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Optimize Stem Cutting Success of Pomegranate (*Punica granatum* L.) cv. 'Bhagwa' with Charcoal and Talc-based Rooting Powder

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ABSTRACT

Pomegranate propagation traditionally relies on liquid-form IBA rooting hormone, but this method poses challenges like preparation complexity, potential cell damage, contamination risks, and accessibility issues. Therefore, there's a need to explore simpler and potentially less chemically-intensive propagation options. The efficacy of charcoal and talc-based IBA rooting powders on 'Bhagwa' pomegranate stem cuttings was studied. Various IBA concentrations in powder form were tested against a standard liquid IBA treatment (T_1, 2500 ppm). Rooting responses to determine the effectiveness of the powder formulations were evaluated. Treatment T_9 (3000 ppm IBA in charcoal+talc powder) produced the best rooting results in the pomegranate cuttings. Notably, treatments T_3 and T_7 exhibited rooting success statistically similar to the traditional liquid IBA (T_1). The powder formulations' longer shelf life reduced contamination risk and easier application suggested that they were a viable alternative to liquid-form IBA for pomegranate propagation. This work demonstrated an innovative and potentially less chemically-intensive approach to plant propagation, contributing to SDGs 9 and 12.

Key words: Auxin, IBA, rooting hormone, stem cuttings, asexual, vegetative, innovative

INTRODUCTION

Pomegranate (*Punica granatum* L.), a commercially valuable fruit crop, is traditionally propagated through hardwood cuttings. The application of auxins, particularly Indole-Butyric Acid (IBA), is widespread to enhance rooting success (Singh, 2017). However, the conventional method of liquid IBA application presents several challenges. High concentrations of IBA can inhibit plant growth, exceeding the threshold of auxin tolerance. The solvents used to dissolve IBA, such as ethyl alcohol, can cause cell desiccation, toxicity and tissue damage when they evaporate. Furthermore, liquid formulations are prone to contamination from cell sap exudation and require frequent preparation of fresh solutions. To address these limitations, powder-based rooting hormones offer a promising alternative. Talcum powder, a chemically inert carrier and charcoal, which has been historically successful in rooting Norway spruce cuttings can serve as effective delivery mediums for IBA. This approach mitigates the need for potentially harmful solvents and reduces the risk of contamination. Several studies have explored the effects of different auxin concentrations on pomegranate cutting success. High IBA and NAA combinations were detrimental to cutting survival and root development. However, limited research exists on the use of powder-based rooting hormones to optimize pomegranate propagation. This study aimed at investigating the efficacy of charcoal and talc-based rooting powder with varying IBA concentrations for enhancing stem cutting success in pomegranate (*Punica granatum* L.) cv. 'Bhagwa'. The outcome of this research was compared with the standard liquid IBA application method to determine the potential benefits of this alternative approach. The findings offered a practical and safer solution for pomegranate growers, improving propagation success rates and reducing the limitations associated with traditional liquid hormone formulations.

MATERIALS AND METHODS

This experimental trial was conducted at Lovely Professional University, Phagwara, Punjab, India. The region has a sub-tropical climate with mild cool winters and warm summers, with an average annual temperature range of 23-28°C. The study was performed during the growing season (February

2022) using a factorial layout in a randomized block design (RBD). Pomegranate (*Punica granatum* L.) cultivar 'Bhagwa' was selected for the experiment. Healthy, mature mother plants were used to obtain approximately 10-15 cm long and 1-1.6 cm thick hardwood cuttings. An inclined cut was made at the distal end to increase surface area for hormone absorption. Various rooting powder formulations containing IBA, charcoal and talc were prepared. Talcum powder (magnesium silicate) acted as a carrier to increase IBA concentration, while activated charcoal was included for its potential benefits in enhancing root development and soil conditioning (Poniewozik *et al.*, 2022). A minimal quantity of the fungicide bavistin was added for protection against fungal diseases. Eleven treatments were applied: T_0 (Control), T_1 (2500 ppm IBA liquid), T_2-T_4 (1500, 3000 and 4500 ppm IBA in talc), T_5-T_7 (1500, 3000 and 4500 ppm IBA in charcoal) and T_8-T_{10} (1500, 3000 and 4500 ppm IBA in charcoal + talc). Cuttings were dipped in honey to enhance rooting hormone adherence and then treated with the respective rooting powders.

Ten cuttings per treatment were replicated thrice (total of 330 cuttings). Cuttings were planted in beds at a depth of 2-5 cm and given uniform irrigation. Data were collected at 20, 40 and 60 days intervals for sprouting percentage, number of sprouts, sprout length and diameter, chlorophyll content and number of leaves. After 60 days, rooting percentage, survival percentage, root length, root diameter and fresh and dry root weights were evaluated.

RESULTS AND DISCUSSION

The maximum sprouting percentage was obtained in T_9 (3000 ppm IBA charcoal + talc based-powder) i.e. (73.3%), which was followed by T_3 (3000 ppm IBA talc-based powder) as 63.33%, T_7 (4500 ppm IBA charcoal-based powder) as 55% and T_1 (2500 ppm IBA liquid form) as 53.33% at 60 days after planting which were at par with each other (Table 1). Among all the various concentrations of IBA treatment, the maximum number of sprouts was recorded in T_9 (3000 ppm IBA charcoal + talc-based powder). The highest number of sprouts per cutting i.e. (9.67) in 60 days after planting, while the minimum number of sprouts per cutting was observed in T_0 (control) i. e. 2.0 in 60 days. Above mentioned results and differences among treatments were statistically significant ($P<0.05$).

The highest length of sprouts per cutting i.e. (8.40 cm) and highest diameter of sprouts per cutting i.e. (3.63 mm) at 60 days after planting were obtained in T_9 (3000 ppm IBA charcoal + talc-based powder, which was followed by T_3 (3000 ppm IBA talc-based powder), T_7 (4500 ppm IBA charcoal-based powder) and T_1 (2500 ppm IBA liquid form; Table 2). The minimum length and diameter of sprouts were recorded in T_0 (control) i.e. (2.40 cm) and (0.90 mm) at 60 days. The above mentioned results and differences among treatments were statistically significant ($P<0.05$).

The maximum amount of chlorophyll content, number of new leaves, rooting percentage and survival percentage were recorded in T_9 (3000

Table 1. Effect of rooting powder formulation on sprouting percentage and number of sprouts per cutting in stem cuttings of pomegranate

Treatment	Sprouting percentage			No. of sprouts/cutting		
	At 20 days	At 40 days	At 60 days	At 20 days	At 40 days	At 60 days
T_0 (control)	11.67	31.67	35.00	0.67	1.66	2.00
T_1 (2500 ppm IBA in liquid form)	30.00	50.00	53.33	4.00	4.66	8.00
T_2 (1500 ppm IBA talc-based powder)	21.67	41.67	40.00	3.00	2.66	3.67
T_3 (3000 ppm IBA talc-based powder)	31.67	58.33	63.33	4.67	6.33	8.67
T_4 (4500 ppm IBA talc-based powder)	21.67	41.67	43.33	2.00	3.00	4.00
T_5 (1500 ppm IBA charcoal-based powder)	25.00	45.00	48.33	2.67	3.33	4.00
T_6 (3000 ppm IBA charcoal-based powder)	18.33	38.33	38.33	3.33	3.66	4.33
T_7 (4500 ppm IBA charcoal-based powder)	28.33	50.00	55.00	4.00	5.00	7.67
T_8 (1500 ppm IBA charcoal+Talc based powder)	26.67	43.33	45.00	3.33	4.00	4.67
T_9 (3000 ppm IBA charcoal+Talc based powder)	38.33	66.67	73.33	5.67	7.00	9.67
T_{10} (4500 ppm IBA charcoal+Talc based powder)	21.67	41.67	43.33	2.67	3.33	4.00
S. E.(m)	2.023	2.150	2.259	0.766	0.791	0.808
S. E.(d)	2.860	3.040	3.194	1.083	1.118	1.143
C. D. (P=0.05)	6.009	6.386	6.710	2.276	2.349	2.402

Table 2. Effect of rooting powder formulation on length and diameter of sprouts of stem cuttings of pomegranate

Treatment	Length of sprouts (cm)			Diameter of sprouts (mm)		
	At 20 days	At 40 days	At 60 days	At 20 days	At 40 days	At 60 days
T_0 (control)	1.00	2.10	2.40	0.30	0.47	0.90
T_1 (2500 ppm IBA in liquid form)	2.70	5.50	5.50	0.62	1.27	2.60
T_2 (1500 ppm IBA talc-based powder)	1.20	3.73	3.90	0.39	0.31	1.00
T_3 (3000 ppm IBA talc-based powder)	2.90	7.32	7.93	0.73	1.57	3.13
T_4 (4500 ppm IBA talc-based powder)	1.36	3.90	4.03	0.48	0.34	1.20
T_5 (1500 ppm IBA charcoal-based powder)	1.20	3.70	3.90	0.46	0.28	1.83
T_6 (3000 ppm IBA charcoal-based powder)	1.46	4.00	4.20	0.27	0.27	1.13
T_7 (4500 ppm IBA charcoal based powder)	2.10	6.30	7.56	0.60	1.17	2.53
T_8 (1500 ppm IBA charcoal+Talc based powder)	1.83	2.46	2.66	0.19	0.31	1.40
T_9 (3000 ppm IBA charcoal+Talc based powder)	3.06	7.40	8.40	0.77	2.03	3.63
T_{10} (4500 ppm IBA charcoal+Talc based powder)	1.36	2.96	3.16	0.42	0.37	1.47
S. E.(m)	0.235	0.390	0.484	0.104	0.169	0.294
S. E.(d)	0.332	0.551	0.685	0.147	0.240	0.416
C. D. (P=0.05)	0.698	1.158	1.439	0.310	0.504	0.873

ppm IBA charcoal + talc-based powder), which was followed by T_3 (3000 ppm IBA Talc base powder), T_7 (4500 ppm IBA charcoal based powder) and T_1 (2500 ppm IBA liquid form) which were statistically at par with each other (Table 3). Among all the various concentrations of IBA treatment, the highest chlorophyll content (52.56) SPU, the highest number of new leaves per cutting (11), highest rooting percentage (97.3) and highest survival percentage (79.3) in 60 days after planting were recorded in T_9 (3000 ppm IBA charcoal + talc-based powder). While the minimum chlorophyll content (20.70) SPU, minimum number of new leaves per cutting (3.0), minimum rooting percentage (61.6) and minimum survival percentage (55) were observed in T_0 (control) in 60 days after planting. Above mentioned results and differences among treatments were statistically significant ($P<0.05$).

The maximum length of roots (length of the longest root) i.e. 4.60 cm, the highest diameter of roots i.e. 3.0 mm, the highest number of roots i.e. 7.3, the highest fresh weight of root i.e. 7.1 g and the highest dry weight of root i.e. 2.02 g were recorded in T_9 (3000 ppm IBA charcoal + talc-based powder) in 60 days after planting (Table 4) which was followed by T_3 (3000 ppm IBA talc-based powder) and T_7 (4500 ppm IBA charcoal-based powder). While the minimum root length i.e. 1.53 cm, the minimum diameter of roots i.e. 0.6 mm, the minimum number of roots i.e. 1.3, the minimum fresh weight of root i.e. 2.2 g and the minimum dry weight of root i.e., 1.16 g were recorded in T_0 (control) in 60 days after

Table 3. Effect of rooting powder formulation on chlorophyll content, number of new leaves/cutting, rooting percentage and survival percentage of stem cuttings of pomegranate

Treatment	Chlorophyll content (Specific pigment unit)		No. of new leaves/cutting		Rooting percentage	Survival percentage
	At 40 days	At 60 days	At 40 days	At 60 days	At 60 days	At 60 days
T_0 (control)	12.93	20.70	2.67	3.00	61.6	55
T_1 (2500 ppm IBA in liquid form)	22.60	37.50	5.67	7.00	93.3	73.3
T_2 (1500 ppm IBA talc-based powder)	19.80	29.90	4.00	6.00	61.6	55.5
T_3 (3000 ppm IBA talc-based powder)	27.40	47.70	7.67	9.33	96.0	76.0
T_4 (4500 ppm IBA talc-based powder)	24.10	34.60	4.67	6.33	86.6	69.3
T_5 (1500 ppm IBA charcoal-based powder)	21.73	24.60	3.67	5.00	76.6	63.3
T_6 (3000 ppm IBA charcoal-based powder)	20.70	30.40	4.67	7.33	83.3	68.3
T_7 (4500 ppm IBA charcoal-based powder)	24.83	40.03	6.00	7.67	93.3	71.6
T_8 (1500 ppm IBA charcoal+Talc based powder)	21.80	26.96	4.00	5.33	78.3	60.0
T_9 (3000 ppm IBA charcoal+Talc based powder)	31.76	52.26	9.00	11.00	97.3	79.3
T_{10} (4500 ppm IBA Charcoal+Talc based powder)	19.60	30.43	5.67	5.67	86.6	66.6
S. E.(m)	2.096	2.378	0.755	0.766	2.347	2.169
S. E.(d)	2.964	3.363	1.068	1.083	3.319	3.068
C. D. (P=0.05)	6.226	7.065	2.244	2.276	6.972	6.444

Table 4. Effect of rooting powder formulation on length of roots (cm), diameter of roots (mm), number of roots, root fresh weight (g) and root dry weight (g) of stem cuttings of pomegranate

Treatment	Length of roots (cm)	Diameter of roots (mm)	No. of roots	Root fresh weight (g)	Root dry weight (g)
	At 60 days	At 60 days	At 60 days	At 60 days	At 60 days
T_0 (control)	1.53	0.60	1.33	2.20	1.16
T_1 (2500 ppm IBA in liquid form)	3.10	2.20	4.67	6.00	1.56
T_2 (1500 ppm IBA talc-based powder)	1.77	1.20	2.67	3.80	1.30
T_3 (3000 ppm IBA talc-based powder)	4.33	2.70	6.00	6.30	1.83
T_4 (4500 ppm IBA talc-based powder)	2.93	1.80	2.33	2.50	1.20
T_5 (1500 ppm IBA charcoal-based powder)	2.17	1.50	4.00	2.40	1.46
T_6 (3000 ppm IBA charcoal-based powder)	3.10	1.40	3.33	2.60	1.28
T_7 (4500 ppm IBA charcoal-based powder)	3.50	2.50	5.00	5.90	1.60
T_8 (1500 ppm IBA charcoal+Talc based powder)	2.03	1.10	3.00	4.20	1.53
T9 (3000 ppm IBA charcoal+Talc based powder)	4.60	3.00	7.33	7.10	2.02
T_{10} (4500 ppm IBA charcoal+Talc based powder)	2.70	1.70	3.67	4.40	1.26
S. E.(m)	0.620	0.384	0.688	0.597	0.119
S. E.(d)	0.876	0.272	0.973	0.844	0.168
C. D. (P=0.05)	1.841	0.807	2.045	1.772	0.353

planting. All the above-mentioned results and differences among various treatments were statistically significant ($P<0.05$), with T_9 (3000 ppm IBA charcoal+talc-based powder) outperforming among other treatments for most parameters.

It was noticed that the cuttings treated with T_9 (3000 ppm IBA charcoal+talc-based powder) were highest in the growth of whole roots, highest rooting percentage, length of roots, the diameter of roots and survival percentage than T_1 (2500 ppm IBA liquid form). On the other hand, results of powder form treatments T_3 (3000 ppm IBA talc-based powder), T_7 (4500 ppm IBA charcoal-based powder) were statically at par with treatment T_1 (2500 ppm IBA liquid form). These results were similar when pomegranate cuttings treated with 3000 ppm IBA and grape cuttings using talc rooting powder @ 3000 ppm concentration (Maninderdeep and Singh, 2022).

Sprouting percentage, number of sprouts per cutting, length and diameter of sprouts indicated the establishment of pomegranate hardwood stem cuttings in the soil and it was a sign of commencement of new growth. Chlorophyll content and number of leaves per cutting parameters indicated that how good the stem cuttings performed photosynthesis for their better survival. Rooting percentage and survival percentage were the two main parameters in which one parameter performance affected the other like if rooting percentage was more than automatically survival percentage of cuttings would be more because if more rooting percentage always gave out a way for better survival efficiency to the stem cuttings. Diameter, length of roots formed, fresh weight and dry weight of root parameters also indicated the healthiness of root system and their good growth could be determined by the exposure to best treatment. All the above parameters were especially more useful in judging the rooting behaviour of pomegranate stem cuttings as hardwood cuttings and going through innovative approach like chemical-free rooting powder usage were taken. All the parameters mentioned were needed to be far superior to estimate exact rooting behaviour of hardwood stem cuttings in pomegranate.

The results performed by treatment T_9 (3000 ppm IBA charcoal+talc-based powder) were recorded high because rooting powders had a stable nature (lasted nearly 10-15 days), less toxic, sanitary when compared to a liquid formulation (Shahab *et al.*, 2018), which avoided wilting (desiccation) and enhanced the survival rate of cuttings. The treatment T_9 (3000 ppm IBA charcoal+talc-based powder) was made of ingredients of IBA @ 3000 ppm concentration, talc powder and charcoal powder. Auxin - IBA (Indole-butyric acid) played an essential role in cell division, cell multiplication, enhancing root initiation and profused root formation in cuttings (Maninderdeep and Singh, 2022). The talc powder was mainly used as a carrier that is inert and did not affect rooting; it absorbed moisture well and kept the basal injured portion of the cutting moist to absorb the rooting hormone IBA more efficiently (Kumar, 2016). The use of IBA in the form of rooting powder for the *B. acetabula* hardwood cuttings was more effective in rooting rates i.e. nearly high 25 to 52% than softwood or herbaceous cuttings (Vlachour *et al.*, 2021). Moreover, the activated charcoal powder acted as an excellent soil conditioner that improved cell growth and development, slowing (or) minimising nutrient runoff by rain (or) irrigation and improved the soil's capacity to hold onto plant nutrients and beneficial soil microorganisms. Furthermore, charcoal's low density lightened heavy soils, allowing for more significant root development, increased drainage and air infiltration. Activated charcoal also affected the root length and weight (Manokari *et al.*, 2021; Kostas *et al.*, 2022; Poinewozik *et al.*, 2022). These were the factors that treatment T_9 (3000 ppm IBA charcoal+talc-based powder) showed better performance. Various studies had demonstrated the efficacy of IBA (Indole-3-butyric acid) in promoting root development within hardwood cuttings across diverse plant species. Adiba *et al.* (2022) observed optimal rooting, root number and root length in pomegranate cultivars treated with IBA 3000 mg/l. Similarly, Patel *et al.* (2020) found the highest rooting and survival percentages, root length and root weight in pomegranate cv. 'Bhagwa' with a combination of IBA 3000 ppm and a 1:1 soil/perlite substrate. Comparably, Guney *et al.* (2021) reported a 73.3% rooting success rate in coniferous plant cuttings using NAA 5000 ppm, a similar auxin. Further supporting IBA's effectiveness, studies on peach hardwood cuttings (Noori and Mohammed, 2020), hemp (McLeod *et al.*, 2022), Clerodendrum splendens (Jamal *et al.*, 2021), and litchi (Mumtaz *et al.*, 2022) demonstrated improved rooting with various IBA concentrations. Additionally, Tanwar *et al.* (2020) observed superior rooting, survival and root length in pomegranate cv. 'Bhagwa' using an IBA 2000 ppm treatment with a coco peat, vermiculite and perlite substrate. However, in control (T_0) because of the lack of auxin, there was no production or activation of cytokinin, which resulted in the least amount of reserve food materials being formed, which, according to some research, resulted in the fewest number of roots, rooting percentage, root length and diameter, root fresh and dry weight and number of sprouts. Rhizopon, rootone, fast root rooting powders, Hormodin 1 and 2 (Paudel *et al.*, 2022) which contained different concentrations of auxins in powder form and were proven to be important and had significant effect in root development, rooting percentage and plant growth, likewise had similar outcomes (Monder, 2016). As in this research IBA was in powder form so there was less scope of contamination causing the plants to die or dry up (Maninderdeep and Singh, 2022). IBA, the rooting hormone in powder form, is a better choice for root induction because of pomegranate stem cuttings. These findings suggest that using 3000 ppm IBA in a charcoal and talc-based powder could significantly improve propagation success for pomegranate growers, easy and readily usage, potentially leading to higher yields and economic benefits. Also gives a way for innovative and chemical-free approach by using charcoal and talcum-based rooting powder for pomegranate propagation which paves a way to achieve SDG's by protecting our soils and environment.

CONCLUSION

The effectiveness of various IBA-based rooting powders for propagating 'Bhagwa' pomegranate stem cuttings was investigated. The treatment T_9 (3000 ppm IBA in charcoal+talc powder) significantly outperformed other treatments in promoting both root and shoot development. Compared to the control (T_0), T_9 resulted in a substantially higher rooting percentage (97.3), longer roots (4.60 cm), greater root diameter (3.0 mm), number of roots per cutting (7.3) and increased fresh weight (7.10 g) and dry root weight (2.02 g). Additionally, shoot parameters, such as the number of sprouts, sprout length and sprout diameter were notably enhanced in this treatment. The superior performance of T_9 could be attributed to the combined benefits of IBA, talc and charcoal. Importantly, the powder-based formulation minimized the risk of contamination often encountered with liquid IBA solutions, enhancing the overall success rate. While the study focused on a single pomegranate cultivar 'Bhagwa', the promising results warrant further investigation. Future research will explore the effectiveness of T_9 on other commercially important pomegranate cultivars. Additionally, optimizing storage conditions for the powder formulation would ensure their long-term efficacy and potential for broader adoption by pomegranate growers. This work demonstrated an innovative and potentially less chemically-intensive approach to plant propagation, contributing to SDGs 9 and 12. Overall, the study highlights the potential of utilizing IBA-based rooting powders with charcoal and talc as a safe, effective and efficient method for pomegranate propagation.

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