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Effect of different Concentrations of PGRs on Shooting and Survival of Stem Cuttings in Lemon (*Citrus limon* Burm.) cv. Pant lemon-1, under Western U.P. conditions

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ABSTRACT: An experiment was conducted to study the Effect of different concentrations of PGRs on shooting and survival of stem cuttings in Lemon (*Citrus limon* Burm.) cv. Pant lemon-1, under western UP conditions at the Horticultural Research Centre, College of Horticulture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh during the year 2021-22. The treatments included T_0 (Control), T_1 (1000 ppm IBA), T_2 (2000 ppm IBA), T_3 (3000 ppm IBA), T_4 (500 ppm NAA), T_5 (750 ppm NAA), T_6 (1000 ppm NAA), T_7 (1000 ppm IBA + 500 ppm NAA), T_8 (1000 ppm IBA + 750 ppm NAA), T_9 (1000 ppm IBA + 1000 ppm NAA), T_{10} (2000 ppm IBA + 500 ppm NAA), T_{11} (2000 ppm IBA + 750 ppm NAA), T_{12} (2000 ppm IBA + 1000 ppm NAA), T_{13} (3000 ppm IBA + 500 ppm NAA), T_{14} (3000 ppm IBA + 750 ppm NAA) and T_{15} (3000 ppm IBA + 1000 ppm NAA) were laid out in Randomized Block Design with three replications. It was further noted that days taken to first bud sprout (8.53 days), sprouting (83.33%), plant height (15.55cm), number of shoots per cutting at 30, 60 and 90 days after planting (2.98, 3.88 and 4.88 respectively), number of leaves per cutting (14.28), shoot diameter (3.41mm) and final survival (83.33%) of cuttings were significantly higher in cuttings dipped in(2000 ppm IBA + 1000 ppm NAA) concentration than other treatments the data also showed that growth parameters were gradually increased with increase in the combination of IBA and NAA *i.e.* T_{12} (2000 ppm IBA + 1000 ppm NAA). The exogenous supply of IBA and NAA has a positive effect on the establishment of stem cuttings of lemon and application of 2000 ppm IBA + 1000 ppm NAA proves to be the best treatment for better root and shoot formations.

Keywords: IBA, Lemon, NAA, Pant Lemon-1, Cuttings.

INTRODUCTION

The genus *Citrus* which includes more than 162 species belongs to the Order *Geraniales*, Family *Rutaceae*, subfamily *Aurantioideae*, tribes *Citreae*, sub-tribe *Citrinae* having chromosome number 2n=18. Most of the Citrus species are native to tropical and sub-tropical regions of South-East Asia, particularly India and China and the regions between these two countries. *Citrus limon* Burm. F. is native to East Asia (Salaria, 2004).

Lemons are one of the important citrus species. It possesses greater adaptability to different climatic conditions, so is grown with equal success in tropical, subtropical and even some favorable parts of the temperate regions of the world. It is a part of a healthy diet and is the best source of vitamin C, sugars, amino acids and other nutrients (Sharma *et al*., 2012).

In India, citrus is the third largest component of the fruit industry next to banana and mango. Citrus ranks are second in area and third in production among all fruits in the Indian scenario. At present, in India total area under citrus cultivation is 1097 thousand hectares with a production of 14245 thousand MT. Whereas, the total area under lemon cultivation is 327 thousand hectares with a production of 3548 thousand metric tonnes. The major citrus-growing states in India are Andhra Pradesh, Maharashtra, Punjab, Madhya Pradesh, Gujarat, Karnataka, Rajasthan, Assam, Orissa, Uttarakhand, Uttar Pradesh, Himachal Pradesh and Tamil Nadu. Uttar Pradesh grows citrus in the 490-thousand-hectare area with a production of 1941 metric tonnes (Anonymous, 2020).

Lemons are generally not propagated from seeds used for commercial cultivation, as these seeds can produce variable seedling populations or longer juvenile stages (Satpal *et al.,* 2014). A cultivar of lemon *i.e.,* Pant Lemon-1 was a selection from Kagzi Kalan. It is a high-yielding, medium-sized fruit (80-100 g), round and smooth, with a thin, juicy skin, resistant to canker, clover and blight. Due to these improved

characteristics, the demand for this breed at the national level is very high. High-quality planting material is always the most important requirement for fruit growers. Therefore, the main goal is to produce high-quality planting material for distribution to growers. For the above purposes, there is a need for a method of rapidly multiplying plant matter to obtain high-quality plants. Obtaining ideal planting materials through vegetative propagation such as cuttings. Cuttings are the cheapest, fastest and easiest way to propagate lemon plants. The type of plants developed by cuttings is real, with uniform growth and uniform crown. This plant blooms and bears fruit earlier than seedlings. The success of cuttings depends on a number of factors related to the plant, such as mother plant, tumefaciens age, tree part used, time of planting, rainfall, moisture, temperature, rooting medium, and post-care (Frey *et al.*, 2006).

Asexual reproduction is preferred as it ensures the true-to-plant type with uniform quality and proper bearing. The purpose of treating cuttings with auxin growth regulators is to increase the rooting rate, accelerate rooting, increase the number and quantity of rooting percent of cuttings, and make rooting uniform. Trees on these rootstocks are vigorous, early-maturing, thorn-less, very drought-tolerant and load-bearing (Singh and Singh, 2016).

Plant growth regulators are artificially generated chemicals that operate in extremely low levels at places other than the site of synthesis to influence various physiological processes that modulate plant growth and development. Plant growth and development are ultimately the functions of all essential elements and five important hormones; Auxin, Gibberellins, Cytokinin, Abscisic Acid and Ethylene (Hajam *et al.*, 2017). These growth regulators develop a higher number of branches, higher leaf area and a better ratio between tiny roots and skeletal ones (Avdiu *et al.*, 2015). In auxins; indole-3-butyric acid (IBA), naphthalene acetic acid (NAA) and 6-Benzylaminopurine (BAP) are used to promote rooting and shooting in cuttings (Hartmann *et al*., 2002).

MATERIALS AND METHODS

This study was conducted during 2021-22 at the Horticultural Research Centre, Faculty of Horticulture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh. Geographically, Meerut is located at latitude 290 40' N, longitude 770 42' E, and 237 meters above sea level (MSL). Meerut's average annual rainfall is about 840 mm, of which nearly 85% is absorbed by the monsoon season from June to September and the rest from October to May. The experiment consisted of 16 treatments and was performed in a randomized block design (RBD) with 3 replicates. Each replicate consisted of 10 cuttings for a total of 30 cuttings per treatment. A total of 480 cuttings were included in the entire experiment. The treatments were T_0 (Control), T_1 (1000 ppm IBA), T_2 (2000 ppm IBA), T_3 (3000 ppm IBA), T_4 (500 ppm NAA), T_5 (750 ppm NAA), T_6 (1000 ppm NAA), T_7 (1000 ppm IBA + 500 ppm NAA), T_8 (1000 ppm IBA + 750 ppm NAA), T_9 (1000 ppm IBA + 1000 ppm NAA), T_{10} (2000 ppm IBA + 500 ppm NAA), T_{11} (2000 ppm IBA + 750 ppm NAA), T_{12} (2000 ppm IBA + 1000 ppm NAA), T_{13} (3000 ppm IBA + 500 ppm NAA), T_{14} (3000 ppm IBA + 750 ppm NAA)andT_{15} (3000 ppm IBA + 1000 ppm NAA).To obtain stem cuttings, one-year-old shoots of the lemon variety Pant Lemon-1 were selected for stem cuttings. The lemon cuttings were immersed in IBA and NAA concentrations, and the control cuttings were directly planted without any treatment. These cuttings are then planted in polyethylene bags (12 cm long, 6.5 cm wide) containing soil, Farm Yard Manure (FYM) and sand in a 2:1:1 ratio. Cuttings treated with IBA and NAA performed better on all growth parameters compared to controls. The various shooting parameters *i.e.*, days taken to first bud sprout, sprouting (%), plant height (cm), number of shoots per cutting, number of leaves per cutting, shoot diameter (mm) and final survival (%) of cutting were recorded. The data recorded were statistically analyzed by using RBD as suggested by Gomez and Gomez (1996).

RESULTS AND DISCUSSION

The effect of different treatments on shoot growth parameters significantly affects the days taken to bud sprout, sprouting (%), plant height (cm), number of shoots at 30, 60 and 90 DAP, number of leaves per cutting, shoot diameter (mm) and final survival (%) of stem cutting in Lemon. In the present investigation, a significant difference has been observed among all the treatments (Table 1).

Days taken to first bud sprout: The different concentrations of PGRs showed a significant effect on days taken to first bud sprout in stem cutting of Lemon. The combined application of T_{12} (IBA 2000 ppm + NAA 1000 ppm) induced early sprouting (8.53 days) followed by T_2 (IBA 2000 ppm) and T_6 (NAA 1000 ppm) treatment. Whereas, the maximum days taken (17.74 days) to first bud sprout were recorded under T_0 (Control) treatment. The earliest number of days taken to first bud sprouting may be caused by the downward transfer of carbohydrates and auxin build-up inside of cuttings for the completion of physiological processes. Similar findings were also reported by Awasthi *et al*. (2008); Patel *et al.* (2018); Kumar and Singh (2020); Patel *et al*. (2021).

Sprouting (%): In the present study, the application of different plant growth regulators has significantly influenced sprouting (%) in stem cutting of Lemon. Among all the treatments, the combined application of T_{12} (IBA 2000 ppm + NAA 1000 ppm) treatment gave maximum sprouting (83.33%) followed by T_2 (IBA 2000 ppm) and T_6 (NAA 1000 ppm) treatment. However, the minimum sprouting (36.66%) was recorded under the T_0 (Control) treatment. It might be due toa high accumulation of callus formation in cuttings with an optimum dose of auxin resulting highest percentage of sprouted cuttings. The present findings collaborated with earlier findings of Bhatt and Tomar (2010); Kumar *et al.* (2015); Fadli *et al.* (2017); Malakar *et al*. (2019).

Table 1: Effect of different concentrations of PGRs on shoot parameters and survival of stem cuttings in Lemon.

Treatments	Days taken to first bud sprout	Sprouting (%)	Plant Height (cm)	Number of shoots			Number of Leaves	Shoot Diameter (mm)	Final Survival (%)
				30 DAP	60 DAP	90 DAP			
T_0	17.74	36.66	6.31	1.62	1.92	2.58	4.82	1.35	36.66
T_1	10.71	70.00	12.23	2.40	3.40	4.49	10.70	2.28	70.00
T_2	9.18	80.00	14.10	2.88	3.82	4.82	11.30	2.56	80.00
T_3	13.13	63.33	10.18	1.90	2.78	3.75	8.54	2.15	63.33
T_4	14.53	60.00	7.86	1.67	2.48	3.50	5.90	1.64	60.00
T_5	13.86	56.66	9.15	1.78	2.49	3.61	6.73	1.94	56.66
T_6	9.61	76.66	13.23	2.74	3.67	4.73	11.06	2.43	76.66
T_7	12.07	66.66	11.11	2.28	3.19	4.28	10.20	2.23	66.66
T_8	11.74	70.00	11.26	2.29	3.29	4.31	10.30	2.24	70.00
T_9	11.36	70.00	12.08	2.32	3.35	4.36	10.60	2.25	70.00
T_{10}	10.61	70.00	12.40	2.48	3.48	4.56	10.90	2.33	70.00
T_{11}	10.07	73.33	13.20	2.67	3.60	4.69	11.00	2.35	73.33
T_{12}	8.53	83.33	15.55	2.98	3.88	4.88	14.28	3.41	83.33
T_{13}	13.04	63.33	10.21	1.96	2.85	3.86	8.66	2.19	63.33
T_{14}	12.72	66.66	10.36	2.19	2.87	3.87	9.07	2.21	66.66
T_{15}	13.40	63.33	9.18	1.82	2.67	3.66	7.86	2.07	63.33
S.E.(m)±	0.17	0.18	0.27	0.14	0.15	0.17	0.13	0.01	0.18
C.D. 5%	0.50	0.52	0.79	0.43	0.44	0.49	0.39	0.04	0.52

Plant height (cm): The favorable and significant influence of plant growth regulators was found on plant height (cm) in stem cutting of Lemon. Among all the treatments, the combined application of T_{12} (IBA 2000 ppm + NAA 1000 ppm) gave maximum plant height (15.55 cm) followed by T_2 (IBA 2000 ppm) and T_6 (NAA 1000 ppm) treatment. Moreover, the minimum plant height (6.31 cm) was recorded under the T_0 (Control) treatment. It might be due to auxin inhibiting axillary bud break on developing shoots and it stimulates the shoot initiation. Auxin treatment enhanced rooting, plant growth and produced taller and healthy plants. Similar results were also observed by Patel *et al.* (2018).

Number of shoots per cutting: In the present investigation, the application of different plant growth regulators significantly influenced the number of shoots per cutting in stem cutting of Lemon. Among all the treatments, the combined application of T_{12} (IBA 2000 ppm + NAA 1000 ppm) treatment gave the better number of shoots (2.98, 3.88 and 4.88 respectively) followed by T_2 (IBA 2000 ppm) and T_6 (NAA 1000 ppm) treatment. Whereas, the minimum number of shoots (1.62, 1.92 and 2.58 respectively) per cutting was recorded under T_0 (Control) treatment at 30, 60 and 90 days after planting of lemon cutting. Such types of observation might be due to activation of auxin in vegetative parts by using auxin like IBA and NAA. Similar results were earlier reported by Kumar *et al.* (2004); Murkute *et al*. (2009); Singh *et al.* (2015); Kumar *et al.* (2015) and Kumar and Singh (2020).

Number of leaves per cutting: In the current investigation, the application of different plant growth regulators significantly influenced the number of leaves per cutting in stem cutting of lemon. Among all the treatments, the combined application of T_{12} (IBA 2000 ppm + NAA 1000 ppm) treatment gave the better number of leaves (14.28) followed by T_2 (IBA 2000 ppm) and T_6 (NAA 1000 ppm) treatment. However, the minimum number of leaves (4.82) per cutting was recorded under the T_0 (Control) treatment. This may be attributed to its effect of shifting of assimilate partitioning from roots to leaves and increased levels of chlorophyll and carbohydrates in leaves, stems and roots besides increased mineral content, hormonal balance and soluble protein in leaves. This result was in agreement with the findings of Seran and Umadevi (2011); Satpal *et al*. (2014); Ahmad *et al*. (2018); Malakar *et al.* (2019); Patel *et al.* (2021).

Shoot diameter (mm): The shoot diameter is significantly influenced by the application of different plant growth regulators in the stem cutting of Lemon. Among all the treatments, the combined application of T_{12} (IBA 2000 ppm + NAA 1000 ppm) treatment gave a better shoot diameter (3.41 mm) followed by T_2 (IBA 2000 ppm) and T_6 (NAA 1000 ppm) treatment. Whereas, the minimum shoot diameter (1.35 mm) was recorded under the T_0 (Control) treatment. It might be due to the activation of auxin content in the vegetative part as acon sequence of better carbohydrate production and assimilation.Similar findings are close in conformity with the earlier results given by Al-Zebari and Al-Brifkany (2015); Satpal *et al.* (2014); Singh *et al*. (2016); Fadli *et al*. (2017) and Patel *et al.*(2021).

Final Survival (%): In the present investigation, the application of different plant growth regulators significantly influenced on final survival (%) of stem cutting of lemon. Among all the treatments, the combined application of T_{12} (IBA 2000 ppm + NAA 1000 ppm) treatment gave better survival (83.33 %) followed by T_2 (IBA 2000 ppm) and T_6 (NAA 1000 ppm) treatment. Moreover, the minimum survival (36.66 %) of stem cutting of lemon was recorded under the T_0 (Control) treatment. The survival percentage is directly associated with the use of root-promoting auxin like IBA and NAA for rooting stem cuttings. Similarly, optimum temperature and high humidity percent also play a vital role in the high accumulation of auxin content in cuttings. These favorable conditions may lead to good photosynthesis to accumulate photosynthates and carbohydrates, resulting significant rate of survival of rooted stem cuttings. Similar results were earlier reported by Saini *et al. (*2010); Chayanika

et al. (2011); Singh *et al.* (2016); Patel *et al*. (2018); Ahmad *et al.* (2018) and Kumar and Singh (2020).

CONCLUSION

Based on the results, different IBA and NAA concentrations and their combinations were applied for shooting and survival of stem cutting of lemon cv. Pant Lemon-1. Out of these, the treatment; T_{12} *i.e.* IBA 2000 ppm + NAA 1000 ppm was found most significant treatment for the shooting and survival percentage of stem cuttings in lemon (*Citrus limon* Burm.) cv. Pant lemon-1 as compared to control ones under Western U.P. conditions.

FUTURE SCOPE

1. Lemon was best grown in an ecologically friendly manner with the different methods of propagation *viz.* air layering and stem cutting etc. Among all Asexual reproduction is preferred as it ensures the true-to-plant type with uniform quality and proper bearing.
2. Standardization of growth regulators for the propagation of lemon cultivar Pant lemon-1 through stem cutting under western Uttar Pradesh conditions.
3. More plants in less time.

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Conflict of Interest. None.

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