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AUXIN INDUCED ROOTING AND BIOMASS ENHANCEMENT IN *FICUS CARICA* L. CV. AFGHAN

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ABSTRACT

The present study entitled "Auxin Induced Rooting and Biomass Enhancement in *Ficus carica* L. cv. Afghan" was conducted during 2022–2023 at a farmer's nursery in Erode District, Tamil Nadu, to evaluate the influence of different auxins on rooting and growth parameters of fig hardwood cuttings. The experiment was laid out in a Completely Randomized Design (CRD) with ten treatments and three replications, using 450 cuttings of the drought-tolerant 'Afghan' cultivar. Treatments included three concentrations each of Indole-3-butyric acid (IBA), Indole-3-acetic acid (IAA) and Naphthalene acetic acid (NAA), along with an untreated control. The basal ends of the cuttings were subjected to a 30-second quick dip in respective plant growth regulator solutions and rooting was carried out under mist chamber conditions. Significant differences were observed among treatments for all measured parameters including number of roots per cutting, root length, rooting percentage, fresh and dry root weight, plant biomass and survival percentage. Among the treatments, IBA at 3500 ppm (T_3) consistently outperformed others, recording the highest values for number of roots (68.91), root length (24.82 cm), rooting percentage (79.34%), fresh root weight (18.03 g), dry root weight (8.16 g), fresh biomass (64.47 g), dry biomass (43.79 g) and survival percentage (87.88%). The positive effects of IBA are attributed to its role in enhancing cell division, root initiation and nutrient mobilization. The study concludes that IBA @ 3500 ppm is most effective for uniform and successful propagation of fig cv. Afghan under Erode conditions.
***Keywords*: ** Afghan, Auxins, Cuttings, Rooting and Biomass

Introduction

Fig (*Ficus carica* L.), a member of the Moraceae family, is an ancient fruit crop native to Asia Minor and now widespread in the Mediterranean region (Gaaliche *et al*., 2012). Historically one of the first domesticated plants, it is known as 'Aththi' in Tamil and 'Anjeer' in Hindi. Botanically termed a *syconium*, the fig fruit is characterized by the presence of latex in parenchyma cells (Lazreg-Aref *et al*., 2012) and is valued for its nutritional and medicinal properties. It played a vital dietary role alongside pomegranate, olive and date palm in early human civilizations (Abbo *et al*., 2015). Recent studies also highlight its potential therapeutic role in managing COVID-19 infections (Hamed *et al*., 2023). Figs are widely grown due to their adaptability to diverse soils and climates, especially in arid and semi-arid regions (Pushpa *et al*., 2023). Globally, fresh fig production is 1.26 million tonnes, led by Turkey (FAOSTAT, 2022). In India, fig is mainly grown in Maharashtra, Gujarat and Tamil Nadu, covering 5.9 thousand hectares (Prabhuling and Huchesh, 2018). The 'Afghan' cultivar is notable in India for its drought tolerance, early ripening and marketable fruit quality (Hssaini *et al*., 2020). Figs are commercially propagated via hardwood cuttings, favored for simplicity and cost-effectiveness (Singh and Rattenpal, 2015). Rooting success improves with auxins like IBA, NAA and IAA, which stimulate adventitious root formation (Dahale *et al*., 2018; Gollagi *et al*., 2019). However, research under Erode's climatic conditions is limited, necessitating location-specific propagation studies.

Material and Methods

The present investigation titled "Auxin Induced Rooting and Biomass Enhancement in *Ficus carica* L.

cv. Afghan" was conducted during 2022–2023 at a farmer's nursery located in Mandaripalayam Pudur, Erode District, Tamil Nadu. The experiment was laid out in a Completely Randomized Design (CRD) with ten treatments replicated thrice. A total of 450 hardwood cuttings of fig cultivar 'Afghan' were used, with 15 cuttings per replication and one cutting per polyethylene bag. The rooting medium consisted of sand, red earth and soil mixed in a 1:1:1 ratio. The experiment was conducted under mist chamber conditions maintained at 35–38°C temperature and 90% relative humidity. Intermittent misting was provided manually for 5 minutes every four hours using misting nozzles fixed at 1.8 m height. The hardwood cuttings were collected from healthy, mature fig plants of the 'Afghan' cultivar. The basal ends of the cuttings were treated using a quick dip method (30 seconds) in different concentrations of Indole-3-butyric acid (IBA), Indole-3-acetic acid (IAA) and Naphthalene acetic acid (NAA). The experiment included treatments with indole-3-butyric acid (IBA) at concentrations of 1500 ppm (T_1), 2500 ppm (T_2) and 3500 ppm (T_3); indole-3-acetic acid (IAA) at 1500 ppm (T_4), 2500 ppm (T_5) and 3500 ppm (T_6); and naphthalene acetic acid (NAA) at 1500 ppm (T_7), 2500 ppm (T_8) and 3500 ppm (T_9), along with an untreated control (T_{10}). The data recorded were subjected to statistical analysis by adopting the standard procedure of Panse and Sukhatme (1985). The critical differences were arrived at 5 per cent probability significance.

Results and Discussion

The parameters measured to assess the effect of growth regulators on fig cuttings included the number of roots per cutting, root length (cm), rooting percentage (%), fresh root weight per cutting (g), dry root weight per cutting (g), fresh plant biomass (g), dry plant biomass (g) and survival percentage (%). Data were recorded for each treatment and replication to evaluate the influence of different concentrations of auxins on rooting and growth performance. Statistical analysis was performed to determine the significance of differences among treatments for all these parameters.

The number of roots per cutting differed significantly among the various concentrations of plant growth regulators. The highest number of roots (68.91) was recorded in T_3 (IBA @ 3500 ppm), followed by T_2 (IBA @ 2500 ppm) with 61.37 roots per cutting. The lowest number of roots (23.32) was observed in the control (T_{10}). The increase in the number of roots per cutting can be attributed to the positive influence of auxins, which stimulate cell division and elongation, leading to the differentiation of cambial cells into root primordia. Auxins also facilitate the mobilization and hydrolysis of reserve food materials to the root initiation sites, enhancing root formation. This enhanced physiological activity promotes early root initiation and a higher number of roots per cutting. These findings align with previous reports by Hiral (2017), Dhand *et al.* (2019), Neelima *et al.* (2018) and Saroj *et al.* (2008) and are consistent with similar observations in fig (Khapare *et al.*, 2012; Patel and Patel, 2018), guava (Kareem *et al.*, 2013), kiwi fruit (Ali *et al.*, 2017) and Phalsa (Ghosh *et al.*, 2017).

Root length varied significantly among the treatments. The maximum root length (24.82 cm) was recorded in IBA @ 3500 ppm (T_3), followed by IBA @ 2500 ppm (T_2) with 20.77 cm. The minimum root length (11.07 cm) was observed in the control (T_{10}). Maximum root length with IBA treatment is attributed to its stimulation of enzymes involved in cell enlargement, enhanced metabolic activity and cell division, promoting root growth (Edmond *et al.*, 1997).

Table 1 : Auxin Enrichment Enhances Rooting and Biomass in Fig (*Ficus carica* L.) Hardwood Cuttings

Treatment Number	Number of roots per cutting	Root length (cm)	Rooting Percentage (%)	Fresh weight of roots per cutting (g)	Dry weight of roots (g) per cutting	Survival Percentage (%)	Fresh plant biomass (g)	Dry plant biomass (g)
T_1	47.32	15.62	66.23	12.91	5.46	73.80	50.71	32.42
T_2	61.37	20.77	74.17	16.43	7.48	83.55	60.69	40.13
T_3	68.91	24.82	79.34	18.03	8.16	87.88	64.47	43.79
T_4	41.40	15.62	60.76	11.92	5.23	69.99	47.58	30.53
T_5	50.08	17.36	69.37	13.24	6.10	76.87	53.16	34.40
T_6	57.33	18.91	71.64	14.23	6.75	80.03	56.24	37.17
T_7	34.70	12.55	51.76	8.51	3.46	67.39	37.72	24.89
T_8	37.40	12.57	55.25	9.60	4.61	63.81	40.93	27.46
T_9	39.53	14.05	58.71	10.93	4.02	61.09	44.43	28.11
T_{10}	23.32	11.07	32.59	7.31	2.95	57.50	32.20	23.17
S. Ed.	**0.97**	**0.68**	**0.97**	**0.45**	**0.24**	**0.83**	**0.99**	**0.58**
C.D. (P=0.05)	**2.03**	**1.41**	**2.02**	**0.93**	**0.50**	**1.73**	**2.08**	**1.22**

Auxin-induced hydrolysis of carbohydrates, metabolite accumulation and protein synthesis further support root elongation (Dey *et al*., 2017). IBA also facilitates metabolite translocation and carbohydrate metabolism, crucial for root development. These results align with findings in fig (Hiral *et al*., 2017), mulberry (Trujillo, 2000), kiwifruit (Srivastava *et al*., 2005) and other fruit crops, confirming auxins' positive effect on root length.

Rooting percentage differed significantly with different growth regulator treatments. The highest rooting percentage (79.34%) was recorded in IBA @ 3500 ppm (T_3), followed by IBA @ 2500 ppm (T_2) with 74.17%. The lowest rooting percentage (32.59%) was observed in the control (T_{10}). The enhanced rooting observed with optimum IBA concentration is attributed to its role in mobilizing carbohydrates and amino acids, providing energy for meristematic activity and root primordia formation (Baghel *et al*., 2016). IBA increases endogenous auxin levels, accumulating at the cutting base to signal root initiation (Maheswari *et al*., 2021). Its effects include increased cell wall plasticity, cell division, callus stimulation and root growth (Upadhyay *et al*., 2020). Enhanced hydrolytic enzyme activity under IBA promotes higher rooting percentage, supported by favorable carbohydrate-to-nitrogen ratios (Singh and Tomar, 2015). IBA's greater stability, low mobility and slow enzymatic degradation contribute to its efficacy (Hartman *et al*., 2002). These findings align with previous reports in pomegranate (Rahman *et al*., 2004), guava (Damer *et al*., 2014) and related studies (Singh, 2014; Raut *et al*., 2015).

Fresh root weight varied significantly among treatments. The maximum fresh root weight (18.03 g) was recorded in IBA @ 3500 ppm (T_3), followed by IBA @ 2500 ppm (T_2) with 16.43 g. The minimum fresh root weight (7.31 g) was observed in the control (T_{10}). The increase in fresh root weight may be attributed to the direct relationship between root number and root biomass per cutting, as auxins both endogenous and exogenously applied enhance root initiation and growth (Kotiyal and Nautiyal, 2019). Auxins promote cell enlargement and overall root development, leading to increased fresh weight. This result is supported by earlier findings in grape (Galavi *et al*., 2013; Chakraborty and Rajkumar, 2018), olive (Khajehpour *et al*., 2014), pomegranate (Damar *et al*., 2014), phalsa (Singh and Tomar, 2015) and fig (Kaur and Kaur, 2017).

Dry root weight showed significant differences among treatments. The highest dry root weight (8.16 g) was recorded in IBA @ 3500 ppm (T_3), followed by IBA @ 2500 ppm (T_2) with 7.48 g. The lowest dry root weight (2.95 g) was observed in the control (T_{10}). The increase in dry weight of roots may be attributed to a greater number and length of roots, which likely enhanced dry matter accumulation. Since dry weight is closely related to fresh weight, a parallel trend was observed. Higher root length and volume per cutting may have contributed to increased carbohydrate storage and biomass accumulation (Singh *et al*., 2006). These findings align with earlier studies in guava (Rhymbai and Reddy, 2010; Maurya *et al*., 2012; Baghel *et al*., 2016), fig (Khapare *et al*., 2012; Sivaji *et al*., 2014; Kumari *et al*., 2020), grapes (Galavi *et al*., 2013) and phalsa (Singh and Tomar, 2015).

Fresh plant biomass varied significantly among the treatments. The highest fresh biomass (64.47 g) was recorded in IBA @ 3500 ppm (T_3), followed by IBA @ 2500 ppm (T_2) with 60.69 g. The lowest fresh biomass (32.20 g) was observed in the control (T_{10}). Dry plant biomass differed significantly among treatments, increasing with auxin concentration. The maximum dry biomass (43.79 g) was recorded in IBA @ 3500 ppm (T_3), followed by IBA @ 2500 ppm (T_2) with 40.13 g. The minimum dry biomass (23.17 g) was observed in the control (T_{10}). The increase in plant biomass may be attributed to enhanced cell division and elongation, as well as the development of a more vigorous root and shoot system in hardwood cuttings, resulting from higher auxin levels. Treatment with IBA stimulated the formation of more roots and shoots, thereby contributing to an increase in the overall fresh weight of the plant (Hiral *et al*., 2017). These findings are consistent with earlier reports by Patel *et al*. (2020) in pomegranate and Pushpa *et al*. (2023) in fig.

Survival percentage differed significantly with growth regulator treatments. The highest survival rate (87.88%) was recorded in IBA @ 3500 ppm (T_3), followed by IBA @ 2500 ppm (T_2) with 83.55%. The lowest survival percentage (57.50%) was observed in the control (T_{10}). The higher survival percentage observed with increased auxin concentration may be attributed to the development of a more effective root system, characterized by greater root number and length, which facilitated better absorption of water and nutrients. Auxins like IBA enhance root initiation and elongation, thereby improving the cutting's ability to establish and survive (Kaur and Kaur, 2017). Additionally, the presence of stored carbohydrates in hardwood cuttings, combined with IBA treatment, likely supported root growth and nutrient uptake (Patel and Patel, 2018). These results are in agreement with earlier findings in fig (Hiral *et al*., 2017; Mewar *et al*., 2016), pomegranate (Tanwar *et al*., 2020) and guava (Gayathiri and Vijayaraj, 2020).

Conclusion

The study revealed that IBA significantly enhanced rooting and growth parameters of fig hardwood cuttings. IBA @ 3500 ppm recorded the highest root number, root length, biomass and survival percentage. This is attributed to auxin's role in promoting cell division, elongation and root initiation, leading to improved nutrient uptake and plant establishment. Therefore, IBA @ 3500 ppm is recommended for efficient and uniform propagation of fig cuttings.

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