Research Article

Effect of Indole Butyric Acid on Quantitative Measurement Responses of Nursery Plants of Fig (*Ficus carica* L.) Cv. Brown Turkey

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Abstract

The investigation was conducted to evaluate the effect of different concentrations of indole-3-butyric acid (IBA) hormone on the rooting capacity and other morphological parameters of nursery plants raised through hard wood cuttings of Fig (*Ficus carica* L.) cv. Brown Turkey. Fifty cuttings with five replications in each treatment were planted in the experiment block during February 2016. The higher concentration of IBA (1250 ppm) resulted in maximum rooting (81.60 %) followed by 68.60, 64.40, 64.20 per cent in 1000, 750 and 500 ppm IBA, respectively. Sprouting was earlier (14.40 days from transplanting) in treatment IBA @ 1250 ppm followed by 16.60 days in 1000 ppm treatment. The maximum mean plant height (67.20 cm) was recorded in treatment 4 (IBA @ 1250) followed by 48.00 and 30.80 cm in treatment 3 (IBA @ 1000 ppm) and 2 (IBA@ 750 ppm), respectively. Average number of leaves per plant (14.60) and number of roots (67.20) were recorded highest in treatment IBA @1250 ppm followed by 11.80 and 36.40 number of leaves and roots per plant in IBA @ 1000 ppm, respectively. Significantly higher fresh and dry weights of leaves, shoots and roots per plant were recorded in IBA @ 1250 ppm treatment. The present study showed that treatment of IBA @ 1250 ppm for 25 seconds is highly effective in increasing aerial and rooting biomass in hardwood cuttings of Fig cv. Brown Turkey transplanted in mid February under sub-tropical conditions of India.

Keywords: Quantitative, Auxins, Aerial Character, Rooting

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Introduction

Fig (*Ficus carica* L.) is one of the minor crops of the Punjab state. Presently, it is of low commercial importance, but it is gaining popularity in the farming community. Brown Turkey cultivar had been recommended for the state for its commercial cultivation. However, availability of good planting material and standardization of propagation techniques are the tasks ahead for the crop popularity. Fig fruit is an important constituent of the balanced diet due to its high nutritive and medicinal value [1]. The fruits are rich source of minerals, vitamins, polyphenols, and dietary fiber and have a high antioxidant activity [2]. The major reasons of its poor productivity are non-availability of healthy planting material and poor orchard management practices. Cutting is well known and old method for vegetative propagation where the desirable trait can easily be fixed in improved cultivars. The use of hardwood cuttings is one of the easiest methods of vegetative propagation in fig. The traditional propagation method in fig involves taking cuttings from one or two-year-old shoots and directly planting them in soil to obtain new true to type plants [3].

However, there are some endogenous factors such as growth hormones and carbohydrates [4] and exogenous factors such as humidity, air and light condition which determine the vegetative responses of the cuttings [5]. Many research workers have reported that the optimum level of hormones should be used to induce rooting on cutting [6-9]. These hormones play an important role in the success of cutting to raise healthy planting material. Plant internal conditions can be evidenced by hormonal balance among rooting inhibitors and promoters. The use of growth regulators on the cutting enables the production of rooting [6]. Auxins are the most commonly used growth regulators which enhance rooting by stimulating the ethylene synthesis. Exogenous application of auxins on cutting base ends is one of the most commonly used methods [8]. Artificial auxins must be used to promote rooting in cutting and to increase success of propagation in fig through cutting [9]. Auxins accelerate root formation of cutting in especially hard-to-root species, and increase root number and other quality parameters of rooted cutting [10]. Highest growth percent, plant height, leaf area, shoot diameter, root number was observed in IBA 4000 ppm treatment and the lowest in control treatment [11]. The application of IBA on cutting before transplanting increased the dry matter weight of shoots and roots in Fig cv. “Roxo de Valinhos’ [12]. Highest root number, root length and shoot length in Fig cv. Banana Fig by the application of IBA 4000 ppm [13].

Very less research work has been reported in India on the propagation techniques through cutting by using the growth hormones in fig [14]. Hence, there is an urgent need to standardize the dose of auxins for its commercial use on hardwood cuttings for enhancing propagation success rate. So the study was planned with an objective to see the effect of various concentrations of IBA on hard wood cuttings of fig on rooting success and other quantitative attributed related to the healthy nursery plant. More importantly, the investigation was necessary to produce techniques for producing good healthy planting material of promising varieties under field conditions to popularize the fig crop under subtropical conditions.

Materials and Methods

The experiment was conducted at college orchard at Punjab Agricultural University during 2016.The study area is located at latitude 30° 54' N and longitude 75° 48' E with sub-tropical climatic conditions. The height above mean sea level is 247 m. Harwood cuttings of 20-25 cm in length and each having 4-5 buds were taken from one year old shoots from five year old Fig plants cv. Brown Turkey during the mid February. The basal horizontal cut portion of the cuttings were dipped for 25 seconds in different concentrations of IBA solution (500, 750, 1000 and 1250 ppm). In control, no IBA treatment was given. The cuttings were then shade dried for 5 minutes and then planted in the field. For eliminating the error in making different working concentrations of IBA, stock solution of 2000 ppm was prepared by dissolving 1 gram of IBA in 50 ml of ethanol and then made the volume 500 ml by adding distilled water. The experiment was replicated five times.

Measured Parameters

After 90 days of transplantation, randomly selected ten sprouted cuttings were selected for recording the data. The following parameters were evaluated: number of leaves, length and breadth of leaf lamina, leaf petiole length and breadth, days for cutting sprouting, plant height and shoot diameter, number of roots per shoot, average length and diameter of roots, rooted cuttings (%), fresh and dry weight of shoots, leaves and roots. Quantitative measurement of diameter was done with digital Vernier Caliper, Mitutoyo Inc., Japan. For dry weight measurement, leaves, shoots and roots were dried in oven at 60 ^{0}C for 72 hours. Weight was measured with electronic weighing balance.

Statistical Analysis

The experiment was laid out by Randomized Block Design [15]. Critical difference at 5% level of probability was computed to compare the statistical significance of different treatments. Analysis of variance was conducted for various quantitative traits using 9.3 version of SAS (Statistical analysis system) software.

Results and Discussion

Influence of Auxins on leaf characters

Number of leaves per shoot

The results in **Table 1** reveal that maximum number of leaves per shoot (14.60) was recorded in treatment 4 (IBA @ 1250 ppm) followed by 11.80 leaves per shoot in treatment 3 (IBA @ 1000 ppm) and it was significantly higher than all the other treatments. However, minimum number of leaves per shoot (8.60) was recorded in control which was statically at par with IBA @ 500 ppm treatment. The results indicate that no significant difference in leaf number was observed at IBA @ 500 ppm treatment but with increase in concentration of IBA, the number of leaves per shoot increased.

The data clearly show the increase in number of leaves per shoot with increase in number of roots with IBA treatments. This may be due to the uptake of more nutrients by more number of roots and hence more growth of the plants. Similarly, higher number of leaves per shoot (8.92) have been reported with the application of IBA and NAA (2500 ppm IBA + 2500 ppm NAA) followed by IBA @ 2500 ppm which recorded 7.74 leaves per shoot [14].

Length and breadth of leaf blade

The data (Table 1) show that leaf length and breadth were varied significantly among treatments. Maximum mean leaf length and breadth (14.83 and 13.99 cm respectively) were recorded in treatment 4 (IBA @ 1250 ppm) which were significantly higher than all other treatments. However, the minimum values of leaf length and breadth were recorded (8.91 and 7.90 cm, respectively) in control and the corresponding values were statically at par with IBA@ 500 ppm treatment but differed significantly from all other treatments.

Table 1 Effect of different doses of IBA on quantitative measurement responses of nursery plant of Fig cv. Brown Turkey

Treatment	No. of leaves per shoot	Length of leaf (cm)	Breadth of leaf (cm)	Leaf petiole length (cm)	Leaf petiole breadth (mm)	Days for sprouting
IBA @ 500 ppm	9.20^{cd}	9.03^{cd}	7.95^{d}	2.80^{cd}	2.80^{d}	24.60^{a}
IBA @ 750 ppm	10.40^{bc}	11.18^{c}	10.33^{c}	3.40^{c}	3.17^{abc}	20.20^{c}
IBA @ 1000 ppm	11.80^{b}	12.79^{b}	12.71^{b}	3.95^{b}	3.26^{ab}	16.60^{d}
IBA @ 1250 ppm	14.60^{a}	14.83^{a}	13.99^{a}	4.37^{a}	3.36^{a}	14.40^{e}
Control	8.60^{cde}	8.91^{cde}	7.90^{de}	2.76^{cde}	2.75^{e}	23.60^{ab}
Mean	10.92	11.35	10.58	3.46	3.07	19.88
LSD ($p \le 0.05$)	2.10	1.05	0.93	0.37	0.20	2.90
C.V.	14.79	6.92	6.57	8.18	4.91	10.92

*Different alphabets show significant difference and same alphabets show non-significant difference among genotypes

Petiole length and breadth (mm)

Significantly higher petiole length (4.37 mm) was recorded in treatment 4 (IBA @ 1250 ppm) followed by 3.95 cm in treatment 2 (IBA @ 1000 ppm). The lowest value of leaf petiole length (7.90 cm) which was recorded in control and it was statistically at par with IBA @ 500 ppm treatment. Mean leaf breath (3.36 mm) was maximum in treatment 4 (IBA @ 1250 ppm) and it was statistically at par with treatment 2 and 3. Minimum value of mean petiole breadth (2.75 mm) was recorded in control which differed significantly from all other treatments.

In a similar study in fig, highest growth per cent, plant height and leaf area have been reported with application of IBA @ 4000 ppm treatment and the lowest in control treatment [11].

Sprouting Time of cutting (Days after transplanting)

Minimum time (14.40 days) was taken by the shoots to sprout in treatment 4 (IBA @ 1250 ppm) followed 16.60 and 20.20 days in treatment 2 and 3. It was significantly lower than all the treatments. The maximum days (24.60) were taken by the shoots to sprout in treatment 1 (IBA @ 500 ppm) and it was statically at par with control which recorded 23.60 days.

Our results clearly indicate the positive effect of IBA on shoots on their early sprouting. The results are supported by the hypothesis that IBA is a root promoting hormone which helped in root induction and increased the sprouting process and hence reduces the time for the sprouting process [16]. Our results are also supported by the finding where the researchers reported more sprouting success in cutting treated by IBA [9] and [11].

Influence of Auxins on shoot and roots characters

Plant height and shoot diameter

A significant variation in plant height was recorded among different mandarin genotypes (**Table 2**). The maximum mean plant height (67.20 cm) was recorded in treatment 4 (IBA @ 1250) followed by 48.00 and 30.80 cm in treatment 3 (IBA @ 1000 ppm) and 2 (IBA@ 750 ppm), respectively. Minimum mean plant height (20.80 cm) was recorded in control which differed significantly from all other genotypes except treatment 1 (IBA@ 500 ppm) which recorded 22.40 cm shoot length. The maximum mean plant height (11.38 mm) was recorded in treatment 4 (IBA @ 1250) followed by treatment 3 (IBA @ 1000 ppm) and 2 (IBA @ 750 ppm) which recorded 8.37 and 6.85 mm plant heights, respectively and it significantly higher than all other treatments. Minimum shoot diameter (5.54 mm) was found in control and it was statistically at par with treatment 1 (IBA @ 500) which recorded 5.58 mm mean shoot diameter.

Results indicate higher plant height and shoot diameter with IBA treatment and these parameters increased significantly with the increase in the concentration of IBA treatment. The increase in plant height and its diameter is directly related to the rate of uptake of water and nutrients by the vascular bundles. Due to higher rooting per cent in IBA treated plants helps the plant to uptake more nutrients and hence increase in plant height and shoot diameter. Our results are supported by the research findings where more sprouting success have been reported in cutting treated by IBA [9, 11].

Table 2 Effect of different doses of IBA on quantitative measurement responses of nursery plant of Fig cv. Brown Turkey

Treatment	Pant height (cm)	Diameter of shoot (mm)	No. of roots/ plant	Average length of roots (cm)	Diameter of roots (mm)	Rooting (%)
IBA @ 500 ppm	22.40^{d}	5.58^{d}	17.00^{cd}	12.22^{cd}	1.60^{d}	64.20^{bcd}
IBA @ 750 ppm	30.80^{c}	6.85^{c}	26.00^{bc}	13.76^{c}	2.08^{abc}	64.40^{bc}
IBA @ 1000 ppm	48.00^{b}	8.37^{b}	36.40^{b}	17.47^{ab}	2.12^{ab}	68.60^{b}
IBA @ 1250 ppm	67.20^{a}	11.38^{a}	67.20^{a}	19.28^{a}	2.24^{a}	81.60^{a}
Control	20.80^{de}	5.54^{de}	15.60^{cde}	12.11^{cde}	1.60^{d}	57.00^{e}
Mean	37.84	7.54	32.44	14.97	1.93	67.16
LSD ($p \leq 0.05$)	6.39	0.73	14.85	2.79	0.35	4.37
C.V.	12.60	7.27	34.18	13.76	13.66	4.86

*Different alphabets show significant difference and same alphabets show non-significant difference among genotypes

Number of roots per shoot

The maximum number of roots per shoot (67.20) was recorded in treatment 1 (IBA @ 1250) followed by 36.40 and 26.00 in treatment 3 and 2 respectively. It was significantly higher than all other treatments including control. However, the minimum number of roots per shoot (15.60) was recorded in control which was statistically at par with treatment 1 (17.00).

Significant increase in number of roots per shoot was observed in the experiment. This may be due to the increase in the metabolite translocation and carbohydrates metabolism due to the role of auxins on root initiation [8, 9, 11]

Average length and diameter of roots

Significant variation in mean length and diameter of roots was recorded among treatments (**Figure 1**) The maximum mean length of roots (19.28 cm) was recorded in treatment 4 (IBA @ 1250) followed by 17.47 and 13.76 in treatment 3 and 2 respectively (Table 2). It was significantly higher than all other treatments except treatment 3. However, the minimum mean length of roots (12.11 cm) was recorded in control which was statistically at par with treatment 1 and 2. The maximum mean root diameter (2.24 mm) was recorded in treatment 1 followed by treatment 3 and 2 which recorded 2.12 and 2.08 mm shoot diameters, respectively and it significantly higher than all other treatments. Minimum root diameter (1.60 mm) was found in control and treatment 1.

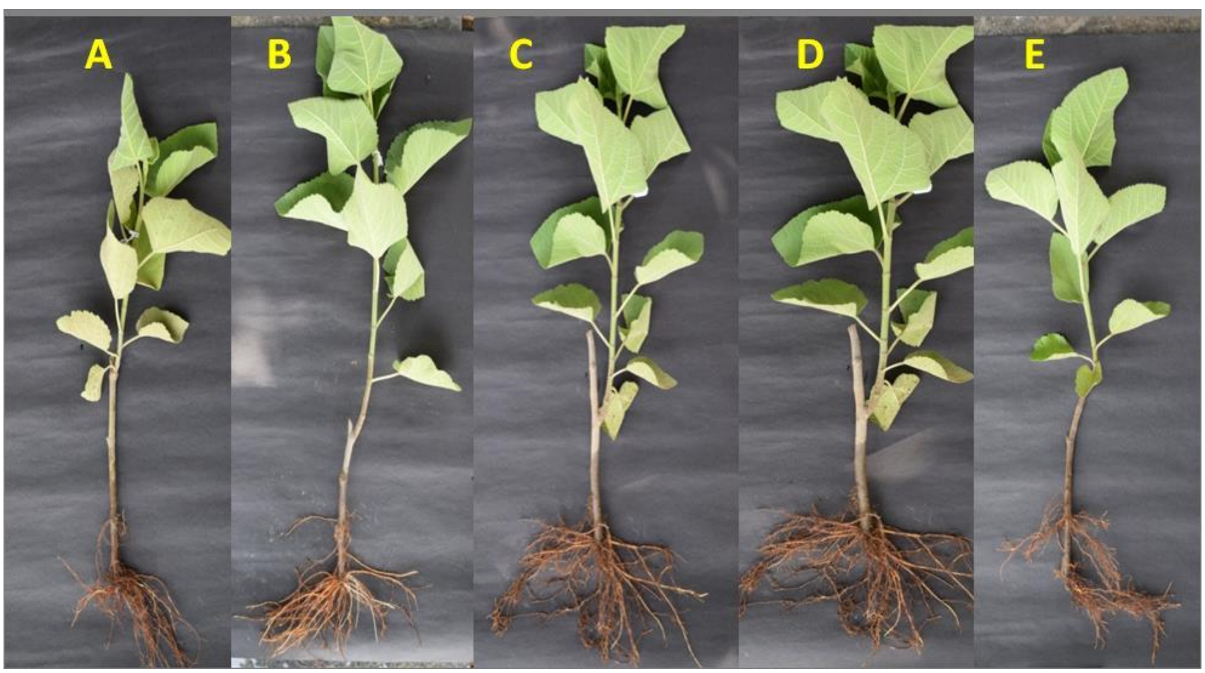

Figure 1 Nursery plants of Fig cv. Brown Turkey showing aerial and root growth after 90 days of cutting transplanting A): IBA @ 500 ppm B): IBA @ 750 ppm C) IBA @ 1000 ppm D) IBA @ 1250 ppm E) Control (No IBA)

The results show significant higher root length and its diameter with the application of IBA treatments. Auxin promotes the translocation of metabolites and carbohydrates metabolism which ultimately increase the length and breadth of the roots in IBA treated cuttings. Our findings are supported by the findings where highest root number and root length in hard wood cutting of fig have been reported with the application of IBA @ 2500 ppm [17].

Rooted cutting (%)

Application of IBA showed significant effect on rooting percent of fig cuttings (Table 2).The stem cutting treated with IBA @ 1250 ppm showed highest rooting (81.60 %) followed by 68.60 and 64.40 % in treatment 3 and 2 respectively. However, the lowest rooting (57 %) was recorded in control which differed statistically from all IBA treatments. Only treatment 4 and 3 are statistically more significant among all the treatments.

The results reveal that with the increase in concentration of IBA treatment the rooted cutting per cent increased. This is due to the more carbohydrate metabolism and translocation of metabolites from aerial parts to underground plant parts. Many researcher also reported better rooting with IBA @ 1000 ppm treatment than control in fig cv. 'Roxo Valinhos' and '*Ficus carica* [18, 12,]. However, some scientists reported higher dose IBA @ 4000 ppm for rooting in hard wood cuttings of fig cv. Hawai [11].

Influence of Auxins on fresh and dry weight accumulation

Fresh and dry weight of leaves/plant

Highest mean fresh and dry weight of leaves per shoot (47.56 and 24.48 g, respectively) were recorded in plants treated with IBA @ 1250 ppm followed by IBA @ 1000 ppm which recorded fresh weight of 34.60 g and dry weight of 16.82 g (**Table 3**). Significantly higher fresh and dry weights were recorded in these treatments as compared control and IBA@ 500 ppm treatment. Minimum fresh and dry weights of leaves per plant (12.20 and 5.26 g respectively) were recorded in controls which were statistically at par with treatment 1 (IBA @ 500 ppm). More accumulation of fresh and dry matter occurred in IBA treated cuttings during the April and May months. The fresh and dry matter increased with increase in the IBA concentration, however no significant effect on weight was observed with IBA @ 500 ppm treatment. IBA concentrations @ 750 or more influence the fresh and dry matter of leaves/plant.

Table 3 Effect of different doses of IBA on quantitative measurement responses of nursery plant of Fig cv. Brown Turkey

Treatment	**Average fresh weight per plant (g)**			**Average dry weight per plant (g)**		
	Leaves	**Shoots**	**Roots**	**Leaves**	**Shoots**	**Roots**
IBA @ 500 ppm	15.10^{cd}	13.22^{d}	6.28^{bcd}	6.04^{cd}	5.40^{d}	2.64^{d}
IBA @ 750 ppm	15.24^{c}	24.92^{c}	7.14^{bc}	6.84^{c}	9.74^{c}	3.72^{bc}
IBA @ 1000 ppm	34.60^{b}	37.28^{b}	7.43^{b}	16.82^{b}	13.94^{b}	3.94^{b}
IBA @ 1250 ppm	47.56^{a}	60.92^{a}	10.40^{a}	24.48^{a}	21.92^{a}	6.80^{a}
Control	12.20^{cde}	12.52^{de}	4.36^{e}	5.26^{de}	5.18^{de}	1.82^{e}
Mean	24.94	29.77	7.12	11.89	11.24	3.78
LSD ($p \leq 0.05$)	3.31	3.97	1.20	1.24	1.98	0.61
C.V.	9.93	9.95	12.64	7.84	13.21	12.11

*Different alphabets show significant difference and same alphabets show non-significant difference among genotypes

The results indicated that unbalance between auxin endogenous and exogenous level results in different measurable quantitative responses of treated plant in relation to fresh and dry matter accumulation. Similar results were reported in *Jatropha curcus* [19], in pear [20], in Ixora [21] and in lemon cuttings [22].

Fresh and dry weight of shoot/plant

Fresh and dry weight of shoot per plant varied significantly among treatments (Table 3). Highest mean fresh and dry weight of shoot per plant (60.92 and 21.92 g, respectively) were recorded in plants treated with IBA @ 1250 ppm followed by IBA @ 1000 ppm which recorded 37.28 g and 13.94 g fresh weight and dry weight of shoots per plant, respectively.

Significantly higher fresh and dry shoot weight were recorded in treatments 4, 3 and 2 as compared to control and IBA@ 500 ppm treatment. The results are in accordance with the findings in which better aerial growth in fig cuttings has been reported with the application of IBA and NAA [23].

Fresh and dry weight of roots/plant

Significant variation in fresh and dry weight of roots was recorded among treatments (Table 3). The maximum mean fresh and dry weights of roots per plant (10.40 and 6.80 g) were recorded in treatment 4 (IBA @ 1250). It was significantly higher than all other treatments. However, the minimum mean fresh and dry weights of roots per plant (4.36 and 1.82 g, respectively) were recorded in control.

Significant plant responses were observed with respect to fresh and dry weight of roots per plant with the application of IBA. Our results are supported by finding of many workers [12, 13, 23].

Conclusions

It is concluded from the studies that IBA treated cuttings showed comparatively better quantitative plant responses in fig. The lower concentration (IBA @ 500ppm) seems to be ineffective to promote aerial and underground growth, however higher concentration of IBA @ 1250 ppm treatment for 25 seconds during mid of February is ideal for promoting aerial and underground parts. The present study reveals that application IBA @1250 ppm to hardwood cuttings in fig is highly effective and can be used commercially in vegetative propagation through cutting.

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