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Effect of different levels of plant growth regulators on rooting of cutting in fig (*Ficus carica* L.)

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Abstract
The experiment was carried out at Central Nursery, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. during kharif season in year 2018-19, on fig variety Dinkar in a randomized block design with three replications and twelve treatment combinations. The objective was to study the effect of different levels of plant growth regulators on rooting of cutting in fig. The experiment was laid out in Randomized Block Design in Twelve treatments with three replications. The treatments were T_1 (IBA-1000 ppm), T_2 (IBA-2000 ppm), T_3 (IBA-3000 ppm), T_4 (IBA-4000 ppm), T_5 (NAA-1000 ppm), T_6 (NAA-2000 ppm), T_7 (NAA-3000 ppm), T_8 (NAA-4000 ppm), T_9 (IBA 1500 ppm + NAA 1500 ppm), T_{10} (IBA 2500 ppm + NAA 2500 ppm), T_{11} (IBA 3500 ppm + NAA 3500 ppm) and T_{12} Control. The study conclusively highlighted that IBA at 4000 ppm (T_4) was superior in promoting cutting growth and establishment, with significantly better shoot length, leaf count, and seedling height compared to other treatments and the control. The enhanced rooting system due to IBA improved nutrient and water uptake, resulting in higher success (90.12%) and survival (87.77%) rates. Furthermore, T_4 also achieved the best cost-benefit ratio (2.25), proving its economic viability. This makes IBA 4000 ppm the most effective and practical treatment for optimizing propagation success and improving overall plant growth.

Keywords: Cutting, growth parameters, growth regulators, rooting percentage, kharif season

Introduction

Fig (*Ficus carica* L.) is one of the most ancient fruits known to mankind which finds its mention in the bible. It is reported to be under cultivation from 3000- 2000 BC in the eastern mediterran region. It later spread into Iraq, Syria, Turkey and into all the Mediterranean countries. Fig belons to family Moraceae. It is thought to be a native to Southern parts of the Arabian Peninsula, Italy. Fig is one of the most salt and drought tolerant crop with a deep root system. The fruit is edible and botanically known as synconium (multiple fruit). Fig is deciduous and subtropical tree with short and twisted trunk with leaves deeply 3 to 5 lobed. The fruits are pear shaped, variable in size and colour and have high sugar content.

Fig consumed fresh or in processed from the dried form being the most popular. It is good source of carbohydrates, including fibre. Fresh fruits are rich in calorie, protein, calcium and iron. Fig helps to maintain the acid-aikali balance of the body by very effective neutralizing excess acid. Citric acid is the predominant acid in fig. Fig contains most of the recognized vitamins and minerals. Fig is moderately important world crop with an estimated annual production of one million tons of fruit of which about 30 per cent is produced by Turkey. The commercial cultivation of common (edible) fig is mostly confined to western parts of Maharashtra. The total area under fig cultivation in India is reported to be 883 ha. with production of 2850 MT. (Anon, 2017-18) [1].

Plant growth regulators improve the rooting of cutting by stimulating the production of adventitious roots. firSt postulated that auxins initiate adventitious root formation in stem cuttings. IBA and NAA are most effective than IAA and 2,4-D for rooting (Hartman and Kester, 1975) [5]. It promotes root initiation, number of roots and shoot growth in number of ornamental and fruit plants. Mixture of auxin have been found in some instances more effective which results into higher root length, root number and survival percentage of rooted cuttings in fig (Reddy *et al* 2008) [15]. Fig is considered as a difficult to root by cuttings. However, it has now become possible to improve percentage and rate of success, reduction in total period required and better rooting in difficult to root species like fig by exploring the techniques such as use of different type of cuttings and different concentration of plant growth regulators. However, natural concentrations of auxins and nature of action of different auxins vary from species to species (Hartman and Kester, 1989) [6]. The government of Maharashtra is encouraging farmers to undertake the planting of fig by giving technical advices, and subsidy through Employment Guaranty Scheme. The situation naturally offers great deals of scope for developing a new technique of nursery plant production in fig.

As the soil and climatic conditions are most suitable for cultivation of fig. there is an ever-increasing demand for planting material in India. Very less research work has far been done on propagation of fig by cuttings using plant growth regulator by (quick dip method). Therefore, it is felt necessary to undertake the study on propagation of fig by using different higher concentrations of plant growth regulators. Hence the aspect behind “Effect of different levels of plant growth regulators on rooting of cutting in fig (*Ficus carica* L.)” experiment is to overcome the problem of less rooting and low success percent by using IBA and NAA along with suitable combinations with the following objective for early and profuse rooting along with more success percentage of cutting in fig.

Materials and Methods

The experiment was conducted at the Central Nursery, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra. during the year 2018-19. The site, located at 19°16' N latitude, 76°47' E longitude, experiences a subtropical climate. During the experiment (June-November 2018), 843.8 mm of rainfall was recorded, with mean temperatures ranging from 19 °C to 31.2 °C, and relative humidity peaking at 75-84%.

The cuttings of fig cv. Dinkar fig used for this research were selected from 5 years old mother plant. Hardwood cuttings from one year old shoots of 15-20 cm length and 1.5-2 cm in diameter having 4-5 nodes each were selected. Fig cutting pre-treated by PGR (quick dip method) and were planted in polythene bags which were properly filled, labeled with tags and placed as per layout. In order to prevent infestation of insect pest and diseases. The plant protection scheduled follow during the course of investigation.

A. Preparation of different concentration of growth regulators

1. Preparation of IBA solutions

A 100 ml of 1000 ppm IBA solution was prepared by dissolving 0.10 g IBA in approximately 25 ml absolute alcohol (95%) then it was diluted with double distilled water to make 100 ml solution. Similarly 2000 ppm, 3000 ppm and 4000 ppm IBA solution was prepared.

2. Preparation of NAA solutions

A 100 ml of 1000 ppm solution was prepared by 0.10 g NAA was diluted with double distilled water to make 100 ml solution. Similarly 2000 ppm, 3000 ppm, 4000 ppm NAA solution was prepared.

3. Preparation IBA + NAA solution

IBA 1500 ppm and NAA 1500 ppm strength was prepared in ethyl alcohol. For this purpose 0.15 g of each growth regulator was weighed on electrical weighing balance. IBA 0.15g + ethyl alcohol + distilled water to make volume 100 ml. similarly NAA of strength 1500 ppm prepared and mixed both solution in one beaker and taken a definite amount for treatment. Similarly IBA 2500 ppm + NAA 2500 ppm and IBA 3500 ppm + NAA 3500 ppm prepared.

B. Treatment Application

The lower portion of cuttings (1-2 cm) was treated with different concentrations of chemicals by quick deep method for 5-10 seconds and planted in poly bags containing soil + sand + FYM (1:1:1) in a such manner that the 1/3rd portion of the cutting insert in the media and light irrigation was applied gradually in the morning and evening with the help of water cane.

Results and Discussion

Effect of different levels of plant growth regulators on shoot growth parameters

During the current investigation the characteristics including Length of shoot at 30, 60, 90 days after planting, Days to first sprouting, were significantly influenced by different treatments as shown in table 1. Characteristics including number of leaves at 30, 60, 90 days after planting and number of shoots at 60 and 90 days after planting, were significantly influenced by different treatments as shown in table 2. and also characteristics like number of branches 60 and 90 days after planting, seedling height (cm) at 30, 60, 90 days after planting and success percentage (%), survival percentage (%) and benefit cost ratio, were significantly influenced by different treatments as shown in table 3 and 4.

1) Length of shoot (cm) at 30, 60, 90 days after planting

At 30 days after planting the significantly maximum length of shoot (5.68 cm) was observed in the treatment T_4 (IBA 4000 ppm), which were found at par with treatments T_{10} (5.48 cm) and T_{11} (5.18 cm) followed by treatments T_3 (4.97 cm) and T_8 (4.37 cm). Among the T_{12} i.e. (Control) recorded minimum length of shoot in the treatment (1.47 cm).

At 60 days after planting the significantly maximum length of shoot (12.96 cm) was observed in the treatment T_4 (IBA 4000 ppm), which were found at par with treatments T_{10} (11.91 cm) and T_{11} (11.47 cm) followed by treatments T_3 (11.04 cm) and T_8 (10.86 cm). Among the treatment T_{12} i.e. (Control) recorded minimum length of shoot (7.58 cm).

At 90 days after planting the significantly maximum length of shoot (18.71 cm) was observed in the treatment T_4 (IBA 4000 ppm), which were found at par with treatments T_{10} (17.71 cm) and T_{11} (16.68 cm) followed by treatments T_3 (16.06 cm) and T_8 (15.53 cm). Among the treatment T_{12} i.e. (Control) recorded minimum length of shoot (10.99 cm).

The positive effect between the type of cuttings and auxin levels could be attributed to the development of a strong root system in certain cuttings. This well-developed root system likely promotes shoot growth by effectively mobilizing water and nutrients from the soil or substrate to the growing tips. These results are in conformity by Patel *et al.* (2017) [12] and Patel and Patel (2018) [11] in fig.

2) Days to first sprouting

The significantly minimum number of days (12.67) required for first sprouting of cuttings was recorded in the treatment T_4 (IBA 4000 ppm), which was found at par with treatment T_{10} (14.57) followed by treatments T_{11} (15.33) and T_3 32 (16.45). Among the maximum number of days (24.37) for appearance of shoot was recorded in the treatment T_{12} (Control).

This might be due to synergic effect of IBA and type of cutting. Earliness in sprouting might be due to the fact that there was better utilization of stored carbohydrates, nitrogen and other factors with help of growth regulators. Similar findings were made by Kaur and Kaur (2016) [7], Singh and Singh (2017) [12] and Patel and Patel (2018) [11] in fig.

Table 1: Effect of different levels of plant growth regulators on Length of shoot (cm) and Days to first sprouting of cutting in fig (*Ficus carica* L.).

Treatment No	Treatment Details	Length of Shoot (cm)			Days to first Sprouting
		30 DAP	60 DAP	90 DAP	
T_1	IBA 1000 ppm	3.33	9.69	13.39	22.07
T_2	IBA 2000 ppm	3.66	9.96	13.71	20.35
T_3	IBA 3000 ppm	4.97	11.04	16.06	16.45
T_4	IBA 4000 ppm	5.68	12.96	18.71	12.67
T_5	NAA 1000 ppm	2.50	9.26	12.50	23.45
T_6	NAA 2000 ppm	2.94	9.49	13.01	21.35
T_7	NAA 3000 ppm	4.02	10.23	13.93	18.55
T_8	NAA 4000 ppm	4.37	10.86	15.53	17.34
T_9	IBA 1500 ppm + NAA 1500 ppm	4.17	10.42	14.75	19.13
T_{10}	IBA 2500 ppm + NAA 2500 ppm	5.48	11.91	17.71	14.57
T_{11}	IBA 3500 ppm + NAA 3500 ppm	5.18	11.47	16.68	15.33
T_{12}	Control	1.47	7.58	10.99	24.37
	S.E. ±	0.21	0.52	0.72	0.83
	C.D.at 5%	0.62	1.53	2.11	2.44

3) Number of leaves at 30, 60, 90 days after planting

At 30 days after planting the significantly maximum number of leaves (5.11) was observed in the treatment T_4 (IBA 4000 ppm), which was found at par with treatment T_{10} (4.73) followed by treatments T_{11} (4.27) and T_3 (3.87). Among the treatment T_{12} i.e. (Control) recorded minimum number of leaves (1.11) per cutting.

At 60 days after planting the significantly maximum number of leaves (7.50) was observed in the treatment T_4 (IBA 4000 ppm), which was found at par with treatment T_{10} (6.74) followed by treatments T_{11} (6.44) and T_3 (6.03). Among the treatment T_{12} i.e. (Control) recorded minimum number of leaves (3.05) per cutting.

At 90 days after planting the significantly maximum number of leaves (9.47) was observed in the treatment T_4 (IBA 4000 ppm), which was found at par with treatment T_{10} (8.70) followed by treatments T_{11} (8.25) and T_3 (7.81). Among the treatment T_{12} i.e. (Control) recorded minimum number of leaves (4.99) per cutting.

Hardwood cuttings produced more leaves, likely due to vigorous rooting induced by plant growth regulators. This enhanced nutrient absorption, leading to more sprouts and longer shoots, influenced by proper shoot-root balance and hydrolysis of stored nutrients. Auxin treatment further stimulated the development and number of primary shoots, contributing to the increase in leaf count. The result in are in conformity with those reported by Khapare *et al.* (2012) [8], Kaur and Kaur (2016) [7] and Dahale *et al.* (2018) [3] in fig.

4) Number of shoots 60, 90 days after planting

At 60 days after planting the significantly maximum number of shoots (2.06) was observed in the treatment T_4 (IBA 4000 ppm), which was found at par with treatment T_{10} (1.82) followed by treatments T_{11} (1.64) and T_3 (1.41). Among the treatment T_{12} i.e. (Control) recorded minimum number of shoots (0.55).

At 90 days after planting the significantly maximum number of shoots (3.07) was observed in the treatment T_4 (IBA 4000 ppm), which was found at par with treatment T_{10} (2.77) followed by treatments T_{11} (2.67) and T_3 (2.41). Among the treatment T_{12} i.e. (Control) recorded minimum number of shoots (1.55).

It might be due to co-effect of type of cutting and auxin concentrations. The more number of shoot formation with the growth regulators might be due to the vigorous root system which increased the nutrient uptake under the influence of IBA. It might also be due to the more number of roots and vigorous growth of the plant. This result in are in conformity with those reported by Kaur and Kaur (2016) [7], Patel *et al.* (2017) [12] and Patel and Patel (2018) [11] in fig.

Table 2: Effect of different levels of plant growth regulators on number of leaves and number shoots of cutting in fig (*Ficus carica* L.).

Treatment No	Treatment Details	Number of Leaves			Number of shoots	
		30 DAP	60 DAP	90 DAP	60 DAP	90 DAP
T_1	IBA 1000 ppm	2.81	4.86	6.84	0.78	1.72
T_2	IBA 2000 ppm	3.11	5.04	7.05	0.93	1.96
T_3	IBA 3000 ppm	3.87	6.03	7.81	1.41	2.41
T_4	IBA 4000 ppm	5.11	7.50	9.47	2.06	3.07
T_5	NAA 1000 ppm	1.49	3.90	5.77	0.69	1.71
T_6	NAA 2000 ppm	1.97	4.15	5.99	0.82	1.83
T_7	NAA 3000 ppm	3.36	5.21	7.24	1.02	2.02
T_8	NAA 4000 ppm	3.84	5.70	7.77	1.35	2.37
T_9	IBA 1500 ppm + NAA 1500 ppm	3.53	5.41	7.45	1.09	2.12
T_{10}	IBA 2500 ppm + NAA 2500 ppm	4.73	6.74	8.70	1.82	2.77
T_{11}	IBA 3500 ppm + NAA 3500 ppm	4.27	6.44	8.25	1.64	2.67
T_{12}	Control	1.11	3.05	4.99	0.55	1.55
	S.E. ±	0.14	0.26	0.36	0.09	0.10
	C.D.at 5%	0.42	0.77	1.05	0.27	0.30

5) Number of branches at 60, 90 days after planting

At 60 days after planting the significantly maximum number of branches (2.56) was observed in the treatment T_4 (IBA 4000 ppm), which was found at par with treatment T_{10} (2.32) followed by treatments T_{11} (2.13) and T_3 (2.01). Among the treatment T_{12} i.e. (Control) recorded minimum number of branches (0.68) per cutting.

At 90 days after planting the significantly maximum number of branches (3.63) was observed in the treatment T_4 (IBA 4000 ppm), which was found at par with treatment T_{10} (3.27) followed by treatments T_{11} (3.20) and T_3 (2.87). Among the treatment T_{12} i.e. (Control) recorded minimum number of branches (1.71) per cutting.

The more number of shoot formation with the growth regulators might be due to the vigorous root system which increased the nutrient uptake under the influence of 36 IBA. It might also be due to the more number of roots and vigorous growth of the plant. This result in are in conformity with those reported by Kaur and Kaur (2017) [7], Patel *et al.* (2017) [12] and Patel and Patel (2018) [11] in Fig.

6) Seedling height (cm) at 30, 60, 90 days after planting

At 30 days after planting the significantly maximum seedling height (15.67 cm) was observed in the treatment T_4 (IBA 4000 ppm), which were found at par with treatments T_{10} (15.48 cm), T_{11} (15.17 cm), T8 (14.98 cm) T_3 (14.35 cm), T_9 (14.18 cm) and T_7 (14.02 cm) followed by treatments T2 (13.65 cm) and T_6 (13.33 cm). Among the treatment T_{12} i.e. (Control) recorded minimum length of shoot (11.45 cm).

At 60 days after planting the significantly maximum seedling height (22.97 cm) was observed in the treatment T_4 (IBA 4000 ppm), which were found at par with treatments T_{10} (21.91 cm), T_{11} (21.45 cm), T8 (21.03 cm) T_3 (20.85 cm) and T9 (20.42 cm) followed by treatments T_7 (20.23 cm) and T_2 (19.95 cm). Among the treatment T_{12} i.e. (Control) recorded minimum length of shoot (17.58 cm).

At 90 days after planting the significantly maximum seedling height (28.71 cm) was observed in the treatment T_4 (IBA 4000 ppm), which were found at par with treatments T_{10} (27.71 cm), T_{11} (26.68 cm) and T_8 (26.07 cm) followed by treatments T_3 (25.52 cm) and T_9 (24.75 cm). Among the treatment T_{12} i.e. (Control) recorded minimum length of shoot (21.00 cm).

Plant height increased significantly with higher concentrations of IBA treatment, as it enhanced rooting, leading to better water and nutrient uptake through the vascular bundles. This improved nutrient absorption contributed to the overall increase in plant height. This result in are in conformity with those reported by Khapare *et al.* (2012) [8] and Singh and Singh (2017) [12] in fig.

Table 3: Effect of different levels of plant growth regulators on number of branches and seedling height (cm) of cutting in fig (*Ficus carica* L.).

Treatment No	Treatment Details	Number of branches		Seedling height (cm)		
		60 DAP	90 DAP	30 DAP	60 DAP	90 DAP
T_1	IBA 1000 ppm	1.13	2.13	12.93	19.47	23.02
T_2	IBA 2000 ppm	1.20	2.25	13.65	19.95	23.70
T_3	IBA 3000 ppm	2.01	2.87	14.35	20.85	25.52
T_4	IBA 4000 ppm	2.56	3.63	15.67	22.97	28.71
T_5	NAA 1000 ppm	1.01	2.02	12.51	19.27	22.51
T_6	NAA 2000 ppm	1.46	2.47	13.33	19.67	23.37
T_7	NAA 3000 ppm	1.56	2.61	14.02	20.23	23.93
T_8	NAA 4000 ppm	1.85	2.83	14.98	21.03	26.07
T_9	IBA 1500 ppm + NAA 1500 ppm	1.72	2.67	14.18	20.42	24.75
T_{10}	IBA 2500 ppm + NAA 2500 ppm	2.32	3.27	15.48	21.91	27.71
T_{11}	IBA 3500 ppm + NAA 3500 ppm	2.13	3.20	15.17	21.45	26.68
T_{12}	Control	0.68	1.71	11.45	17.58	21.00
	S.E. ±	0.09	0.12	0.66	0.88	1.01
	C.D.at 5%	0.27	0.36	1.98	2.58	2.96

7) Success percentage (%)

The success obtained in the nursery condition in regard of success of cuttings with various treatments has been converted in to percentage and was recorded 60 days after planting of cuttings. The significantly maximum success percentage (90.12%) was observed in the treatment T_4 (IBA 4000 ppm), which was found at par with treatment T_{10} (83.33%) followed by treatments T_{11} (81.11%) and T_3 (71.11%). Among the treatment T_{12} i.e. (Control) recorded minimum success percentage (41.33%).

This might be due to synergistic effect of auxin and phenolic compound on early root initiation, more number of root, more length and diameter of root, which might results in translocation of food material to different parts of shoot. Hence it may results superior growth of different shoot parameters and ultimately final success and survival of cuttings. This result in are in conformity with those reported by Kumar Sanjay *et al.* (2004) [9] in sweet lime, Ram *et al.* (2005) in pomegranate, Reddy *et al.* (2008) [15] in fig and Diwakar and Katiyar (2013) [4] in kagzi lime also reported similar results.

8) Survival Percentage (%)

The survival was obtained in the nursery condition in regard of survival of cuttings with various treatments has been converted in to percentage and was recorded 90 days after planting of cuttings. The significantly maximum survival percentage (87.77%) was observed in the treatment T_4 (IBA 4000 ppm), which was found at par with treatment T_{10} (79.00%) followed by treatments T_{11} (78.88%) and T_3 (64.44%). Among the treatment T_{12} i.e. (Control) recorded minimum survival percentage (31.11%).

The development of an effective root system, characterized by an increased number and length of roots, likely enhanced water and nutrient uptake, leading to a higher survival rate of the cuttings. Hardwood cuttings, with their higher carbohydrate reserves, combined with IBA and NAA treatments, promoted better root growth, further improving nutrient and moisture absorption. Similar findings were made by Khapare *et al* (2012) [8], Patel *et al* (2017) [12] and Patel and Patel (2018) [11] in fig.

9) Benefit cost ratio

The benefit cost ratio obtained in the nursery condition in regard of cuttings with various treatments recorded 90 days after planting of cuttings. The significantly maximum cost benefit ratio (2.25) was observed in the treatment T_4 (IBA 4000 ppm), which were found at par with treatments T_{10} (2.20) and T_{11} (2.04) followed by treatments T_9 (1.91) and T_3 (1.76). Among the treatment T_{12} i.e. (Control) recorded minimum benefit cost ratio (1.07).

The result in are in conformity with those reported by Maurya *et al.* (2012) [10] in guava, Bhosale *et al.* (2014) [2] in pomegranate and Reddy *et al.* (2014) [14] in fig.

Table 4: Effect of different levels of plant growth regulators on success percentage (%), survival percentage and B:C ratio of cutting in fig (*Ficus carica* L.).

Treatment No	Treatment Details	Success percentage (%) 60 DAP	Survival Percentage (%) 90 DAP	B:C ratio
T_1	IBA 1000 ppm	56.67	52.21	1.66
T_2	IBA 2000 ppm	63.33	57.07	1.70
T_3	IBA 3000 ppm	71.11	64.44	1.76
T_4	IBA 4000 ppm	90.12	87.77	2.25
T_5	NAA 1000 ppm	50.00	44.44	1.52
T_6	NAA 2000 ppm	52.22	45.55	1.55
T_7	NAA 3000 ppm	53.33	46.66	1.57
T_8	NAA 4000 ppm	55.56	47.77	1.60
T_9	IBA 1500 ppm + NAA 1500 ppm	68.89	63.33	1.91
T_{10}	IBA 2500 ppm + NAA 2500 ppm	83.33	79.00	2.20
T_{11}	IBA 3500 ppm + NAA 3500 ppm	81.11	78.88	2.04
T_{12}	Control	41.33	31.11	1.07
	S.E. ±	2.93	2.93	0.10
	C.D.at 5%	8.79	8.79	0.29

Conclusion

The study demonstrated that IBA at 4000 ppm (T_4) significantly improved the growth and survival of cuttings compared to the control. T_4 produced the longest shoot lengths (18.71 cm at 90 days), the highest number of leaves (9.47), shoots (3.07), and seedling height (28.71 cm). It also recorded the highest success (90.12%) and survival (87.77%) rates, as well as the best cost-benefit ratio (2.25). In contrast, the control treatment showed considerably lower growth and economic performance. Therefore, IBA 4000 ppm was found to be the most effective treatment for enhancing plant propagation success.

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