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EFFECT OF PLANT EXTRACTS ON ROOT AND SHOOT DEVELOPMENT OF FIG (*FICUS CARICA*) CUTTINGS IN CV. POONA

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ABSTRACT

Ficus carica L. (Fig), a prominent subtropical fruit species, exhibits a strong affinity for arid and semiarid environments. Its nutritional benefits have increased the demand for high-quality, disease-free planting material for orchards. This study investigated the impact of diverse cultivation conditions and treatments on the propagation of fig cuttings, a conventional horticultural practice. While traditional plant growth regulators (PGRs) have proven effective, their associated health and environmental risks necessitate the exploration of safer alternatives. In this context, natural extracts emerge as a viable eco-friendly option for enhancing plant growth and overall productivity. Hardwood cuttings from one-year-old branches of the cultivar Poona were collected in September 2023 and underwent a series of treatments involving plant extracts. Specifically, extracts from *Aloe vera* and *Ficus benghalensis* aerial roots were evaluated at concentrations of 20%, 30%, and 50%, both individually and in combination. These treatments were compared to the application of 3000 ppm of Indole-3-butyric acid (IBA) and Naphthaleneacetic acid (NAA), conducted in both shade house and polyhouse settings. Cuttings treated with IBA 3000 ppm (T_{17}) under shade house conditions (G_1T_{17}) showed the best results for the minimum days for first sprouting (13.47), maximum per cent of sprouting (76.66), Number of leaves per cutting (13.40), leaf area (244.42 cm^2), shoot length (16.44 cm) at 90 days after planting, shoot fresh and dry weight (51.28 and 24.21 g) and shooting percentage (83.33%), primary, secondary and total number of roots per cutting (15.72, 24.11 and 43.33), length of longest root (28.41 cm), root fresh and dry weight (6.25 and 2.83 g), rooting percentage (80%) and maximum survival percentage (75.00%) was recorded in cuttings treated with IBA 3000 ppm (T_{17}) under shade house condition followed by treatment T_{15} (*Aloe barbadensis* 50% + *Ficus benghalensis* aerial root extract 50%). Experimental results indicated that fig cuttings placed in the shade house and treated with IBA 3000 ppm (T_{17}) demonstrated the most significant shoot growth metrics. T_{15}, comprising a 50% concentration of *Aloe barbadensis* and 50% *Ficus benghalensis* aerial root extract, closely followed. Regarding root development, IBA at 3000 ppm yielded superior outcomes, producing results comparable to T15 (*Aloe barbadensis* 50% + *Ficus benghalensis* aerial root extract 50%).

Keywords **:** Fig, plant extracts, *Aloe vera, Ficus benghalensis,* IBA.

Introduction

Ficus carica L., (fig) is a significant subtropical fruit crop, particularly suited for arid and semiarid climates. As a member of the Moraceae family, it shares genetic ties with various tropical fruits and ornamental plants. The genus Ficus is one of the largest among angiosperms, encompassing over 800 species (Hssaini *et al*., 2020). Major fig-producing countries include Turkey, Egypt, Morocco, Iran, the USA, and Italy, with Turkey leading the global market by contributing 28% of fresh fig production and 56% of dried figs. In India, fig cultivation covers approximately 5,600 hectares, yielding around 13,802 metric tons, with an average productivity of 12.32 tons per hectare (Anonymous, 2020). Nutritionally, figs are characterized by their high sugar content and low acidity; fresh figs contain approximately 16% total sugar while dried figs reach up to 52%. They rank among the highest plant sources of calcium and dietary fiber (Joseph and Raj, 2011), with a notable caloric value of 269 kcal, second only to dates. The composition of fig fruit is as follows: moisture content at 80.8%, calcium (7.0 mg), carbohydrates (17%), iron (10.6 mg), protein (1.3%), carotene (600 µg), fat (0.2%), vitamin B1 (90 µg), mineral matter (0.6%), and riboflavin (30 µg). A portion of the crop is sun-dried, while significant amounts are processed into jams and alcoholic beverages (Mars *et al*., 2015). The rich nutritional and medicinal profiles of figs position them as one of the healthiest fruits, contributing to longevity and, therefore, warranting a prominent place in dietary recommendations (Nale *et al*., 2024).

Figs can be propagated using several methodologies, including seed propagation, cuttings, layering, and tissue culture (Dhage *et al*., 2012). Among these, hardwood cutting propagation stands out as the most straightforward and economically viable technique. Asexual propagation is especially advantageous for producing true-to-type planting material, thereby facilitating the mass propagation of superior cultivars for commercial planting. The rooting efficacy of fig cuttings is influenced by a myriad of factors, including the specific cultivar, environmental conditions, seasonal timing, and the maturity of the branch from which the cuttings are sourced. Key determinants of successful rooting include the health status of the donor plant, the anatomical source of the cuttings, the timing of the propagation process, the composition of the rooting medium, and the environmental conditions such as rainfall and temperature fluctuations. Rigorous aftercare also plays a critical role in promoting root initiation. Furthermore, both environmental factors and the application of growth regulators can considerably affect the rooting success and subsequent growth of fig cuttings (Rajan and Singh, 2021).

The propagation of fig plants through stem cuttings is a simple and quick method that relies on callus formation, root initiation, and lateral growth. To enhance root formation, synthetic auxins like Indole-3-butyric acid (IBA) and Naphthalenacetic acid (NAA) are commonly used, as extensive research shows their effectiveness in various species (Yusnita *et al*., 2024). IBA is particularly stable and effective for species that are difficult to root compared to Indole-3-acetic acid (IAA). However, rising costs and limited availability of synthetic hormones have spurred interest in alternative rooting solutions (Dunsin *et al*., 2014). Moreover, these synthetic chemicals may pose environmental risks and affect organisms through the food chain (Sezgina and Kahya, 2018). Auxins are commonly used growth regulators that enhance rooting by stimulating ethylene synthesis, with exogenous application being a popular method (Rajan and Singh, 2021). As consumers increasingly favor organic fruits, there's a growing interest in non-chemical substances for propagating horticultural plants, especially for organic certification. Organic rooting substances are cost-effective alternatives to synthetic hormones and promote sustainable soil productivity. They improve the quality and quantity of rooting, making them environmentally friendly substitutes for synthetic growth hormones like IBA. Research is needed to identify effective biostimulants for root encouragement. Various natural plant extracts, including coconut water, willow leaf, licorice, honey, humic acid, seaweed, moringa, ginger, garlic, aloe vera, and cinnamon powder, are being explored for use in cuttings propagation.

This study investigates the influence of *Aloe vera* and *Ficus benghalensis* extracts on the rooting of cuttings and the development of shoots, with the aim of facilitating large-scale propagation with suitable growing conditions.

Material and Methods

Description of the experiment site

The Kittur Rani Channamma College of Horticulture, Arabhavi, Department of Fruit Science is where the experiment was conducted. The experimental site is located at 16^{o}15' North latitude, 74^{o}45' East longitude, and 640 meters above mean sea level (MSL) in the northern dry zone of Karnataka state. The experiment was conducted during the 2023-2024 year, focusing on the crop Fig (*Ficus carica*), specifically the 'Poona' cultivar. The study employed a

Factorial Completely Randomized Design with two factors. Factor one growing conditions was tested at two levels *i.e* shade house (G_1) and poly house (G_2), while Factor 2 had seventeen levels (Table 1.) with three replications for each treatment. Each replication involved ten cuttings; the cuttings were dipped in the solution for approximately 60 minutes. The experimental season was September, providing ideal conditions for the trial.

The propagation material for the investigation was sourced from a fruit orchard at the UHS Bagalkot. Hardwood cuttings, 20–25 cm in length with 4–6 nodes, were obtained from one-year-old shoots of two- to three-year-old fig plants. These cuttings were carefully selected from healthy, uniformly sized, and disease-free plants. Polythene bags were filled with a soil mixture prepared by thoroughly mixing red soil, vermicompost, and well-rotted farmyard manure (FYM) in a 1:1:1 ratio.

Preparation of treatments

For the preparation of treatments, *Aloe vera* gel was extracted by collecting fresh, healthy Aloe vera leaves, which were peeled, cut into small pieces, and blended for uniformity. The blended mixture was strained through muslin cloth, and the filtered juice was diluted with distilled water to prepare solutions of 20%, 30%, and 50% concentrations. Similarly, *Ficus benghalensis* aerial root extract was prepared by harvesting aerial roots (5–8 cm from the edge), weighing, and grinding them with cold water. The resulting extract was squeezed, filtered through muslin cloth, and diluted with distilled water to achieve treatment concentrations of 20%, 30% and 50%.

The details of the treatments are presented in Table 1, including combinations of *Aloe vera* gel and *Ficus benghalensis* root extract at different concentrations. Additionally, treatments with NAA (3000 ppm) and IBA (3000 ppm) were used as controls. Various parameters were recorded during the experiment, such as the number of days taken for first sprouting, sprouting percentage, number of leaves per cutting (90 DAP), leaf area (calculated as the product of length and width) at 90 DAP, number and length of shoots (90 DAP), shoot diameter (measured using a digital vernier calliper) at 90 DAP, shoot fresh and dry weights, number of primary, secondary, total number of roots, length of longest root(cm) and girth of longest root(mm), root fresh and dry weight(g), rooting percentage and survival percentage.

The sprouting percentage was calculated using the formula:

$$\text{Shooting percentage (\%)} = \frac{\text{Number of shoots}}{\text{Total number of sprouts}} \times 100$$

Shoot length, length of longest root and shoot diameter, root diameter was measured using a measuring scale and vernier calliper. Shoot fresh and dry weights, root fresh and dry weight were determined using an electronic balance. Similarly, rooting and survival percentages were computed using the formulas:

$$\text{Rooting percentage (\%)} = \frac{\text{Number of successful rooted cuttings}}{\text{Total number of cuttings planted}} \times 100$$

$$\text{Survival percentage (\%)} = \frac{\text{Number of survival cuttings}}{\text{Number of sprouted planted}} \times 100$$

The data collected were statistically analyzed using Fisher's method of analysis of variance, following the suggestions of Panse and Sukhatme (1985) for data interpretation. A significance level of p = 0.05 was used in the "F" and "t" tests. In cases of significant results in the "F" test, critical difference (CD) values were calculated to identify treatment differences.

Table 1 : Treatment details

T_1 - *Aloe barbadensis* 20%
T_2 - *Aloe barbadensis* 30%
T_3 - *Aloe barbadensis* 50%
T_4 - *Ficus benghalensis* aerial root extract 20%
T_5 - *Ficus benghalensis* aerial root extract 30%
T_6 - *Ficus benghalensis* aerial root extract 50%
T_7 - *Aloe barbadensis* 20% + *Ficus benghalensis* aerial root extract 20% (T_1+T_4)
T_8 - *Aloe barbadensis* 20% + *Ficus benghalensis* aerial root extract 30% (T_1+T_5)
T_9 - *Aloe barbadensis* 20% + *Ficus benghalensis* aerial root extract 50% (T_1+T_6)
T_{10} - *Aloe barbadensis* 30% + *Ficus benghalensis* aerial root extract 20% (T_2+T_4)
T_{11} - *Aloe barbadensis* 30% + *Ficus benghalensis* aerial root extract 30% (T_2+T_5)

T_{12} - *Aloe barbadensis* 30% + *Ficus benghalensis* aerial root extract 50% (T_2+T_6)
T_{13} - *Aloe barbadensis* 50% + *Ficus benghalensis* aerial root extract 20% (T_3+T_4)
T_{14} - *Aloe barbadensis* 50% + *Ficus benghalensis* aerial root extract 30% (T_3+T_5)
T_{15} - *Aloe barbadensis* 50% + *Ficus benghalensis* aerial root extract 50% (T_3+T_6)
T_{16} - NAA 3000 ppm
T_{17} - Control (IBA 3000 ppm)

Results and Discussion

The effect of different treatments and their interactions on vegetative growth and rooting parameters significantly affects the days for first sprouting, sprouting percent, number of leaves per cutting, leaf area, number of shoots, shoot length, shoot diameter, shoot fresh weight, shoot dry weight, shooting percentage, number of primary roots, number of secondary roots, total number of roots, length of longest root and girth of longest root, root fresh and dry weight, rooting percentage and survival percentage of stem cutting in fig cv. Poona in the present study significant difference has been observed among all the treatments.

Days for first sprouting

Fig cuttings in a shade house sprouted significantly faster (19.07 days) than in a poly house. Among treatments, (T_{17}) showed the fastest sprouting (15.47 days), followed by T_{14} (16.50 days). The interaction showed fastest sprouting (13.47 days) was occurred (G_1T_{17}) followed by G_1T_{15} (14.67) and minimum (25.55) in (G_2T_1). The shade house conditions, with higher humidity, optimal light, and lower evapotranspiration, likely enhanced plant tissue activity, leading to earlier bud sprouting compared to the poly house. Improved utilization of stored carbohydrates and nutrients, aided by growth regulators, may have further reduced the time to sprouting (Kaur and Singh, 2022) and the cell division in the presence of IBA resulting in quick callus formation (Singh and Attri, 2000).

Sprouting percentage

Fig cuttings in shade house recorded maximum sprouting percentage (66.27%) compared to poly house. Among treatments, (T_{17}) recorded the highest sprouting percentage (76.66%) followed by T_{15} (73.33%). Though the interaction between growing conditions and treatments was non-significant. The buildup of carbohydrates and other root-forming substances, along with high callus formation, can trigger earlier bud opening. Auxins at optimal doses enhance the hydrolysis and translocation of carbohydrates and nitrogenous compounds to the base of the cuttings, promoting faster cell division, elongation and higher sprouting percentages (Singh and Chouhan, 2016).

Number of leaves per cuttings

Fig cuttings recorded the highest number of leaves per cutting in shade house (7.47) compared to poly house. Among treatments, (T_{17}) recorded the highest number of leaves per cutting (10.96) followed by T_{15} (8.70). The interaction (G_1T_{17}) resulted in maximum number of leaves per cuttings (13.40) followed by G_1T_{15} (11.07) and minimum (2.73) G_2T_1 at 90 days after planting. Rapid meristem growth, driven by auxins, enhances cell division, leading to stem elongation and more leaf production. This could be explained by its effect on the partitioning of assimilate from roots to leaves, as well as the greater mineral content, hormonal balance and soluble protein in foliage, in addition to the higher levels of carbohydrates and chlorophyll in leaves. This result was in conformity with the discoveries of Rolaniya and Sarvanan (2018), Malakar *et al.* (2019), Rajamanickam and Balamohan (2019) and Shahzad *et al*. (2019).

Leaf area (cm^2)

Fig cuttings recorded the maximum leaf area per cutting in shade house (144.86 cm^2) compared to poly house. Among treatments (T_{17}) recorded the maximum number of leaves per cutting (212.04 cm^2) followed by T_{15} (169.00 cm^2). The interaction of shade house with the application of I (G_1T_{17}) resulted in maximum leaf area per cuttings (244.42 cm^2) followed by G_1T_{15} (184.53 cm^2) and minimum (81.81 cm^2) in (G_2T_1) at 90 days after planting. It could be because the plants that grew quickly produced more leaf area and as vice versa, due to the increase in the number of roots, that allowed a plant to absorb more nutrients and generate larger leaves. Comparable results have been reported by Kishorbhai (2014), Devi *et al.* (2016), Kaur and Kaur (2016).

Number of shoots

Fig cuttings recorded the highest number of shoots per cutting in shade house (3.55) compared to poly house. Among treatments, (T_{17}) recorded the highest number of shoots per cutting (3.86) followed by T_{15} (3.30). The interaction effect between different growing conditions and treatments was found non-significant for number of shoots per cutting. Growth regulators like IBA boost shoot formation by promoting a strong root system, enhancing nutrient absorption. This is linked to auxin mobilization, which aids in the hydrolysis of stored nutrients into sugars, phenolics and metabolites, supporting rapid plant growth (Tanwar *et al*., 2020; Wakle *et al*., 2021).

Shoot length (cm)

Fig cuttings recorded the maximum shoot length of fig cuttings in shade house (11.01 cm) compared to poly house. Among treatments, (T_{17}) recorded the maximum shoot length of cuttings (13.73 cm) followed by T_{15} (12.11 cm). The interaction of shade house with the application of (G_1T_{17}) resulted in maximum shoot length of cuttings (16.44 cm) followed by G_1T_{15} (15.82 cm) and minimum (5.17 cm) in (G_2T_1) at 90 days after planting. Auxin, particularly IBA, enhances shoot growth by promoting cell elongation and root regeneration, influencing hormonal balance, nutrient hydrolysis and tissue differentiation. A well-developed root system, stimulated by auxin, supports efficient water and nutrient uptake, boosting shoot growth (Kumar and Singh, 2020).

Shoot diameter (cm)

Fig cuttings recorded the maximum shoot diameter of fig cuttings in shade house (0.83 cm) compared to poly house. Among treatments, (T_{17}) recorded the maximum shoot diameter of cuttings (0.88 cm) followed by T_{15} (12.11 cm). The interaction between growing conditions and different treatments was found non-significant for number of shoot diameter of fig cuttings at 90 days of planting. Shoot diameter increased most likely as a result of hormonal effects and accumulation of other internal substances and their down- ward movement. Pandey *et al*. (2003) also explained that application of IBA may have an indirect influence by enhancing the speed of transformation and movement of sugar to the base of cuttings and consequently increase in shoot diameter.

Shoot fresh and dry weight (g)

Fig cuttings recorded the maximum shoot fresh and dry weight of fig cuttings in shade house (34.71 and 14.40 g) compared to poly house. Among treatments, (T_{17}) recorded the maximum shoot fresh and dry weight of cuttings (47.28 and 22.82 g) followed by T_{15} (41.38 and 19.25 g). The interaction (G_1T_{17}) resulted in maximum shoot fresh and dry weight of cuttings (51.28 and 24.21 g) followed by G_1T_{15} (45.18 and 19.83 g) and minimum (17.98 and 9.63 g) in (G_2T_1) at 90 days after planting. Auxin application increased shoot diameter, length and number of leaves resulting in higher fresh weight of shoots. This may be because auxins increased cell permeability for nutrients and moisture, which caused cell enlargement and more plant growth. The dry weight also depends upon the fresh weight, as similar result was observed in findings of (Benedetto *et al*., 2023) in fig.

Shooting percentage

Fig cuttings recorded the maximum shooting percentage of fig cuttings in shade house (54.69%) compared to poly house. Among treatments, (T_{17}) recorded the maximum shooting percentage of cuttings (79.16%) followed by T_{15} (73.60%) and T_{14} (73.60%) and. The interaction (G_1T_{17}) resulted in maximum shooting percentage of fig cuttings (83.33%) followed by G_1T_{15} (75.00%) and G_1T_{14} (75.00%), minimum (16.66 %) in (G_2T_1) at 90 days after planting. With the application of growth regulators, the number of sprouts may have increased because of improved utilization of nitrogen, carbohydrates and other stored resources. Auxin application may have encouraged cell division and elongation by causing the breakdown and transfer of nitrogenous compounds and carbohydrates at the base of cuts (Singh *et al*., 2015). It has also been found to improve histological characteristics such as vascular tissue differentiation and callus and tissue development along with shade house condition with more humidity, optimum light intensity, temperature and low evapotranspiration favoured the shooting percentage.

Number of primary, secondary and total number of roots

Fig cuttings in the shade house recorded maximum primary, secondary and total number of roots per cuttings (8.81, 16.00 and 24.19) compared to the poly house. The treatment with (T_{17}) has recorded maximum primary, secondary and total number of roots per cuttings (14.63, 23.44 and 39.93) which was on par with T_{15} (14.40, 22.16 and 39.67). Among the interactions, (G_1T_{17}) recorded maximum primary, secondary and total number of roots (15.72, 24.11 and 43.33) per cuttings which was on par with T_{15} (15.49, 22.55 and 43.21) G_1T_{15} and minimum (3.55, 5.77 and 10.20) in (G_2T_1). The probable reason for this could be that auxin administration stimulates cell division and elongation, which in turn causes cambial cells to differentiate into root primordia. According to Husen and Pal (2007), IBA increases the number of roots per cutting by hydrolyzing polysaccharides, which gives meristematic tissues energy and, in turn, root precursors for root development. This could also be attributed to enhanced growth-promoting substances and nutrient availability, leading to improved root parameters.

Table 1 : Effect of growing conditions, different treatments and their interactions on days for first sprouting, sprouting per cent, number of number of leaves, leaf area, number of shoots per cuttings in fig cv. Poona

Treatment (T)	Days for first sprouting			Sprouting percentage			Number of leaves per cuttings (90 DAP)			Leaf area (cm^2) 90 DAP			Number of shoots (90 DAP)		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
T_1	22.74	25.55	24.14	53.33	46.66	50.00	5.53	2.73	4.13	114.34	81.81	98.078	2.93	1.53	2.23
T_2	19.27	16.67	17.97	63.33	56.66	60.00	5.73	2.93	4.33	116.65	85.76	101.21	3.20	1.73	2.46
T_3	17.47	25.26	21.37	70.00	63.33	66.66	7.93	3.73	5.83	126.98	103.14	115.06	3.80	2.20	3.00
T_4	20.87	18.07	19.47	60.00	53.33	56.66	6.13	2.93	4.53	115.31	85.27	100.29	3.06	1.86	2.46
T_5	19.86	24.07	21.97	63.31	56.66	59.99	6.13	3.73	4.93	117.33	89.31	103.32	3.40	1.80	2.60
T_6	19.27	17.00	18.13	66.66	60.00	63.33	6.33	3.93	5.13	122.20	101.36	111.78	3.66	2.00	2.83
T_7	22.00	23.07	22.54	63.33	56.66	60.00	6.53	3.53	5.03	119.73	100.91	110.32	3.33	2.06	2.70
T_8	22.00	18.07	20.04	63.33	56.66	60.00	6.73	3.13	4.93	124.55	105.24	114.90	3.40	1.86	2.63
T_9	21.26	21.87	21.57	66.66	60.00	63.33	6.53	3.53	5.03	130.73	108.14	119.44	3.46	2.00	2.73
T_{10}	21.26	15.87	18.57	66.66	60.00	63.33	6.73	3.53	5.13	137.60	111.30	124.45	3.46	2.06	2.76
T_{11}	20.07	21.47	20.77	60.00	53.33	56.66	6.93	3.33	5.13	148.41	118.03	133.22	3.46	2.13	2.80
T_{12}	19.07	17.20	18.14	66.66	60.00	63.33	6.93	3.33	5.13	154.71	121.95	138.33	3.60	2.20	2.90
T_{13}	17.87	18.67	18.27	63.33	56.66	60.00	7.13	4.73	5.93	158.60	128.15	143.38	3.60	2.26	2.93
T_{14}	17.47	15.53	16.50	70.00	63.33	66.66	7.93	5.33	6.63	165.28	132.87	149.07	3.60	2.26	2.93
T_{15}	14.67	19.60	17.13	76.66	70.00	73.33	11.07	6.33	8.70	184.53	153.47	169.00	4.06	2.53	3.30
T_{16}	15.60	19.00	17.30	73.33	66.66	70.00	9.33	4.33	6.83	181.23	151.93	166.58	3.86	2.33	3.10
T_{17}	13.47	17.47	15.47	80.00	73.33	76.66	13.40	8.53	10.96	244.42	179.66	212.04	4.46	3.26	3.86
Mean	19.07	19.67		66.27	59.60		7.47	4.10		144.86	115.19		3.55	2.12	
	G	T	G × T	G	T	G × T	G	T	G × T	G	T	G × T	G	T	G × T
S. Em±	0.07	0.22	0.31	0.25	0.73	1.04	0.02	0.06	0.09	0.85	2.48	3.51	0.04	0.13	0.18
CD @ 5%	0.21	0.62	0.88	0.71	2.08	NS	0.06	0.19	0.27	2.61	7.61	10.76	0.13	0.40	NS

Table 2 : Effect of growing conditions, different treatments and their interactions on shoot diameter, shoot length, shoot fresh and dry weight and shooting percentage per cuttings in fig cv. Poona

Treatment (T)	Shoot diameter (cm)			Shoot length (cm)			Shoot fresh weight (g)			Shoot dry weight (g)			Shooting percentage		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
T_1	0.36	0.30	0.33	8.20	5.17	6.69	25.18	17.98	21.58	10.03	9.63	9.83	25.00	16.66	20.83
T_2	0.43	0.32	0.37	8.40	5.40	6.90	28.80	21.53	25.16	11.56	10.00	10.78	41.66	33.33	37.50
T_3	0.47	0.45	0.46	11.74	6.593	9.17	32.98	25.65	29.31	13.60	11.72	12.66	50.00	41.66	45.83
T_4	0.427	0.32	0.37	8.31	5.29	6.80	26.63	19.49	23.06	10.27	10.69	10.48	33.33	25.00	29.16
T_5	0.45	0.36	0.40	8.69	5.33	7.01	27.80	20.53	24.16	10.64	10.10	10.37	41.65	33.33	37.49
T_6	0.48	0.45	0.46	10.71	5.74	8.22	28.90	21.86	25.38	12.31	10.74	11.52	50.00	41.66	45.83
T_7	0.49	0.47	0.48	9.24	5.65	7.44	30.61	22.81	26.71	12.57	11.30	11.93	41.00	33.33	37.16
T_8	0.52	0.48	0.50	9.45	5.74	7.59	31.36	24.03	27.70	12.86	12.07	12.47	41.66	33.33	37.50
T_9	0.54	0.51	0.53	10.22	6.02	8.12	32.58	25.32	28.95	13.53	12.54	13.03	50.00	41.66	45.83
T_{10}	0.55	0.52	0.53	11.03	6.10	8.57	33.00	25.67	29.34	13.61	12.76	13.18	61.07	55.53	58.30
T_{11}	0.56	0.54	0.55	11.09	6.36	8.73	33.48	26.14	29.81	13.98	12.85	13.41	61.07	55.53	58.30
T_{12}	0.58	0.54	0.56	11.29	6.48	8.88	34.68	27.11	30.90	14.52	13.40	13.96	63.86	61.07	62.46
T_{13}	0.58	0.55	0.56	11.70	6.61	9.15	41.42	33.88	37.65	17.97	16.84	17.40	69.40	66.60	68.00
T_{14}	0.58	0.56	0.57	12.06	6.70	9.38	42.66	34.86	38.76	14.52	17.29	15.90	75.00	72.20	73.60
T_{15}	0.69	0.67	0.68	15.82	8.40	12.11	45.18	37.58	41.38	19.83	18.67	19.25	75.00	72.20	73.60
T_{16}	0.64	0.61	0.62	12.86	7.12	9.99	43.56	35.94	39.75	18.87	17.95	18.41	66.66	63.86	65.26
T_{17}	0.88	0.77	0.83	16.44	11.02	13.73	51.28	43.28	47.28	24.21	21.42	22.82	83.33	75.00	79.16
Mean	0.54	0.50		11.01	6.45		34.71	27.28		14.40	13.53		54.69	48.354	
	G	T	G × T	G	T	G × T	G	T	G × T	G	T	G × T	G	T	G × T
S. Em±	0.004	0.010	0.015	0.03	0.09	0.13	0.06	0.16	0.23	0.09	0.25	0.35	0.17	0.49	0.68
CD @ 5%	0.010	0.029	NS	0.09	0.28	0.40	0.17	0.49	0.70	0.26	0.75	1.07	0.50	1.47	2.08

Length of longest root (cm)

Fig cuttings recorded the maximum length of longest root of fig cuttings in shade house (15.56 cm) compared to poly house. Among treatments, (T_{17}) recorded the maximum length of longest root of cuttings (26.45 cm) followed by T_{15} (23.96 cm). Among the interactions (G_1T_{17}) recorded maximum length of longest root (28.41 cm) followed T_{15} (25.02 cm) G_1T_{15} and minimum (5.89 cm) in poly house with *Aloe barbadensis* 20% (G_2T_1). Increase in length of root is due to auxins stimulate elongation of roots of many species (Fitter, 2002), which amplify the histological characteristics such as vascular tissue differentiation and callus development. IBA promotes root length by influencing the synthesis of enzymes which stimulate cell enlargement (Abdel-Rahman, 2020). IBA proteins disrupt hydrogen bonds among cellulose micro fibrils which loosens cell wall and cells will ultimately elongate. Similar results were reported by Siddiqua *et al.* (2018) and Kumar and Singh (2020).

Root fresh and dry weight

Fig cuttings recorded the maximum root fresh and dry weight of fig cuttings in shade house (4.20 and 1.69 g) compared to poly house. Among treatments, (T_{17}) recorded the maximum root fresh and dry weight of cuttings (5.30 and 2.46 g) which was on par with T_{15} (4.92 and 2.26 g). Among the interactions (G_1T_{17}) recorded maximum root fresh and dry weight (6.25 and 2.83 g) which was on par with T_{15} (5.89 and 2.68 g) G_1T_{15} and minimum (1.48 and 0.28 g) in (G_2T_1). Applying auxins increases the fresh weight of roots since they are essential for the beginning and growth of roots. It is possible that a larger build-up of dry matter was brought about by an increase in the quantity and length of roots, which is why the dry weight of roots increased (Patel *et al*., 2017; Patel and Patel, 2018).

Girth of longest root (mm)

Fig cuttings recorded the maximum girth of longest root of fig cuttings in shade house (1.23 mm) compared to poly house. Among treatments, (T_{17}) recorded the maximum girth of longest root of cuttings (2.05 mm) which was on par with T_{15} (1.96 mm). The interaction was found non-significant for girth of longest root of fig cuttings. The diameter increased as planting time increased because of increased cell activity, more food being generated and photosynthesis enhanced by auxin. Similar findings have been reported by Kamboj *et al.* (2017).

Rooting percentage

Fig cuttings recorded the maximum rooting percentage of fig cuttings in shade house (51.34%) compared to poly house. Among treatments, (T_{17}) recorded the maximum rooting percentage of cuttings (71.66%) which was on par with T_{15} (71.18%). Among the interactions (G_1T_{17}) recorded maximum rooting percentage (80%) which was on par with T_{15} (79.53%) G_1T_{15} and minimum (10.00%) in (G_2T_1). According to Hartmann *et al.* (2011), IBA stimulates rooting by enhancing root initiation, quantity, length, and diameter. Auxin works with phenolic compounds to facilitate early root development and improve nutrient translocation, leading to better root growth and enhanced shoot characteristics.

Table 3 : Effect of different growing conditions, treatments and their interactions on number of primary roots, number of secondary roots, total number of roots, length of longest root and girth of longest root of fig cutting in cv. Poona

Treatment (T)	Number of primary roots			Number of secondary roots			Total number of roots			Length of longest root (cm)			Girth of longest root (mm)		
	G_1	G_2	Mean	G_1	G_2	Mean	G_2	G_1	Mean	G_1	G_2	Mean	G_1	G_2	Mean
T_1	4.61	3.55	4.08	7.34	5.89	7.34	11.86	10.20	11.03	7.34	5.89	6.61	0.73	0.64	0.69
T_2	5.66	4.55	5.11	7.52	6.07	7.52	13.60	12.00	12.80	7.52	6.07	6.79	0.76	0.67	0.72
T_3	8.72	5.55	7.13	12.22	10.77	12.22	20.60	19.00	19.80	12.22	10.77	11.49	1.13	0.98	1.05
T_4	4.72	4.55	4.63	10.42	8.97	10.42	14.20	12.60	13.40	10.42	8.97	9.69	0.79	0.67	0.73
T_5	5.72	5.55	5.63	11.02	9.57	11.02	16.00	14.40	15.20	11.02	9.57	10.29	0.84	0.74	0.79
T_6	6.72	6.55	6.63	12.02	10.54	12.02	18.80	17.20	18.00	12.02	10.54	11.28	1.14	0.98	1.06
T_7	5.72	5.55	5.63	12.42	10.90	12.42	17.60	16.00	16.80	12.42	10.90	11.66	1.17	1.04	1.11
T_8	6.72	6.55	6.63	12.62	11.10	12.62	19.00	17.40	18.20	12.62	11.10	11.86	1.17	1.01	1.09
T_9	6.72	7.55	7.13	13.82	12.30	13.82	22.40	20.80	21.60	13.82	12.30	13.06	1.17	1.01	1.09
T_{10}	7.72	8.55	8.13	14.22	12.64	14.22	24.40	22.80	23.60	14.22	12.64	13.43	1.22	1.08	1.15
T_{11}	8.72	9.55	9.13	15.02	13.50	15.02	25.60	23.80	24.70	15.02	13.50	14.26	1.25	1.11	1.18
T_{12}	9.72	7.55	8.63	15.82	14.24	15.82	26.66	24.60	25.63	15.82	14.24	15.03	1.27	1.13	1.20
T_{13}	10.72	7.55	9.13	21.82	19.77	21.82	28.60	25.60	27.10	21.82	19.77	20.79	1.28	1.14	1.21

T_{14}	12.72	8.55	10.63	22.02	19.90	22.02	31.20	27.80	29.50	22.02	19.90	20.96	1.28	1.10	1.19
T_{15}	15.49	13.3	14.40	25.02	22.90	25.02	43.21	36.14	39.67	25.02	22.90	23.96	2.08	1.84	1.96
T_{16}	13.72	9.55	11.63	22.82	20.70	22.82	34.20	31.06	32.63	22.82	20.70	21.76	1.43	1.24	1.34
T_{17}	15.72	13.55	14.63	28.41	24.50	28.41	43.33	36.53	39.93	28.41	24.50	26.45	2.17	1.92	2.05
Mean	8.81	7.54		15.56	13.78	15.56	24.19	21.64		15.56	13.78		1.23	1.08	
	G	T	G × T	G	T	G	G	T	G × T	G	T	G × T	G	T	G × T
S. Em±	0.02	0.07	0.10	0.05	0.14	0.05	0.05	0.16	0.22	0.05	0.14	0.20	0.02	0.05	0.07
CD @ 5%	0.07	0.22	0.32	0.15	0.43	0.15	0.16	0.48	0.67	0.15	0.43	0.61	0.05	0.16	NS

Table 4 : Effect of different growing conditions, treatments and their interactions on root fresh and dry weight, rooting percentage and survival percentage of fig cutting in cv. Poona

Treatment (T)	**Root fresh weight (g)**			**Root dry weight (g)**			**Rooting percentage**			**Survival percentage**		
	G_1	**G_2**	**Mean**	**G_1**	**G_2**	**Mean**	**G_1**	**G_2**	**Mean**	**G_1**	**G_2**	**Mean**
T_1	1.99	1.48	1.73	0.65	0.28	0.46	23.33	10.00	16.66	31.23	21.40	26.31
T_2	2.59	1.86	2.23	0.84	0.40	0.62	26.66	13.33	20.00	42.03	37.50	39.76
T_3	3.53	2.75	3.14	1.19	0.98	1.09	50.00	36.66	43.33	57.10	47.30	52.20
T_4	3.36	2.54	2.95	1.13	0.53	0.83	30.00	16.66	23.33	45.00	37.50	41.25
T_5	3.49	2.44	2.96	1.14	0.63	0.89	33.32	20.00	26.66	47.08	37.50	42.29
T_6	3.99	2.76	3.37	1.46	0.93	1.19	46.66	33.33	39.99	51.40	55.53	53.46
T_7	3.29	2.31	2.80	1.15	1.05	1.10	43.33	30.00	36.66	47.10	41.00	44.05
T_8	3.79	2.63	3.21	1.27	1.12	1.20	46.66	33.33	40.00	47.10	37.50	42.30
T_9	4.09	2.82	3.46	1.40	1.15	1.28	53.33	40.00	46.66	50.00	41.63	45.81
T_{10}	4.39	3.01	3.70	1.65	1.19	1.42	56.66	43.33	50.00	51.66	50.00	50.83
T_{11}	4.66	3.20	3.93	1.85	1.24	1.54	60.00	46.66	53.33	55.53	47.86	51.70
T_{12}	4.99	3.40	4.19	2.10	1.27	1.68	60.00	46.66	53.33	55.00	55.53	55.26
T_{13}	5.19	3.52	4.36	2.28	1.42	1.85	56.66	43.33	50.00	57.83	54.06	55.95
T_{14}	5.39	3.65	4.52	2.47	1.62	2.04	63.33	50.00	56.66	61.86	63.10	62.48
T_{15}	5.89	3.95	4.92	2.68	1.84	2.26	79.53	62.83	71.18	69.56	64.26	66.91
T_{16}	5.68	3.91	4.79	2.57	1.74	2.15	63.33	53.33	58.33	68.20	60.00	64.10
T_{17}	6.25	4.35	5.30	2.83	2.10	2.46	80.00	63.33	71.66	75.00	66.66	70.83
Mean	4.20	2.98		1.69	1.15		51.34	37.81		53.68	48.13	
	G	T	G × T	G	T	G × T	G	T	G × T	G	T	G × T
S. Em±	0.04	0.13	0.18	0.01	0.03	0.04	0.20	0.60	0.83	0.17	0.50	0.70
CD @ 5%	0.13	0.39	0.54	0.03	0.09	0.12	0.61	1.80	2.55	0.50	1.47	2.08

Survival percentage

Fig cuttings recorded the maximum survival percentage of fig cuttings in shade house (53.68%) compared to poly house. Among treatments, (T_{17}) recorded the maximum survival percentage of fig cuttings (70.83%) followed by T_{15} (66.91%). Among the interactions (G_1T_{17}) recorded maximum survival percentage (75.00%) followed by T_{15} (69.56%) G_1T_{15} and minimum (21.40%) in (G_2T_1). The increased survival rate of treated cuttings is likely due to enhanced root and shoot growth. IBA promotes root development, increasing root number and length, which improves water and nutrient absorption, leading to higher survival rates. (Singh and Chouhan, 2016). Similar results were reported by Kaur and Kaur (2016) and Kumar and Singh (2020).

Synergetic effect of *Aloe vera* and *Ficus benghalensis*

The positive interaction between *Aloe vera* and *Ficus benghalensis aerial* root extract resulted in maximum number of primary roots, secondary roots, total number of roots, root fresh weight, root dry weight, girth of longest root and rooting percentage, are might be due to *Aloe vera* extracts contain nutrients, vitamins, enzymes, amino acid and sugars, as well as plants sterols, gibberellins, and salicylic acid (Dagne *et al*., 2000) and *Ficus benghalensis* aerial root extracts contains flavonoid, auxin, saponin, steroid, triterpenoids, glycosides, tannins and phenols (Mazumder *et al*., 2018), which are associated with improvements of root growth. Dunsin *et al*. (2014) recommended using of organic substance to boost root growth instead of rooting hormone. The plant extracts high levels of phenols and auxin function as an auxin co-factor to encourage adventitious root development.

The main role of phenolic compounds in adventitious root formation is hypothesized to be in protecting the rooting inducer endogenous auxin IAA from being destructed by peroxidase, which can act as an IAA oxidase (De-Klerk *et al.*, 2011, Izadi *et al.*, 2016). This auxin's synergistic relationship with exogenous auxin results in the manufacture of ribonucleic acid, which in turn induces the primordial root (Hartmann *et al.*, 2002). Similar outcomes showed that *Aloe vera* and IBA treatments had a significant impact on root attributes overall, including longest root length, number of roots per cutting, number of acrobasal roots, root diameter, total length of root, and fresh and weight of pomegranate cuttings (Aryan *et al.*, 2023). The effect of natural extracts is might be due to *Aloe vera* extracts which contain nutrients, vitamins, enzymes, amino acid and sugars, as well as plants sterols, gibberellins, and salicylic acid (Dagne *et al.*, 2000) and *Ficus benghalensis* aerial root extracts contains flavonoid, auxin, saponin, steroid, triterpenoids, glycosides, tannins and phenols (Mazumder *et al.*, 2018). Wilson and Staden (1990) stated phenolics protect auxins from decarboxylation, ensuring that after their application, more auxin remains available to induce root formation thus increased the shoot growth. However, it is unlikely that decarboxylative catabolism of auxins plays a vital role in plants.

Conclusion

The study confirmed that shade house conditions significantly enhanced rooting and survival rates of fig cuttings compared to polyhouse conditions, with IBA at 3000 ppm (T_{17}) being the most effective treatment, followed by the 50% *Aloe vera* and 50% *Ficus benghalensis* aerial root extract combination (T_{15}). Future research should explore higher concentrations of *Aloe vera* and *Ficus benghalensis* extracts, test other natural extracts like coconut water, willow and moringa, standardize dipping times and assess the impact of seasonal variations and lower IBA doses in combination with natural extracts for improved fig cutting propagation. We can create the foundation for a more resilient and sustainable agricultural future by harnessing the bioactive compounds found naturally in plants. The transition to non-chemical propagation methodologies is critical for establishing healthier production systems that benefit both environmental sustainability and human health.

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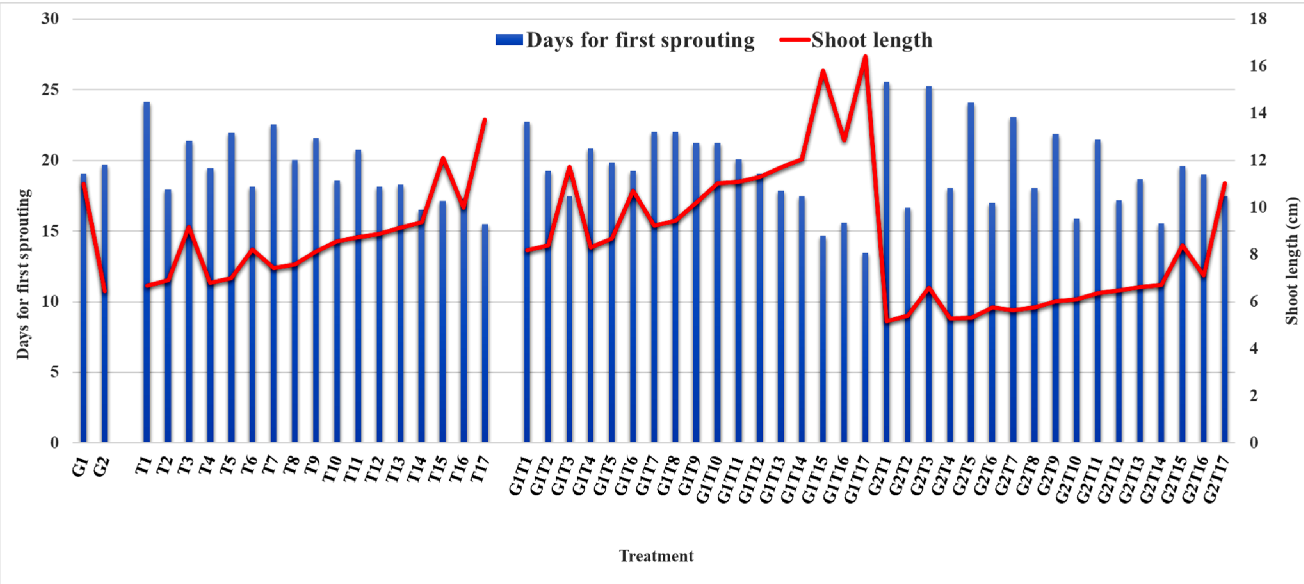


Fig. 1 : Effect of different growing conditions, treatments and their interactions on days for first sprouting and shoot length of fig cuttings in cv. Poona

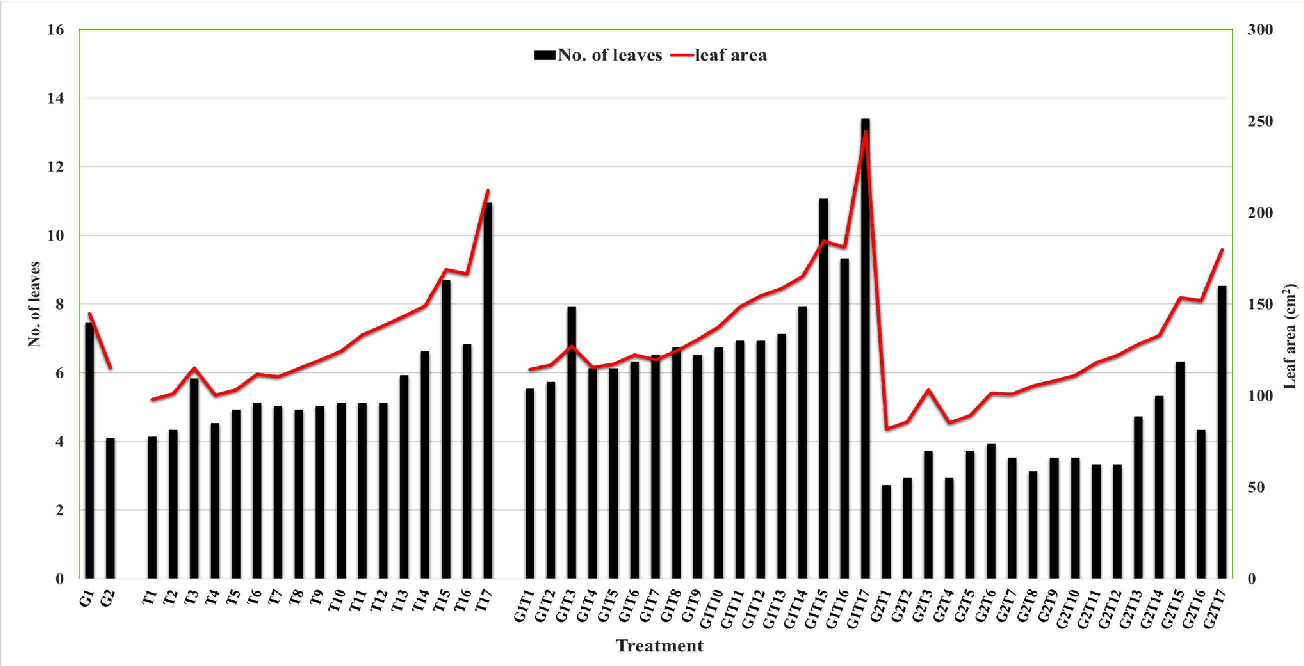


Fig. 2 : Effect of different growing conditions, treatments and their interactions on number of leaves and leaf area of fig cuttings in cv. Poona

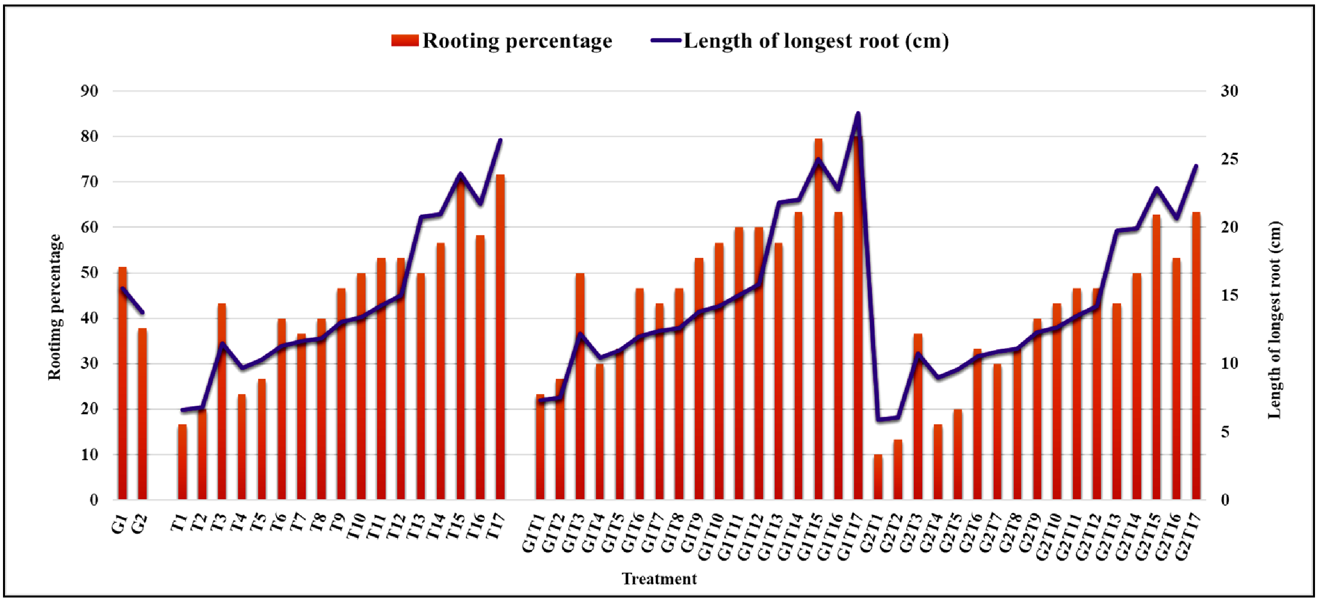
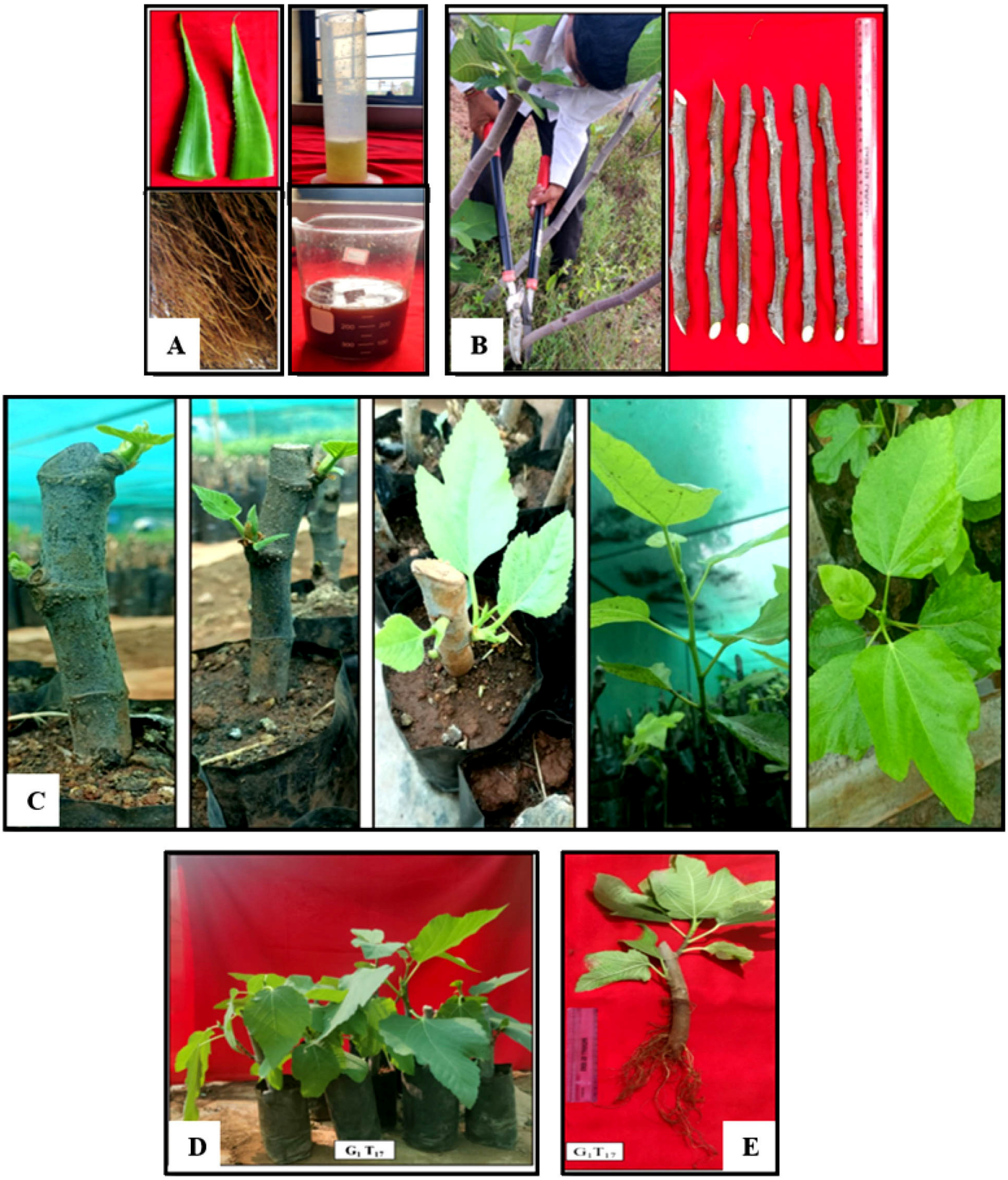


Fig. 3 : Effect of different growing conditions, treatments and their interactions on rooting percentage and length of longest Root of fig cuttings in cv. Poona



A- *Aloe vera* leaf and *Ficus bengalensis* root extracts
B- Preparation of fig cuttings
C- Stages from bud to shooting in fig cuttings
D & E- Shooting and rooting of fig cuttings under shade house conditions

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