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STUDY OF ROOTING POWDER WITH IBA ON ROOT INDUCTION BEHAVIOUR OF HARDWOOD CUTTING OF *CITRUS KARNA*

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ABSTRACT

Background: Clonal propagation is essential to propagate citrus rootstocks like *C. karna.* Most citrus plants are propagated by hardwood stem cutting by using exogenously applied Auxin (Indole Butyric Acid) on rooting. Auxin (Indole Butyric Acid) is typically used in liquid form. However, using auxin in liquid form has drawbacks, such as the need for always fresh auxin solutions and the possibility that cutting ends may exude cell sap when dipped in the solution. Therefore, in the present study, auxin hormone is applied in powder form by developing a new product by using talcum powder as the base material to address these issues.

Methods: This study aimed to evaluate the rooting abilities of hardwood cuttings of *citrus karna* using different IBA concentrations alone along with Zinc Sulphate and to determine the synergistic effect of Zinc Sulphate and IBA on the cutting. After 30 days of each treatment, rooting percentage, average root number, average root length, root diameter, number of sprouts, days to first rooting, days to first bud spout, root fresh weight, root dry weight, dry weight percentage were assessed.

Result: The results indicate that root induction behaviour was best in citrus cuttings treated with IBA @ 0.15 % with Zinc Sulphate @ 0.50 % in powder form(T_9). However, in most cases, observations were *at par* with IBA @ 0.10 % (powder form) in T_6 and with treatment T_8 (IBA 0.1% in powder form + 0.5% $ZnSO_4$). However, if additional advantages are taken into accounts, such as long shelf life and the absence of contamination, it can be said that the new product innovation of rooting hormone in powder form is preferable to the liquid form for root induction.

Keywords: *Talc base, Zinc Sulphate, clonal, stem cutting, vegetative, auxin, propagation, product innovation*

Introduction

Citrus karna Raf (Family - Rutaceae) is a wild species found in India. Indigenous Citrus Germplasm in India Locally named id-nimbu, jamuri, khatta nimbu. *Citrus Karna* (Karna-khatta) has leaves and flowers that resemble rough lemons but are larger in size. *Citrus karna* is a native of India. It can grow up to 300 meters in elevation all over India. It counters two primary problems of cracking and sun-scalding (Chadha, 2019) and produces vigorous trees of pineapple, Jaffa, Mosambi, Valencia and Hamlin Oranges (Chattopadhyay, 2007). Rootstocks can influence the availability and distribution of nutrients within the plant and help maintain the proper balance. The results of the leaf analysis differentiated the rootstocks. Results showed that the leaves of Mosambi plants budded on the 'Karna Khatta' rootstock had higher levels of macronutrients (N, P, and K) and micronutrients (Zn and Fe) than those from plants on other rootstocks. It is because of "*Karna Khatta's*" extensive root system, which aids in efficiently absorbing nutrients from the soil and their subsequent delivery to the scion. 'Mosambi' budded on 'Karna Khatta' had larger fruits in terms of fruit weight and fruit volume (Srivastav,2005). Citrus fruits are a particularly excellent source of vitamin C and folates. Vitamin C is an antioxidant which reduces some aspects/elements of the inflammatory response. Citrus fruit juices contain substantial amounts of hesperidin, narirutin, and naringin bioactive polyphenols. (Mills and Calder, 2021)

In horticulture, cutting is frequently preferred to other methods of propagation because it is less expensive, quicker, and easier to propagate. This method is required for citrus, as it is for many other fruit crops, to maintain the mother plant's desirable traits (Hartmann *et al.* 1983) and to supply them with an adequate supply of true-to-type rootstocks. Since rootstocks are known to influence many scion characteristics, including vigour, yield, fruit quality, and disease resistance, conditioning the success of the citrus industries, this fact may be of great significance. In addition, cutting-derived plants are uniform (Fadli *et al.* 2017).

Several investigation have been conducted to determine the ideal auxin treatment concentration for citrus hardwood cuttings. A hormonal solution was used to make, and cuttings were treated by dipping for a while. However, most of the time, auxin, primarily IBA, is used in liquid form. One of the studies stated how different IBA concentrations and growing environments affect the stimulation of adventitious root formation in stem cuttings of kagzi-lime. An *et al.* (2019) researched the rooting Ability of Hardwood Cuttings in Highbush Blueberry (*Vaccinium corymbosum* L.) Using Different Concentrations of IBA and observed that for the majority of cultivars, 1000 and 2000 ppm IBA were enough to reflect the maximum rooting percentage. Marković *et al*. (2014) researched Cornelian Cherry using IBA powder and observed maximum rooting, i.e., 96.7% in cuttings. Bowman & Albrecht (2017) conducted research on various diversity of citrus rootstock genotypes by single node cuttings for root induction using (Hormodin 2, rooting powder E.C. Geiger, Inc., Harleysville, PA, USA) containing 0.3% IBA. Albrecht *et al* (2020) also has used (Hormodin 2, E.C. Geiger, Inc., Harleysville, PA, USA) containing 0.3% IBA. Kour et al. (2022) worked on the Rough lemon to check the Response of IBA on rooting behaviour using various concentrations of IBA 500, 1000, and 1500 ppm and found that Cuttings treated with 500 ppm IBA showed the best root growth, root length, root thickness, and leaf sprouting results. Karam & Gebre (2004) used IBA Powder in research at 0.3 % & 0.8 %, resulting in 60% or 73% rooting. Shahab *et al*. (2013) also used Talc base IBA Powder on Alstonia Cuttings for the assessment of various shoot & root parameters.

There were some drawbacks to using auxin in liquid forms, such as the potential for contamination when cutting ends are dipped in the solution because cell sap may release from them. We cannot reuse this IBA solution for longer than 15 days due to contamination and denaturing, so it must be prepared from scratch each time it is used. In addition, some worker overuse ethanol to hasten the breakdown of auxin in the solution; this can cause toxicity and dryness in the cuttings after application. Auxin hormone is applied in powder form using talcum powder (magnesium silicate) as a base substance to fix these issues.

Materials and Methods

This experiment was conducted in the horticultural nursery of Lovely Professional University, Phagwara, Punjab. Different combinations and concentrations of IBA-containing rooting powder were tested to induce rooting in citrus hardwood cuttings in July 2021. In this investigation, the recommended amount of IBA was used and mixed with the minimum quantity of Ethyl alcohol; after the uniform mixing, Magnesium silicate talc powder was added to the powder form. The rooting powder was magnesium silicate (talcum powder) as a carrier to raise the overall concentration of IBA. With the aim to develop new product, total of nine treatments, comprising viz. **T_1 -** Control; **T_2 -** IBA @ 0.15 % (Liquid form); **T_3 -** Only Magnesium silicate (Talc only) **;** **T_4 -** IBA @ 0.05% ; **T_5 -** IBA @ 0.10 % **;** **T_6 -** IBA @ 0.15 % ; **T_7 -** IBA @ 0.05 % with Zinc Sulphate @ 0.50 % ; **T_8 -** IBA @ 0.10 % with Zinc Sulfate @ 0.50 % ; **T_9 -** IBA @ 0.15 % with Zinc Sulphate @ 0.50 % were used. About seven (T_3 to T_9) treatments were prepared in powder form with the base material (as a carrier) Talcum powder (Magnesium silicate). In this investigation, cuttings of healthy hardwood were taken from the mother plant. The cutting base was moistened. The container was poured with the recommended amount of rooting hormone, and then the cutting's base was coated with this rooting powder mixture before being rolled up and planted into the soil. There were 10 cuttings in each replication, i.e., 30 cuttings in each treatment and a total of 270 hardwood stem cuttings for the investigation. These were wounded at the base to encourage the early emergence of plant roots from cutting. Cuttings were uniformly irrigated after being planted in each bed at 5 to 10 cm below the soil's surface. Observations concerned with rooting parameters were recorded, *viz*. Rooting percentage, Number of roots, Length of the roots (cm), diameter (girth) of the roots (mm), number of sprouts, time taken for rooting, time taken for first bud sprouts, Fresh root weight (g) and Dry root weight (g) were taken. These observations were made at 30, 60, and 90 days, and the data were analyzed per those intervals. This study was conducted using the Randomized Block Design (RBD) statistical methodology.

Results and Discussion

The results obtained in the current investigation are presented hereunder.

Treatment 1

Treatment 2

Treatment 3

Treatment 4

Treatment 5

Treatment 6

Treatment 7

Treatment 8

Treatment 9

Fig: 1. Images showing the rooting behaviour of the citrus cuttings after 90 days of planting.

1. Effect on rooting percentage (%)

Table 1 shows that the different IBA concentrations had a noticeable impact on the root induction. The maximum rooting percentage was obtained in T_9 (IBA 0.15% in powder form+0.5% $ZnSO_4$) followed by T_6 (IBA 0.15% in powder form) and T_8 (IBA0. 1% in powder form+0.5% $ZnSO_4$) which were *at par* with each other. The ability of cuttings to withstand the conditions, innate growth regulators, etc., may have contributed to the variation in response to different treatments. Additionally, favourable conditions like the optimum temperature (25-30 ºC) and high relative humidity (80-90%) that could promote better rooting in cuttings could be attributed to when growth regulators were being used to boost the rooting of cuttings. These findings confirm earlier research by Sokhuma *et al*. (2018) using Mulberry cuttings which reported 86 % rooting success.

Table 1: Effect of various concentrations of IBA in powder form on rooting percentage of hardwood cuttings of citrus at different intervals.

Treatment	Rooting percentage (%)		
	At 30 days	At 60 days	At 90 days
$T_{1(control)}$	41.4^f	43.8^f	44.2^f
T_2 (IBA0.15 % in liquid form)	46.2^e	48.1^e	49.1^e
T_3(Only magnesium silicate)	45.8^e	47.3^e	48.8^e
T_4(IBA 0.05% in powder form)	55.9^d	61.4^d	62.1^d
T_5(IBA 0.10% in powder form)	70.9^c	72.8^c	75.1^c
T_6(IBA 0.15% in powder form)	83.8^b	84.4^b	85.1^b
T_7(IBA0.0 5% in powder form+0.50%ZnSO4)	58.7^d	61.3^d	62.4^d
T_8(IBA0. 1% in powder form+0.5% ZnSO4)	82.1^b	82.9^b	83.5^b
T_9(IBA0.15% in powder form+0.5% ZnSO4)	90.8^a	91.7^a	92.6^a

The effects of various IBA treatments on the rooting percentage of citrus cuttings were found to be significant. The highest rooting percentage (92.6%) was found in the treatment T_9 (IBA0.15% in powder form+0.5% $ZnSO_4$) at 90 days after planting; it was statistically *at par* with treatment T_6 (IBA 0.15% in powder form), i.e., 85.1% and T_8 (IBA0. 1% in powder form+0.5% $ZnSO_4$), i.e., 83.5 % at 90 days after planting. Conversely, the lowest rooting percentage was found in T_1 (Control), i.e., 44.2 % at 90 days after planting.

2. Effect on the number of roots.

The maximum number of roots were obtained in T_9 (IBA0.15% + 0.5% $ZnSO_4$), followed by T_6 (IBA 0.15% in powder form) and T_8 (IBA 0.1% +0.5% $ZnSO_4$) which were *at par* with each other, while the minimum number of roots were observed in T_1 (control) that is (6.15) in 90 days. Increased metabolic activity and optimal starch and sugar utilization following stem hydrolysis may be responsible for these plants' better rooting and development. However, Upadhayay *et al.* (2020) observed almost the same number of roots (23.11) in the case of apple rootstock cuttings using IBA 2000 ppm, which may be caused by the higher cambial activity in tissues involved in root initiation (Ullah *et al.,* 2005). Bhatt and Tomar (2010) also observed the most significant possible number of primary roots (18.66) in *Citrus auriantifolia* Swingle (Kagzi-lime) using 1000 ppm IBA in a polyhouse environment.

Table 2: Effect of various concentrations of IBA in powder form on the number of roots of hardwood cuttings of citrus at different intervals.

Treatment	Number of roots		
	At 30 days	**At 60 days**	**At 90 days**
T_{1} (control)	3.27^{e}	4.54^{g}	6.15^{e}
T_{2} (IBA0.15 % in liquid form)	11.02^{bcd}	14.34^{e}	17.28^{c}
T_{3} (Only magnesium silicate)	10.84^{cd}	12.27^{f}	13.22^{d}
T_{4} (IBA 0.05% in powder form)	10.56^{d}	15.42^{d}	18.12^{c}
T_{5} (IBA 0.10% in powder form)	11.21^{bcd}	18.75^{b}	20.21^{b}
T_{6} (IBA 0.15% in powder form)	12.51^{b}	16.72^{c}	21.28^{b}
T_{7} (IBA0.0 5% in powder form+0.50%ZnSO4)	12.25^{bc}	15.27^{de}	18.15^{c}
T_{8} (IBA0. 1% in powder form+0.5% ZnSO4)	11.84^{bcd}	15.23^{de}	20.81^{b}
T_{9} (IBA 0. 15 % in powder form+0.5% ZnSO4)	16.54^{a}	20.43^{a}	24.22^{a}

3. Effect on root length (cm)

Table 3 shows that the different IBA concentrations significantly influenced the growth of the root length. This table reveals that root length increased at the dose of (IBA 0.15% in powder form+0.5% $ZnSO_4$ in treatment T_9 followed by T_6 (IBA 0.15% in powder form), which were *at par* with T_8 (IBA 0.1% in powder form+0.5% $ZnSO_4$) in treatment T_8 and Minimum root length was observed in T_1 (control) that is (9.8 cm) in 90 days. Singh (2018) also observed almost the same root length (10.22 cm) in mulberry when treated with 2000 ppm of IBA. On the other hand, Bhatt and Tomar (2010) found the maximum length of the root (15.11 cm) under (500 ppm of IBA) treatment. The assimilation and translocation of auxin compound in rooted cuttings and well-drained soil also promoted the better development of roots by root penetration, which was significantly favoured by the optimal dose of IBA (0.15%) and Zinc Sulphate (0.50%). However, due to the interaction between the growth regulator (IBA) and the zinc Sulphate (0.50%) in the treatments, the most extended root length at 90 DAP varied significantly between the treatments.

Table 3: Effect of various concentrations of IBA in powder form on root length (cm) of hardwood cuttings of citrus at different intervals.

Treatments	Root length (cm)		
	At 30 days	At 60 days	At 90 days
$T_{1(control)}$	7.8^{c}	9.6^{c}	9.8^{d}
$T_{2\ (IBA0.15\%\ in\ liquid\ form)}$	10.7^{b}	12.9^{ab}	14.3^{bc}
$T_{3(Only\ magnesium\ silicate)}$	9.2^{bc}	11.5^{b}	12.9^{c}
$T_{4(IBA\ 0.05\%\ in\ powder\ form)}$	10.5^{b}	13.6^{a}	14.5^{bc}
$T_{5(IBA\ 0.10\%\ in\ powder\ form)}$	9.1^{bc}	12.9^{ab}	15.1^{abc}
$T_{6(IBA\ 0.15\%\ in\ powder\ form)}$	10.6^{b}	12.4^{ab}	15.5^{ab}
$T_{7(IBA0.0\ 5\%\ in\ powder\ form+0.50\%ZnSO4)}$	10.1^{b}	12.3^{ab}	14.6^{abc}
$T_{8(IBA0.\ 1\%\ in\ powder\ form+0.5\%\ ZnSO4)}$	9.3^{bc}	12.5^{ab}	15.4^{ab}
$T_{9(IBA\ 0.15\ \%\ in\ powder\ form+0.5\%\ ZnSO4)}$	12.5^{a}	14.1^{a}	16.8^{a}

4. Effect on root diameter (mm)

Table 4 reveals that the various IBA concentrations significantly influenced the variation in root diameter growth. Results showed that root diameter increased with a concentration of (IBA0.15% in powder form+0.5% $ZnSO_4$ in the treatment T_9 followed by T_6 (IBA 0.15% in powder form) in treatment T_6 and T_8 (IBA 0.1% in powder form+0.5% $ZnSO_4$) in treatment T_8 and declined after that in control. The minimum root diameter was observed in T_1 (control) which was (1.12 mm) at 90 days. Upadhayay et al. (2020) observed the same results and found that the maximum root diameter is 1.33 mm when treated with 2500 ppm of IBA in the case of apple rootstock cuttings. These results are consistent with the reports of Singh (2017) in Phalsa observed diameter of the thickest root was (1.681mm) using 1000ppm IBA.

Table 4: Effect of various concentrations of IBA powder form on root diameter (mm) hardwood cuttings of citrus at different intervals.

Treatments	Root diameter (mm)		
	At 30 Days	At 60 Days	At 90 Days
$T_{1(control)}$	0.88^{c}	1.01^{d}	1.12^{d}
$T_{2\ (IBA0.15\%\ in\ liquid\ form)}$	1.14^{bc}	1.2^{cd}	1.38^{cd}

$T_{3(\text{Only magnesium silicate})}$	1.11^{bc}	1.18^{cd}	1.32^{d}
$T_{4(\text{IBA 0.05\% in powder form})}$	1.18^{abc}	1.24^{cd}	1.51^{cd}
$T_{5(\text{IBA 0.10\% in powder form})}$	1.26^{abc}	1.38^{bcd}	1.98^{abc}
$T_{6(\text{IBA 0.15\% in powder form})}$	1.53^{abc}	1.84^{abc}	2.32^{ab}
$T_{7(\text{IBA0.0 5\% in powder form+0.50\%ZnSO4})}$	1.33^{abc}	1.48^{abcd}	1.73^{bcd}
$T_{8(\text{IBA0. 1\% in powder form+0.5\% ZnSO4})}$	1.74^{ab}	1.96^{ab}	2.31^{ab}
$T_{9(\text{IBA 0.15\% in powder form+0.5\%ZnSO4})}$	1.83^{a}	2.12^{a}	2.35^{a}

5. Effect on the number of sprouts

Table 5 illustrates that the various IBA concentrations had a major impact on the studied characteristics, including the increase in sprouts. The maximum number of sprouts were obtained in T_9 (IBA0.15% in powder form+0.5% $ZnSO_4$ in the treatment T_9 followed by T_6 (IBA 0.15% in powder form) in treatment T_6, followed by T_8 (IBA 0.1% in powder form+0.5% $ZnSO_4$) which is at par with T_5 IBA 0.10% in powder form and Minimum numbers of sprouts were observed in T_1 (Control) 1.12 mm.

Table 5: Effect of various concentrations of IBA in powder form on the number of sprouts of hardwood cuttings of citrus at different intervals.

Treatments	Number of sprouts		
	At 30 days	At 60 days	At 90 days
$T1_{(\text{control})}$	1.24^{d}	1.37^{c}	1.12^{f}
$T_{2(\text{IBA0.15\% in liquid form})}$	1.81^{c}	2.56^{b}	1.62^{def}
$T_{3(\text{Only magnesium silicate})}$	1.12^{d}	1.46^{c}	1.28^{ef}
$T_{4(\text{IBA 0.05\% in powder form})}$	1.42^{cd}	1.69^{c}	1.72^{de}
$T_{5(\text{IBA 0.10\% in powder form})}$	2.8^{b}	3.94^{a}	2.62^{c}
$T_{6(\text{IBA 0.15\% in powder form})}$	3.31^{a}	3.64^{a}	3.32^{b}
$T_{7(\text{IBA0.0 5\% in powder form+0.50\%ZnSO4})}$	1.54^{cd}	1.78^{c}	2.02^{d}
$T_{8(\text{IBA0. 1\% in powder form+0.5\% ZnSO4})}$	2.6^{b}	2.84^{b}	2.76^{bc}
$T_{9(\text{IBA 0.15\% in powder form+0.5\%ZnSO4})}$	3.47^{a}	3.81^{a}	4.68^{a}

6. Effect on the time taken for first bud sprout and rooting (In days).

A perusal of Table 6 indicates that the different concentrations of IBA did not affect the days to first rooting and shooting non-significantly. However, the first rooting was observed in T7 (IBA0.05% in powder form+0.50% $ZnSO_4$) 22 days after planting into the soil, and the first bud sprout was observed at 18 days after planting and in treatment T6 (IBA 0.15 % in powder form) .days taken for the formation of first rooting and sprouting was late recorded as 27 days for rooting and 23 days for sprouting in the T1 (Control). In each treatment, the data was recorded every 5 to 7 days. Treatments had no impact on rooting or sprouting over several days on root emergence. Bowden *et al*. (2022), who used the quick dip method to apply IBA at various concentrations, noted that the quick dip was more effective than a foliar spray for rooting cuttings. Early sprouting in cuttings treated with 2000 ppm IBA solution may result from growth regulators' improved use of nitrogen, stored carbohydrates, and other factors (Maurya *et al*., 2022). Hardwood cuttings had a dry matter and more accumulates, which may have led to the earliest completion of the physiological process involved in sprouting. As its concentration increases, IBA's increased inhibitory action may cause slower bud-sprouting at higher concentrations (Kumari *et al*.,2020).

Table 6: Effect of various concentrations of IBA in powder form on time taken for first bud sprout and rooting (In days).

Treatments	Days to first rooting	Days to first bud sprout
$T_{1(control)}$	27^{a}	23^{a}
T_{2} (IBA0.15 % in liquid form)	23^{cd}	22^{ab}
T_{3}(Only magnesium silicate)	24^{bcd}	23^{a}
T_{4}(IBA 0.05% in powder form)	26^{ab}	21^{ab}
T_{5}(IBA 0.10% in powder form)	25^{abc}	20^{bc}
T_{6}(IBA 0.15% in powder form)	24^{bcd}	18^{c}
T_{7}(IBA0.0 5% in powder form+0.50%ZnSO4)	22^{d}	22^{ab}
T_{8}(IBA0. 1% in powder form+0.5% ZnSO4)	25^{abc}	20^{bc}
T_{9}(IBA 0.15% in powder form+0.5% ZnSO4)	24^{bcd}	21^{ab}

7. Effect on fresh root weight and root dry weight at 90 days after planting.

A perusal of Table.7 indicates that the different concentrations of IBA significantly affected the studied characteristics increase in the root dry weight percentage.

Table 7: Effect of various concentrations of IBA in powder form on fresh root weight and root dry weight at 90 days after planting.

Treatments	Root Fresh weight (gm)	Root Dry weight (gm)	Dry weight percentage
$T_{1(control)}$	1.32^{c}	0.18^{b}	13.63^{h}
$T_{2(IBA0.15\ \%\ in\ liquid\ form)}$	2.45^{b}	0.35^{ab}	14.28^{fg}
$T_{3(Only\ magnesium\ silicate)}$	1.21^{c}	0.17^{b}	14.04^{gh}
$T_{4(IBA\ 0.05\%\ in\ powder\ form)}$	2.24^{b}	0.33^{ab}	14.73^{ef}
$T_{5(IBA\ 0.10\%\ in\ powder\ form)}$	1.11^{c}	0.17^{b}	15.31^{cd}
$T_{6(IBA\ 0.15\%\ in\ powder\ form)}$	2.78^{ab}	0.45^{a}	16.18^{b}
$T_{7(IBA0.0\ 5\%\ in\ powder\ form+0.50\%ZnSO4)}$	3.21^{a}	0.48^{a}	14.95^{de}
$T_{8(IBA0.\ 1\%\ in\ powder\ form+0.5\%\ ZnSO4)}$	2.73^{ab}	0.43^{a}	15.75^{bc}
$T_{9(IBA0.15\ \%\ in\ powder\ form+0.5\%\ ZnSO4)}$	2.46^{b}	0.42^{a}	17.07^{a}

This table reveals that dry weight percentage increased at the concentration of (IBA 0.15% in powder form+0.5% $ZnSO_4$ in treatment T_9 followed by IBA @ (IBA 0.15% in powder form in treatment T_6 and (IBA 0.1% in powder form+0.5% $ZnSO_4$) in treatment T_8.

In this study, hardwood cuttings produced noticeably more fresh weight than other types of cutting due to their larger diameter. The fresh weight (g) after 90 DAP was found to be significantly different among treatments because of the interaction effect of the type of cutting and growth regulator IBA. The maximum root dry weight percentage over fresh root weight was obtained in T_9 (17.27%) IBA @ (IBA 0.15% in powder form followed by T_6 (16.48%) (IBA 0.15% in powder form and T_8 (15.87 %) (IBA 0.1% in powder form+0.5% $ZnSO_4$) and declined after that in control. The freshly lifted/drawn roots from the soil were used to calculate the percentage of dry weight in this case. Maximum root dry weight percentage was found in T_9, indicating that these roots are the best in strength and quality because they can withstand a diverse range of challenging climatic conditions and are disease-resistant. Based on the results of the present trial, it can be observed that cuttings treated with (IBA 0.15% in powder form+0.5% $ZnSO_4$ (T_9) showed promising results in terms of rooting percentage, number of roots, length of the roots (cm), diameter (girth) of the roots (mm), number of sprouts, time taken for rooting, time taken for first bud sprouts, fresh root weight (gm.) and dry root weight (gm.) were taken parameters. However, in most cases, observations were *at par* with T_6 @ (IBA 0.15% in powder form in treatment T_6 and T_8 (IBA 0.1% in powder form+0.5% $ZnSO_4$). In contrast to IBA in liquid form, which can cause cuttings to dry out and cause cell sap to exude from the cutting end and mix with the solution, IBA in powder form does not have any alcohol residues that could cause a fungal or bacterial infection.There were fewer chances of the plants drying out and dying because of contamination because we used IBA in powder form. This makes the rooting hormone IBA in powder form a preferable alternative for root induction.

In terms of maximum rooting percentage, induction of roots, and increases in root length, root diameter, and root fresh and dry weight, (IBA 0.15% in powder form+0.5% $ZnSO_4$ was concluded to be superior to control. It is because auxin stimulates cell division, causing cambial initials to grow and differentiate into root primordial, as well as the transfer and translocation of food reserves to root formation and initiation sites by promoting the growth of as many roots as possible and increasing root length and diameter.The region of meristematic tissues known as cambial cells later assists in forming vascular bundles (Xylem and Phloem) that facilitate the easy transfer of reserve food material during photosynthesis. The application site of IBA, the base of the cutting, may have received more metabolites and reserved food material, increasing the rooting percentage. More metabolites and reserve food material might have been transported and translocated to the application site of IBA, i.e., cutting's base, enhancing the rooting percentage (Singh, 2022). It is widely acknowledged that auxin promotes adventitious root formation during cutting propagation (Hartmann et al., 1997). When cuttings are treated with auxin, it aids in the later stages of cytokinin activation, which results in the formation of reserve food material. However, in control (T1), due to the absence of auxin, there was no cytokinin activation, which resulted in minimal reserve food material formation, which resulted in the lowest number of roots, rooting percentage, root length and diameter, root fresh and dry weight, and the number of sprouts (Adsule *et al.*, 2012). Kumari *et al.* (2020) found that the cutting of figs treated with IBA 3500 ppm was found to be most suitable for the highest percentage of roots per cuttings,. Zn's well-known function in the synthesis of tryptophan, a precursor to the main auxin form IAA, has been attributed as a reason for its significance in the formation of adventitious roots. However, this role may be associated with the ammonium zinc acetate's favourable effect on *Physocarpus opulifolius* rooting, which was observed in terms of more rooting percentage, rooting quality and stem elongation (Pacholczak & Szydlo 2008). Combining the synthetic auxin 1-naphthaleneacetic acid (NAA) with the effect of Zn on *Mangifera indica* cuttings may show independent behaviour of auxin and a positive effect on the rooting in forms of Increased rooting percentage, adventitious roots number and total adventitious roots length (Yamashita *et al.* 2006). Hussein *et al*. (2019) researched the Rooting Response of Sensitive, Moderately Tolerant and Tolerant Plants to Boron under Exogenous Zinc sulphate on Mung bean, Cucumber and Tomato and observed that Zinc – sulphate has significantly enhanced the average root number/cuttings. Druege *et al.* (2019) reported the effects of applying local nutrients to the stem base on cuttings adventitious root formation. These studies, which show that N, K, Ca, B, Fe, and Zn have favourable impacts, involved a variety of plant species and were frequently carried out under various growth systems, which further transformed the chemical composition of the rooting zone. Yamashita *et al.* (2006) discovered that zinc treatment improved the rooting of mango cuttings. It was proposed that Zinc can encourage the biosynthesis of tryptophan, a precursor of auxin, which results in a higher auxin (IAA) level in plants, even though the mechanism underscore the role of Zinc in the rooting of plants has not yet been clarified. Zinc treatment in rice further improved auxin-induced callus growth and root formation (Oguchi *et al*., 2004). Yamashita *et al.* (2006). evidenced that combining auxin and zinc treatments could enhance the rooting of mango cuttings.

Conclusions

The result findings of this research trail can be used to create a protocol for producing high-quality *Citus Karna* planting material from cuttings. It is established that rooting substrates and Zinc Sulphate have their own effectiveness. Based on the current investigation, it can be concluded that new innovative product of rooting powder containing IBA @ 0.15 % in powder form + 0.5 % $ZnSo_4$ (T_9) was found to be best for the induction of roots with all quality parameters. However, in most cases, observations were *at par* with another innovative product formulation i.e. T_6 (IBA 0.15%) in powder form and T_8 (IBA 0.1% in powder form + 0.5% $ZnSO_4$). However, let us consider other benefits, viz., the long shelf life of powder form compared to liquid form, Fewer chances of toxicity of Ethyl alcohol with cutting. Furthermore, the powder form prevents the need for any dilution with liquid because cuttings can be dipped in powder, avoiding any chance of contamination from unhealthy cuttings to healthy cuttings. IBA hormone mixed with powder is therefore considered to be a better-rooting alternative.

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