10.16**	**5.12**	**6.58**	**3.11**	**0.03**	**NS**	**0.85**	**0.32**

Table II. Influence of growth regulators leaf and root characters of plum cuttings cv. Kala Amritsari.

Treatments	Number of leaves per cutting	Average leaf area (cm^2)	Average root length per cutting (cm)	Length of longest root (cm)	Number of roots per cutting	Fresh weight of roots (g)	Dry weight of roots (g)
T_1 (IBA 50ppm) Slow dip	93.11	154.78	7.44	10.37	21.36	0.84	0.51
T_2 (IBA 100ppm) Slow dip	99.66	177.78	8.03	11.29	26.33	0.94	0.57
T_3 (IBA 150ppm) Slow dip	109.66	205.88	9.23	12.9	38.80	1.08	0.72
T_4 (IBA 1000ppm) Quick dip	101.21	185.68	6.57	10.98	27.16	0.81	0.37
T_5 (IBA 1500ppm) Quick dip	121.20	217.31	8.31	12.30	34.16	0.94	0.63
T_6 (IBA 2000ppm) Quick dip	154.28	305.79	10.88	13.5	44.90	1.52	1.09
T_7 (PHB 500ppm) Quick dip	80.10	125.13	7.67	9.41	25.00	0.67	0.24
T_8 (PHB 1000ppm) Quick dip	69.00	105.85	6.44	8.33	21.90	0.57	0.21
T_9 (PHB 1500ppm) Quick dip	67.13	99.78	6.07	5.70	15.70	0.39	0.13
T_{10} Control	70.11	102.70	4.21	7.44	10.19	0.60	0.33
C.D. (p = 0.05)	**10.43**	**44.29**	**1.23**	**1.42**	**6.02**	**0.16**	**0.10**

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