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Effect of Indole-3-Butyric Acid (IBA) on Hardwood Cutting of Grapes (*Vitis vinifera* L.) cv. Pusa Navrang

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The study aims to investigate the influence of different IBA concentration on the rooting and subsequent growth of hardwood cuttings of "Pusa Navrang" grapevine.
Study Design: The study was performed in RBD design with replicate 5 times.
Place and Duration of Study: The study was conducted at Research Farm, College of Horticulture, Mandsaur, during the period November 2020- March 21.
Methodology: Polybags size of 5 X 7 inch was used for experiment. After the filling of growing media in poly bags, the hard wood cuttings of Pusa Navrang with uniform size having 4-5 functional bud was taken from one year matured canes from research farm, College of Horticulture,

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Mandsaur. The diameter of cutting about 0.75 to 1 cm (pencil thickness) were taken and before planting cuttings were treated with IBA solution by quick dip method.
Results: The significant result were found for shoot parameter like shoot length, number of nodes per shoot, internodal length, number of buds per shoot, stem diameter, stem fresh weight, stem dry weight. Root Parameters like number of primary and secondary roots, root length, root thickness, whole root volume, fresh weight of root and dry weight of root. Leaf Parameters like number of leaves per plant, fresh weight of leaf, dry weight of leaf, leaf area, leaf area index, specific leaf weight, minimum days taken to emergence of 1st leaf and water content of leaf found in IBA @ 6000 ppm (G_3).
Conclusion: Among four concentration of growth regulator (IBA), the application of IBA @ 6000 ppm (G_3) responded well in terms of rooting and shooting in hard wood cutting of grapes.

Keywords: Auxin; hard wood cutting; IBA and grapes.

1. INTRODUCTION

Grapes (*Vitis vinifera* L.) stand as a paramount fruit crop on the global stage due to their immense economic significance. They are cherished for their fruits and their various derivatives, which encompass wine, juice, and raisins [1,2]. The primary method for proliferating grapevines revolves around the utilization of cuttings, with a particular emphasis on hardwood cuttings. The successful establishment of new grapevine plants, crucial for expanding or replacing vineyards, hinges significantly on the successful rooting of these cuttings [3].

In the present day, India boasts a grape cultivation area spanning 1.62 lakh hectares & production of 34.45 lakh metric tons with a productivity rate of 21.00 metric tons per hectare. The primary grape-growing states in India, namely Maharashtra (70.67%), Karnataka (24.49%), Tamil Nadu (1.43%), Andhra Pradesh (1.34%), Madhya Pradesh (1.02%), and Mizoram (0.50%), collectively contributes to nearly 99% of the total grape production (NHB, 2022).

Seed propagation is a time-consuming method that leads to genetically diverse and slower-growing plants. In contrast, vegetative propagation through cuttings is a more efficient and quicker process, resulting in genetically identical plants that bear fruit earlier but with reduced vigor [4,5].

Indole-3-butyric acid (IBA), a synthetic plant hormone with auxin-like properties, is renowned for its ability to stimulate root development in plant cuttings. It has been extensively studied in horticultural practices to enhance rooting and overall plant establishment. However, there is limited research on the application of IBA to hardwood grapevine cuttings, necessitating a comprehensive investigation to assess its potential impact on successful rooting and subsequent growth [6-9].

This study aims to assess the influence of IBA (a synthetic auxin) on the rooting capacity and growth enhancement of hardwood grapevine cuttings. Understanding the effects of IBA on grapevine cuttings is crucial not only for establishing new grapevines successfully but also for improving the efficiency and productivity of grape cultivation, thereby contributing to sustainable viticultural practices [10].

In this research, we will investigate the impact of varying concentrations of IBA on hardwood grapevine cuttings and analyze their resulting rooting performance and subsequent vegetative growth. The knowledge gained from this study will deepen our comprehension of IBA's role in grapevine propagation and provide practical recommendations for optimizing the rooting process, promoting robust growth, and ultimately enhancing grapevine cultivation methods.

2. MATERIALS AND METHODS

Experimental Location: The experiment conducted at Research Farm, College of Horticulture, RVSKVV, Mandsaur (Madhya Pradesh) in the 2020-21 year. Mandsaur is situated within the Malwa plateau agro-climatic zone in the western part of Madhya Pradesh, with coordinates ranging from approximately 23.45º to 24.13º North latitude and 74.44º to 75.18º East longitude with the elevation of 435.02 meters above mean sea level, and it falls under AgroClimate No. 10 of the state. Mandsaur experiences a subtropical climate characterized by hot summers and cool winters. Summer temperatures can reach as high as 46°C, while winter temperatures can drop to 3.6°C, occasionally leading to frost. The region receives an average annual rainfall of 797.6 mm.

The grapevine cuttings (*Vitis vinifera* L. cv. Pusa Navrang) used in this study was sourced from the grape orchard at the College of Horticulture, Mandsaur, Madhya Pradesh. These plants were five years old, and cuttings were obtained from one-year-old canes. To create the solutions, pure IBA crystals were dissolved in 0, 20, 40, or 60 ml of 1N NaOH, respectively, and then diluted with distilled water to a final volume of 1000 ml for each solution. Cuttings were treated by dipping them in the respective IBA solutions for 5 seconds before being planted in the rooting media. The experiment was laid out in a Randomized Block Design (RBD) with four treatments G_0 (Control), G_1 (IBA @2000 ppm), G_2 (IBA @4000 ppm), and G_3 (IBA @6000 ppm). The treatments were replicated five times, with each treatment consisting of 20 cuttings. Data were recorded and statistically analyzed using the analysis of variance method as described by R. A. Fisher [11].

3. RESULTS AND DISCUSSION

3.1 Shoot Parameters

Under shoot parameters different observations i.e., shoot length, Number of nodes, internodal length, Number of buds per shoot, Stem diameter were recorded at 30, 60 & 90 DAP. While the fresh weight and dry weight of stem at 90 DAP, are presented below. At 30 DAP, effect of IBA found non-significant and at 60 and 90 DAP found significant effect on shoot parameters.

3.1.1 Shoot length (cm)

Shoot length was recorded at 30, 60, 90 DAP and presented in Table 1. Maximum shoot length with treatment G_3 (IBA @ 6000 ppm) i.e., 7.60 cm, 53.86 cm and the minimum shoot length was recorded in case of G_0 (control) i.e., 2.80cm, 11.90 cm at 60 & 90 DAP respectively and shoot length found non-significant at 30 DAP. This might be due to the application of IBA @ 6000 ppm, which raised the amount of growth promoting chemicals and accessible nutrients. Shoots length might be due to better utilization of stored carbohydrates, nitrogen and other factors with the aid of growth regulators Kaur et al. [12]. Similar result was reported Kaur [13] in pomegranate cv. Ganesh, Padekar et al. [14] in kartoli.

3.1.2 Number of nodes per shoot

After 60 and 90 DAP, the maximum number of nodes per shoot was found in IBA treatment IBA @6000 ppm (G_3) i.e., 7.08, 16.39, while the lowest number of nodes per shoot was reported in treatment control (G_0) i.e., 3.60, 6.04 respectively. This might be because external application of auxin promotes growth and produce favorable conditions for sprouting of dormant buds on the cutting. These results supported by Isci et al. [15] in Ramsey American grapevine rootstock.

3.1.3 Internodal length (cm)

Data from Table 1 revealed that highest internodal length was observed in IBA @ 6000 ppm (G_3) i.e., 2.68 cm, 6.10 cm, shortest internodal length was detected in control treatment (G_0) i.e., 1.17 cm, 1.91 cm respectively. It could be due to the availability of a large amount of stored carbohydrate, which aided the rapid growth. Similar results found by Somkumar et al. [16] in grapes, Chakraborty and Rajkumar [17] in grapes.

3.1.4 Number of buds per shoot

Data show in Table 1 show that the treatment IBA @ 6000 ppm (G_3) i.e., 11.35, 26.58 had the most buds per shoot. Treatment control (G_0) i.e., 4.59, 8.71 had the lowest number of buds per shoot at 60 and 90 days after planting, respectively. Treatments with auxin promote the hydrolysis of nutritional reserves and the mobilization of sprouting. Chakraborty and Rajkumar [17] in grapes. The findings of this study matched those of previous studies Singh et al. [18] in lemon, Rolaniya et al. [7], Siddiqua et al. [19], Kumar et al. [20] in pomegranate, Tanwar et al. [21] in pomegranate.

3.1.5 Stem diameter (mm)

In respect of different IBA concentration maximum stem diameter was reported with treatment IBA @ 6000 ppm (G_3) i.e., 16.38 mm and 25.71 mm after 60 and 90 days after planting and the treatment control (G_0) reported the minimum stem diameter per shoot i.e., 8.38 mm and 17.33 mm at 60 and 90 days after planting, respectively. It might be due to the use of growth regulators to improve the use of stored carbohydrates, nitrogen and other variables, Kaur Sukhjit [13] in Flordaguard peach and Siddiqua et al. [19] in dragon fruit, also recorded these results.

3.1.6 Stem fresh and dry weight (g)

Among the different concentration of IBA, maximum stem fresh weight and dry weight recorded with IBA @ 6000 ppm (G_3) i.e., 16.09 g, 6.74 g respectively, and the minimum stem fresh weight and dry weight was found in treatment control (G_0) i.e., 5.67 g and 1.81 g respectively. This could explain by the fact that auxins increased cell permeability to moisture and nutrients, resulting in cell enlargement and increased plant growth. IBA increases the number of shoots resulting in higher fresh and dry weight of shoots, Kaur et al. [12] in fig. Similar results are confirmed by Kishorbhai [22] also reported the same in fig, Singh [23] in pomegranate, Dahale et al. [24] in Fig and Tanwar et al. [21] in pomegranate.

3.2 Root Parameters

In respect of root parameters, different observations i.e., Number of primary and secondary roots, whole root volume, root length of longest root, root thickness taken and recorded at 30, 60 & 90 DAP. While the fresh weight and dry weight of root reported at 90DAP, are presented below. At 30 DAP, effect of IBA were found non-significant, while at 60 and 90 DAP found significant effect on root parameters.

3.2.1 Number of roots

Those stem cuttings dipping in the IBA @6000 ppm (G_3) were recorded significantly maximum number of primary (22.54, 16.66) and secondary (28.68, 28.02) roots per cutting and minimum number of primary (12.03, 5.67) and secondary (15.83, 15.89) roots per cutting were reported in treatment G_0 at 60 and 90 DAP respectively. IBA application resulted in a robust, fibrous root system, where as phenoxy acetic acid application resulted in a bushy, stunted root system with bent and thick roots. Bauri et al. [25] in Burmese grape, Kaur [13] in peach, Ali et al. [26] in kiwi, Kaur et al. [12] in fig, Rolaniya et al. [7] in grape, Siddiqua et al., [19] in dragon fruit, Singh et al. [27] in peach, Kumar et al. [20] in pomegranate carried studies and find similar results.

3.2.2 Whole root volume

Whole root volume per cutting found maximum in treatment IBA @ 6000 ppm (G_3) i.e., 18.56 cm^2 and 24.69 cm^2 and lowest whole root volume per cutting observed in treatment control (G_0) i.e., 8.63 cm^2 and 10.17 cm^2 at 60 and 90 days after planting, respectively. It may be due to higher root length which is accumulated more stored carbohydrates and more number of roots increased their volume [10]. Similar results also reported by Singh and Tomar [9], Singh [18] in Phalsa, Rolaniya et al. [7] in grapes, Siddiqua et al. [19] in dragon fruit, Rajamanickam and Balamohan [28] in pomegranate.

3.2.3 Root length of longest root

In respect of different IBA concentration, maximum root length of longest root in case of treatment IBA @ 6000 ppm (G_3) i.e., 20.56 cm and 21.86 cm. While, minimum root length of longest root observed in treatment IBA @ 0 ppm (G_0) i.e., 7.79 cm and 8.56 cm had recorded at 60 and 90 days after planting, respectively. This may be due to increased synthesis and accumulation of growth promoting substance as well as availability of more nutrients under this treatment, which enhance the rooting in cuttings. Similar findings were also reported by Kareem et al., [29] in guava, Bauri et al., [25] in Burmese grape, Ali et al., [26] in kiwi, Kaur et al., [12] in fig, Rolaniya et al., [7] in grape, Siddiqua et al., [19] in dragon fruit, Rajamanickam and Balamohan [28] in pomegranate, Singh et al., [27] in peach, Kumar et al., [20] in pomegranate.

3.2.4 Root thickness

As per the research data analysis, in respect of IBA concentration, highest root thickness was observed in treatment IBA @6000 ppm (G_3) i.e., 1.85 mm and 1.98 mm. Constantly, the minimum root thickness was observed in control treatment (G_0) i.e., 1.61 mm and 1.72 mm had recorded at 60 and 90 days after planting, respectively. This might be due to increased synthesis and accumulation of growth-promoting substances, as well as the availability of additional nutrients, both of which improve root parameters. These conclusions are in agreement with the findings of Rolaniya et al. [7] in grape, Siddiqua et al. [19] in dragon fruit, Singh et al. [27] in peach, Kumar et al. [20] in pomegranate.

3.2.5 Root fresh and dry weight (g)

Different concentration of IBA recorded significant effect on root fresh weight at all growth stages and the maximum root fresh and dry weight recorded in treatment IBA @ 6000 ppm (G3) i.e., 5.70 g and 2.41 g respectively. While, the lowest root fresh weight observed in treatment control (G_0) i.e., 2.51 g and 0.81 g respectively at 90 days after planting. This might be due to the treatment's strong root system, which returns enhanced nutrient absorption and increases fresh and dry weight of roots. Others have reported similar findings, Narula [30] in plum cv. Kala Amritsari, Kaur et al. [12] in fig, Chakraborty and Rajkumar [17] in grapes, Rolaniya et al. [7] in grapes, Siddiqua et al. [19] in dragon fruit, Isci et al. [15] in Ramsey American grape rootstock, Rajamanickam and Balamohan [28] inpomegranate Singhetal. [27] in peach and Kumar et al. [20] in pomegranate.

3.3 Leaf Parameters

3.3.1 Days taken to emergence of 1st leaf

In case of different concentration of growth regulators, IBA @ 6000 ppm (G_3) i.e., 22.20 DAP recorded minimum number of days to emergence of 1st leaf after planting and the maximum number of days to emergence of 1st leaf were found in IBA concentration control (G_0) i.e., 27.00 DAP. This might be because the higher levels of auxins resulted in the physiological processes of rooted and sprouting cuttings completed sooner. These findings are in agreement with the findings of Cleland (1973) stated that auxin has varying degree of effectiveness in promoting adventitious roots in stem cuttings of many species. These findings were also similar with findings of Kareem et al. [29] in guava, Kaur [13] in peach, Kaur et al. [12] in fig, Siddiqua et al. [19] in dragon fruit, Rajamanickam and Balamohan [28] in pomegranate, Kumar et al. [20] in pomegranate.

3.3.2 Number of leaves per cutting

In case different concentration of IBA, maximum number of leaves per cutting found with treatment IBA @6000 ppm (G_3) i.e., 10.00 and 25. While the minimum number of leaves per cutting was observed in control treatment (G0) i.e., 3.98 and 8.79 had recorded at 60 and 90 days after planting, respectively. This might attributed to a higher amount of growth-promoting chemicals and accessible nutrients because of using IBA @6000 ppm. Similar findings were reported by Kaur [13] in peach, Kaur et al. [12] in fig, Rolaniya et al., [7] in grapes, Rajamanickam and Balamohan [28] in pomegranate, Shahzad et al. [31] in grapes.

3.3.3 Fresh and dry weight per leaf (g)

Stem cuttings those dipping in the IBA @6000 ppm (G_3) were recorded significantly maximum (1.59 g and 0.68 g) fresh and dry weight per leaf respectively at 90 DAP and it was found minimum in control (G_0) i.e., 0.95 g and 0.31 g, respectively at 90 DAP. This might be due to a higher amount of growth promoting chemicals and accessible nutrients because of using IBA @6000 ppm. These findings are in agreement with the findings of Barde et al. [32] in pomegranate, Kumawat et al. [33] in pomegranate, Kaur [13] in peach.

3.3.4 Water content per leaf (%)

In case of different IBA concentration, maximum water content per leaf was observed with IBA concentration control IBA treatment 0 ppm (G_0) i.e., 67.50 % and the minimum water content per leaf was noted with IBA concentration IBA @ 6000 ppm (G_3) i.e., 57.21 %. It may due to increased synthesis and accumulation of growth promoting substances as well as availability of more nutrients in this treatment. It may due to increase in dry weight per leaf which decreases water content of leaf. Supported by Barde et al. [32] in pomegranate, Kumawat et al. [33] in pomegranate.

3.3.5 Leaf area (cm^2)

Stem cuttings those dipped in the IBA 6000 ppm recorded maximum leaf area (G_3) i.e., 65.39cm^2. While, the minimum leaf area was noted under control treatment of IBA (G_0) i.e., 10.98 cm^2. Same results found by Kaur [13] in peach, Kaur et al. [12] in fig, Shahzad et al. [31] in grapes.

3.3.6 Leaf area index

Among the different IBA concentration taken for research, maximum leaf area index were observed with IBA @ 6000 ppm (G_3) i.e., 3.99 while the minimum leaf area index was noted under IBA @ 0 ppm (G_0) i.e., 2.33. Similar findings recorded earlier by Barde et al. [32] in pomegranate and Kumawat et al. [33] in pomegranate.

Table 1. Effect of IBA on Hardwood Cutting of Grapes for shoot parameters

Treatments	Shoot length(cm)		Number of nodes per shoot		Intern odal length (cm)		Stem diameter (mm)		Number of buds per shoot		Stem fresh weight(g)	Stemdry weight (g)
	At60 DAP	At90 DAP	At60 DAP	At90 DAP	At60 DAP	At90 DAP	At60 DAP	At90 DAP	At60 DAP	At90 DAP	At90 DAP	At90 DAP
G_0-IBA@0ppm	2.80	11.90	3.60	6.04	1.17	1.91	8.38	17.33	4.59	8.71	5.67	1.81
G_1-IBA@ 2000 Ppm	3.54	25.28	5.08	9.00	1.61	3.80	9.90	19.99	5.67	16.94	10.38	3.93
G_2-IBA@ 4000 Ppm	6.95	49.08	6.78	15.67	2.56	5.90	16.00	25.18	10.43	25.37	15.61	6.47
G_3-IBA@ 6000 Ppm	7.60	53.86	7.08	16.39	2.68	6.11	16.38	25.71	11.35	26.58	16.09	6.74
S.Em±	**0.10**	**0.54**	**0.08**	**0.21**	**0.04**	**0.05**	**0.31**	**0.42**	**0.20**	**0.43**	**0.22**	**0.11**
CD(%)	**0.28**	**1.54**	**0.22**	**0.61**	**0.10**	**0.15**	**0.88**	**1.19**	**0.57**	**1.23**	**0.64**	**0.32**

Table 2. Effect of IBA on Hardwood Cutting of Grapes for root parameters

Treatments	Number of Primary roots		Number of Secondary roots		Root length (cm)		Root thickness (mm)		Wholer ootvolume		Fresh weightof root (g)	Dryweight of root (g)
	At60 DAP	At90 DAP	At60 DAP	At90 DAP	At60 DAP	At90 DAP	At60 DAP	At90 DAP	At60 DAP	At90 DAP	At90 DAP	At90 DAP
IBA@0ppm	12.03	15.83	5.67	15.89	7.79	8.56	1.61	1.72	8.68	10.17	2.51	0.81
IBA@2000 Ppm	17.28	20.23	10.36	18.99	11.84	11.36	1.69	1.80	12.25	15.68	3.60	1.37
IBA@4000 Ppm	22.02	26.97	15.79	26.97	19.22	20.60	1.84	1.96	17.81	23.94	5.41	2.26
IBA@6000 Ppm	22.54	28.68	16.66	28.02	20.56	21.86	1.85	1.86	18.56	24.69	5.70	2.41
S.Em±	**0.07**	**0.53**	**0.28**	**0.42**	**0.30**	**0.36**	**0.01**	**0.01**	**0.29**	**0.40**	**0.11**	**0.04**
CD(%)	**0.19**	**1.52**	**0.80**	**1.21**	**0.87**	**1.02**	**0.04**	**0.03**	**0.83**	**1.14**	**0.30**	**0.11**

Table 3. Effect of IBA and Different Growing Mediaon Hardwood Cutting of Grapes for leaf parameters

Treatments	Days taken to emergence of 1st leaf	Number of leaves/plant		Fresh weight of leaf (g)	Dry weight of leaf (g)	Leaf area (cm^2)	Leaf Area Index	Water Content of Leaf (%)	Specific Leaf Weight ($mgDW.cm^2$)
		At 60 DAP	At 90 DAP	At 90 DAP	At 90 DAP	At 90 DAP	At 90 DAP	At 90 DAP	At 90 DAP
IBA@0ppm	27.00	3.98	8.79	2.51	0.81	10.98	2.33	67.50	27.26
IBA@ 2000ppm	25.67	6.92	11.73	3.60	1.37	26.18	2.95	61.63	19.04
IBA@ 4000ppm	22.73	9.31	24.25	5.41	2.26	62.61	3.83	58.06	10.57
IBA@ 6000ppm	22.20	10.00	25.75	5.70	2.41	65.39	3.99	57.21	10.56
S.Em±	0.33	0.16	0.42	0.11	0.04	0.81	0.05	0.76	0.69
CD (%)	0.94	0.510.45	1.19	0.30	0.11	2.31	0.15	2.19	1.96

3.3.7 Specific leaf weight (mgDW.cm^{-2})

Application of IBA had showed significant influence on specific leaf weight at 90 days after planting. Maximum specific leaf weight was observed with IBA concentration 6000 ppm (G_3) i.e., 23.53 mgDw.cm^{-2}. While, the minimum specific leaf weight was noted under control (G_0) i.e., 10.32 mgDw.cm^{-2}.

4. CONCLUSION

It can conclude that the Pusa Navrang grapevine cutting with application of IBA @6000 ppm responded well in term of root and shoot growth in hardwood cuttings. In order to confirm the validity of results the experiment must be repeated over years, location and different season with more accuracy.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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