ISSN 2664-4010 (Print) & ISSN 2664-6730 (Online)
South Asian Research Journal of Agriculture and Fisheries
Abbreviated Key Title: South Asian Res J Agri Fish

| Volume-5 | Issue-5 | Sep-Oct -2023 | **DOI: 10.36346/sarjaf.2023.v05i05.002**

Original Research Article

Influence of Shading and Anatomical Structure of the Stem Cutting on Rooting Performance of Fig (*Ficus Sp.*)

Margaret Mollick[1*], Dr. Shamim Ahmed Kamal Uddin Khan[2], Nurjahan Sultana[3]

[1]Agrotechnology Discipline, Khulna University, Khulna, Bangladesh
[2]Professor, Agrotechnology Discipline, Khulna University, Khulna-9208, Bangladesh
[3]Agrotechnology Discipline, Khulna University, Khulna, Bangladesh

***Corresponding Author:** Margaret Mollick
Agrotechnology Discipline, Khulna University, Khulna, Bangladesh

Article History
Received: 16.08.2023
Accepted: 19.09.2023
Published: 28.09.2023

Abstract: Fig (*Ficus sp*.) belongs to tropical and subtropical climates which have great potential for the commercial cultivation. Cutting is the most common and effective method of propagation for figs which is influenced by different exogenous and endogenous factors. In this light, a study was conducted to observe the responses of stem cutting of fig (*Ficus sp*.) of one exotic and two indigenous varieties (Teen- *Ficus carica;* wild fig- *Ficus hispida* and joggo fig- *Ficus racemosa*) in respect of duration of shade and anatomical status of stem. The study was laid in Completely Randomized Design (CRD) with two factors (duration of shade and cultivars) and three replications of the treatments. The four different treatments of shade duration were as T1= open or control, T2=3 days of shading, T3= 6 days of shading and T4= 9 days of shading. Data were collected on root and sprout growth of the cuttings at weekly interval from two weeks of planting the cuttings in sand filled plastic cups. When the duration of shading increased, the teen (*Ficus* carica) showed the longest sprout (1.59 mm) and root (2 mm) as well as maximum number of root (5.67) and sprout (2.33). Better rooting performance was found in teen and it was very low in wild fig. A relationship between rooting performance and anatomical structure was clearly observed in this study. Long period of shading has positive effect on number and length of sprout in teen and wild fig. On the other hand, short period of shading minimized the days required for sprouting in teen Presence of thin cuticle, thin trichome and the absence of druses crystal in ground tissue and medulla also enhanced the performance of stem cutting of teen.

Keywords: Fig, stem, shade, anatomy, cutting performance, rooting performance.

1. INTRODUCTION

One of the world's oldest fruit plants is the fig (*Ficus sp*) which is a member of the Moraceae family and the Urticales order [1]. Over 1400 species are found in the genus *Ficus sp.* which is divided into about 40 genera [2]. Figs can be grown in more humid regions, such as the tropics and subtropics, but they are typically grown in Mediterranean climates [1]. Fig is found anywhere in Bangladesh but not for commercial purposes. It grows as wild and used as vegetable in rural areas of some localities. Despite being referred to as a fruit it is technically a syconium where inverted flowers are growing inside a pod. There are hundreds of flowers in each pod, and each flower gives rise to a small seed, which is the fig plant's actual fruit [3]. It can be consumed fresh, dried, or preserved, and they are frequently used to make jam. As a nutritious fruit, figs are high in calories, proteins, calcium, iron, and fiber [1]. As a source of food for people, it has undoubtedly of utmost importance [2]. Figs have been well known not only because of their better taste but also because of their medicinal values [4]. According to Washburn and Brennand [5], the Greeks valued the fig as "more precious than gold" more than two thousand years ago. Fig tree is also significant in religious aspects [6]. It is tolerant to most soil types and can be grown even in the coastal areas [7]. In Bangladesh, fig tree is found in Khulna also as it is coastal area. According to Banglapedia [8], and Pasha and Uddin [9], Bangladesh's monsoon season (March to May) is ideal for fig production. The most lag period for fruits in this country is November to May [10]. Fig trees produce fruit throughout the year [2], and claimed by [11], figs tolerate moderate salinity. It can withstand in salinity up to 10 dS/m and can give acceptable yield [12]. The environment and soil type of Bangladesh is suitable for cultivation and [2], suggested that it might be a good fruit crop in Bangladesh. However, a better or suitable method of its propagation is yet to be explored. Propagation of fig can be occurred both sexually by seed and asexually by utilizing specialized vegetative structures of the plant or by employing such techniques as cutting, layering, grafting, and tissue culture [13]. Commercially, the propagation method by cutting is still the most used for this crop [14- 16]. The demand for fig seedlings is currently on the rise, but the main problem is that there is insufficient production of fig seedlings which causes lower production of fig [17]. Shamsuddin *et al.,* also claimed that stem cutting can be utilized for propagation since it can help with large-scale production. There are different types of article found on the effect of various factors on the responses and rooting performance of stem cutting. Dias *et al.,* [18], told that cuttings with larger diameter values have more carbohydrates stored within them, which led to improved shoot development. A variety of factors such as hormone, fertilizer, rooting media, cutting type, cutting time, climate, growing environment (shading), internal structure (anatomy of stem) etc [19]. Also influence the performance of stem cuttings. The stem cuttings when grown under shade showed significantly earliest sprouting, highest survival shoot and root growth of stem cutting [20]. Relationship between shade on cutting and anatomy of stem has significant effect on the responses of cutting and rooting performance of fig. Shade has impact on days required for sprouting, number and length of sprout, number and length of root [21]. Different anatomical characteristics such as trichome, cuticle, druses crystal, pith, and medulla also influence the rooting performance of stem cutting [22]. There are a number of works already have been done on the shading effect and anatomical structure of different plant species, however, the scarce of relevant information relating the fig warrants a detailed study. In this regard, a study was conducted to observe the effect of duration of shade and anatomical structures of fig stem on rooting performances of its cuttings.

2. MATERIALS AND METHODS

The experiment was conducted to observe the effect of shade duration on responses of cutting and rooting performance by using the stem cutting of teen (*Ficus carica*) and two indigenous cultivar; wild fig (*Ficus hispida*) and joggo fig (*Ficus racemosa*). Additionally the relationship of stem anatomy and shade duration was also observed on the performance of the cuttings. The methodology followed and materials used in this study have been described in this chapter.

2.1 Experimental Site and Period of Study

The Experiment was conducted at the Prof. Dr. Purnendu Gain Field Laboratory, Agrotechnology Discipline, Khulna University, Khulna from February to May, 2022.

2.2 Collection and Preparation of Plant Material

Stem cuttings of wild fig (*Ficus hispida*), joggo fig *(Ficus racemosa*) and teen fruit (*Ficus carica*) were used as the plant material in this study. In total 180 stem cuttings were used including 60 stem cutting of each cultivar.

2.2.1 Stem Cutting Preparation

Stem cuttings with 2-3 nodes were used in this experiment. A slanting cut was given in proximal end for planting in sand or virgin media. Those stem cuttings were around 17 cm in length and 4 mm in diameter. It was measured by using measuring tape.

2.2.2 Location of Cutting Collection

Cutting of wild fig and joggo fig were collected from healthy mother plant from Prof. Dr. Purnendu Gain Field Laboratory. Teen cuttings were collected from farmers' field of Botiaghata upazila, Khulna.

2.3 Preparation of Rooting Media and Planting of Cutting

Only sand or virgin media was used as the rooting media. The media was taken in plastic cup of medium sized (10.6 cm long) by keeping one-third of the cup empty. Before placing the cutting in the cup, all the cuttings were rinsed into fungicide named Cluster (Wp) (05g in 2L) for 30 minutes in a bucket. The cuttings were allowed to dry and then placed in the media. After, 1 month of sowing of cutting, the sand media was changed and filled all of the cups with 100% cocopeat. Cocopeat was collected from Green Globe Nursery, Nirala, and Khulna.

2.4 Experiment Details

2.4.1 Treatments

Black plastic polythene sheet was used as a shade material on the cup. Four treatments; T1= open, T2=3 days of shading, T3= 6 days of shading and T4= 9 days of shading were there in respect of maintaining shade by using black plastic polythene sheet. The cuttings were placed in the cups on February, 2022. The media was changed in the cup and filled with cocopeat on April during recording the rooting performance. The cuttings were finally kept in the cocopeat media.

2.4.2 Design of Experiment

Completely Randomized Design (CRD) was followed in this study with three replications for each shade treatments. However each of the replications for the treatments included five cuttings setted in five separated cups. As a result, each of the treatment contains 45 (3×15) cups of three varieties under four shade conditions. So total numbers of cup in this experiment were 180 (45×4).

2.5 Intercultural Operations

Watering to pots was done at two days interval and the excess water was drained out through the hole below the cup.

2.6 Collection of Data

Data were collected on the following parameters for three days during March- April 2022 at an interval of 7 days.

2.6.1 Days Required for Sprouting

The data of required days for sprouting from a cutting was noted as the days from the date of placing the cutting on rooting media to the date of sprout initiation.

2.6.2 Number of Sprout

The sprout number was counted by visual observations. The little new green spouts were also taken in considerations to count the number of sprouts.

2.6.3 Sprout Length

A measuring tape was used to measure the length (mm) of the sprout. New little green sprouts were also taken in account.

2.6.4 Number of Root

Root number was counted for once on April 11, 2022 while changing the rooting media from sand to cocopeat. It was counted after 45 days of placing the cuttings in media.

2.6.5. Root Length

Root length was measures carefully in "mm" scale. It was measured from the base to the tip of the root.

2.7 Anatomy of Stem

2.7.1 Location and Date of the Study

The experiment on anatomy of teen stem was conducted during October 2022 at plant protection laboratory, Agrotechnology Discipline, Khulna University, Khulna, Bangladesh.

2.7.2 Materials Needed for the Study

Stem cutting of three varieties, slide, glass jar, blade, needle, compound microscope, formalin-aceto-alcohol (FAA) solution were used to prepare stem slice for observation of anatomical structure.

2.7.3 Preparation of Stem Sample

Stem samples from teen species were used in the anatomical studies. After cleaning with distilled water, the samples were fixed by using formalin-aceto-alcohol (FAA) solution (formalin: glacial acetic acid: alcohol at 5:5:90), and then stored in a glass jar with an airtight lid [23].

2.7.4 Slide Preparation for Anatomical Study

Soft wooded 2-3 stock stems were taken and section of stem samples was done by sterilized blade using hands [24]. Then thin sections of stem sample were taken to the slide for observations. One drop of water mixed with glycerin was added on the thin sliced stem. After that a cover slip was added on the sample. Excess water was wiped off from the bottom of the slide. Then the slides were placed on the microscope carefully. Careful observations were made on epidermal hair or trichome, cuticle, druses crystal, xylem cluster, pith, medulla, leptocentric bundle etc.and photographs of microscopic view of stem samples were taken [6], for interpreting the relationship between anatomical structure and performance of stem cuttings.

2.8 Statistical Analysis

Analysis of variance was used to determine the variations between cultivars and the treatments. The Duncan's multiple range test (DMRT) was used to compare the mean values ($P < 0.05$). The statistical software named as Statistical Tools for Agricultural Research (STAR) was used to analyze data statistically [25].

3. RESULT AND DISCUSSION

The study was conducted on the rooting performance of stem cutting of three fig species in response to the period of shading and stem anatomy. A relationship between the anatomical structure of stem cutting and rooting performance has been tried to draw here. The findings from current study have been presented in table and figures and discussed in this chapter under different headings and sub headings.

3.1 Effect of Shade Period on Rooting Performance of Stem Cutting of Fig

The findings from the study were discussed on the parameters as day required for sprouting, number of sprouts, sprout length, number of roots, root length and the anatomical characteristics of stem. The joggo fig did not survived and thereby no data of this fig have been presented and discussed here in this chapter.

3.1.1 Days Required for Sprouting

Stem cutting of teen (*Ficus carica*) showed 1.89 days early sprouting while 9 days shading (T4) was maintained. The cutting under 6 days shading also showed 0.55 days earlier sprouting than the cutting left under 3 days shading (7.55) (Fig 3.1). The results from the current study show positive effect of longer shading on sprouting in cutting of teen. Ruchi and Handa [26] reported the effect of the level of shading and recorded early sprouting in the cutting while they were left under 35% of continuous shading.

On the other hand, the indigenous or wild fig showed an opposite response to the shade treatment. Here longer period of shading (e.g. 9 days in T4) delayed the sprouting from the cutting. It was found that the cutting under 9 days shading showed sprouting after 5.6 days of sprouting in the cutting under 3 days of shading where it needed only 2.1 days for sprouting. There were noticed dissimilarities between teen and wild fig in the case of shad effect (Fig 3.1).

Full sun and shading condition was comprised on each sampling day for eucalyptus cutting. On the first day, referring to the first evaluation, it was observed that full sun promoted positive effects over all studied variables; and on second and third days, shading had positive effects too [27]. But Teen showed the positive effect in 6 and 9 days of shading and delayed sprouting in open sunlight.

This difference in finding might be due to the differences in crops species. However, Khan *et al.,* [28] explained that shaded plants are less sensitive to infections than etiolated ones and take less time to acclimate to full ambient light condition. This findings of Khan *et al.,* [28], supports the findings from current study.

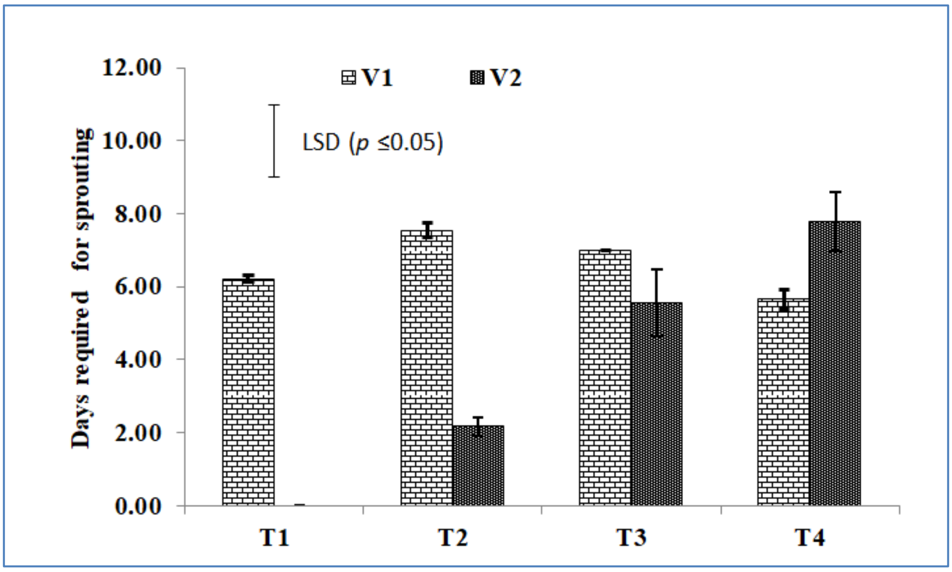


Fig 3.1: Days required for sprouting due to the effect of Shade treatment

T1= without shading, T2 = 3 days of shading, T3= 6 days of shading, T4= 9 days of shading; V1= Teen, V2= Wild fig

3.1.2 Number of Sprouts

Sprout number was significantly affected by the shade treatment for teen and wild fig. There was significant difference among the treatments in this regard. Highest sprout number of sprouting was counted as 2.33 in T3 for teen. T3 and T1 treatments showed the better result. It was noticed that shading for short (3 days) and long duration (9 days) showed minimum sprouts and medium shade duration (6 days of shading) gave better result (Fig 3.2).

In wild fig, no sprouts were noticed in un-shaded cutting though maximum number of sprout was found in 9 days shaded cutting. The number of sprouts was favored by the long duration of shade period (Fig 3.2).

Sprout size and number are determined by the plant's metabolic processes and uptake of photosynthates [29]. Leaf sprout growth on cuttings is strictly controlled by external and internal factors. External factors are environmental factors which includes temperature and sunlight,[30] and internal factors are plant factors including genetics, auxins, cytokinins, number of bud nodes, and content in stem tissue [31] Teen performed well in number of sprouts than wild fig.

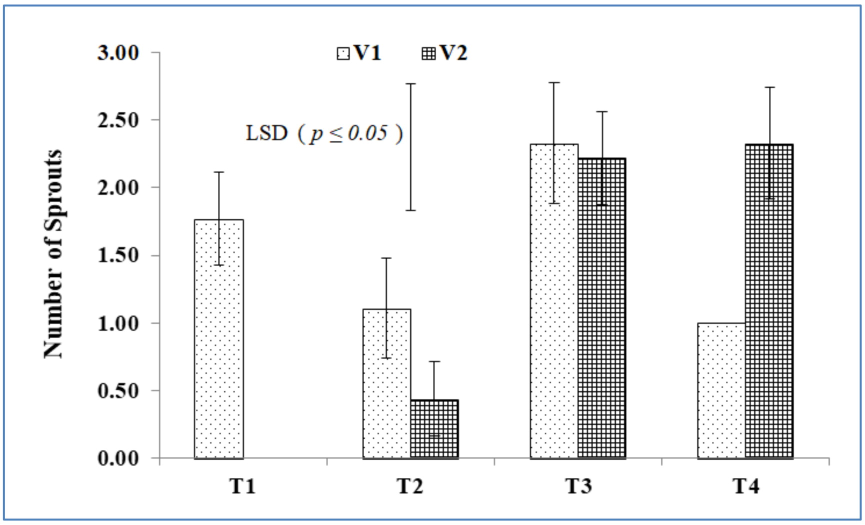


Fig 3.2: Number of sprouts of two varieties of fig due to the effect of Shade treatment
T1= without shading, T2 = 3 days of shading, T3= 6 days of shading, T4= 9 days of shading: V1= Teen, V2= Wild fig

3.1.3 Sprout Length

In case of teen variety, the 4 treatments differed non-significantly though longer sprout was observed in teen with 6 days of shading while the stem cutting of wild gave longer sprout with T4. It was found that the length of leaf sprout was not much influenced by the duration of shading in case of teen. However, in the wild fig, sprout length was observed as maximum (1.64 mm) in T4 and minimum T1 and T2 as no sprouts were there in T1 and T2. In both of the varieties, T4 showed better length of sprouts (Fig 3.3).

According to Wu *et al.*, [32], the decreased leaf size caused by shade was largely attributable to cell proliferation in young leaves and both cell proliferation and enlargement in old leaves. Shade induced the expression of a set of genes related to cell proliferation and/or enlargement, but depended on the developmental stage of leaf. Shade significantly increased the auxin and gibberellin content, and significantly decreased the cytokinin content in sprouts. Taken together, these results indicated that shade inhibited leaf size by controlling cell proliferation and enlargement where auxin, gibberellin and cytokinin may play important roles. Though teen and wild fig responded well under long period shade conditions.

According to Safeer *et al.*, [33], single-node (3.0 cm long) stem cuttings planted under a 50% continuous shading survived and sprouted. Stem cuttings showed significantly higher survival rates under shade net conditions. Though they observe longer shoots and better growth performance under open sunlight. The findings from current study also showed better performance of the stem cutting in respect of survival ability and rooting while the shade maintained for a moderate period of time as 6 days (Table 3.1).

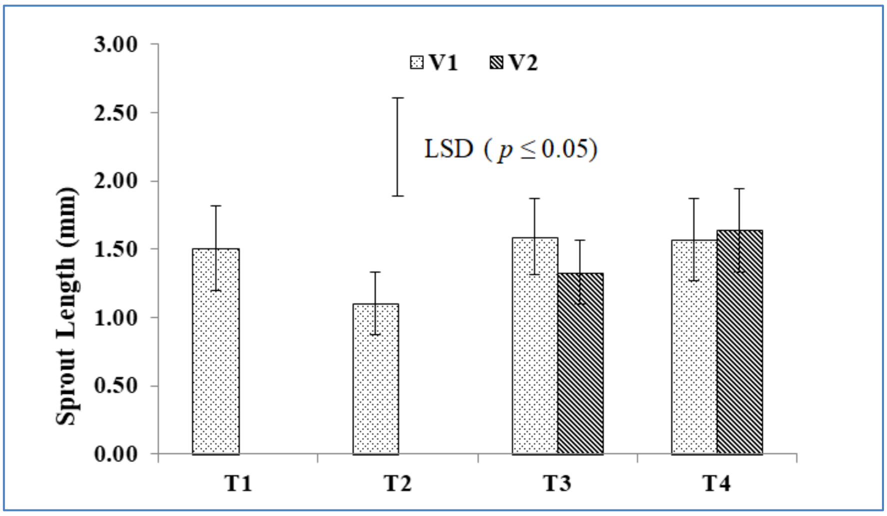


Fig 3.3: Sprouting length of two varieties of fig due to the effect of Shade treatment
T1= without shading, T2 = 3 days of shading, T3= 6 days of shading, T4= 9 days of shading; V1= teen, V2= Wild fig

Table 3.1: Sprouting performance of two varieties of fig due to the effect of Shade treatment

Variety	Treatments	Number of Sprouts	Sprout length (mm)
V1= Teen	1.	1.78 ab	1.51 a
	2	1.11 b	1.10 a
	3	2.33 a	1.59 a
	4	1.00 b	1.57 a
V2= Wild fig	1	0.00 b	0.00 b
	2	0.44 b	0.00 b
	3	2.22 a	1.33 a
	4	2.33 a	1.6411 a
LSD ($p \leq 0.05$)		0.95	0.72

Note: Means with the same letter are significantly similar.

3.1.4 Number of Root

Root number was counted only in teen (*Ficus carica*) (V1). Wild fig (V2) failed to produce root or the roots were too small to count. Teen cutting under T1 treatment showed no roots and the cuttings died earlier. In case of other treatments, an average of 5.6 roots was observed without any significant difference among the treatments. However, higher number of rooting was observed in the cutting where shading was maintained for longer periods (Table 3.2).

There was similar report observed in Maynard and Bassuk [34] where percent rooting increased proportionally to the degree of shading, with a maximum response at 95% shade. At 95% shade and 3.7 mm Indole-3-butyric acid, auxin concentration correlated with shading to produce the highest rooting percentage as well as the highest root counts and lengths.

Table 3.2: Rooting performance of teen *(Ficus carica*) due to the effect of Shade treatment

Treatments	Number of Roots	Root length (mm)
1	0.00 b	0.00 b
2	5.44 a	1.31 a
3	5.67 a	2.00 a
4	5.56 a	1.29 a
LSD	0.92	0.88

Note: Means with the same letter are significantly similar.

3.1.5 Root Length

The T3 showed long of roots in teen than other three treatments. But the cutting under different period of shading differed significantly with the unshaded cutting in respect of root length (Table 3.2).

Similarly, when grown in shade, the stem cuttings showed the earliest sprouting as well as the highest survival and shoot and root growth. However, when stem cuttings were grown in an open environment, poor survival and sprout and root growth were observed [20]. In findings of the study, T1 showed the poor or no result of rooting while long period shading showed better performance on root number and length.

3.2 Anatomical Study on Fig Stems

The findings of the anatomical structure of figs (teen, joggo and wild) have been presented in tables (Table 3.3 and 3.4) and plates followed by discussion to explore the relationship of anatomical structure and the rooting performance of the stem cutting.

Table 3.3: Anatomical characteristics of stem of three fig species of the stem cuttings

SL. no	Characteristics	Wild fig (*F. hispida*)	Joggo fig (*F. racemosa*)	Teen (*F. carica*)
1	Epidermal hair of trichome both thick and thin (+) or thin (-)	+	+	_
2	Epidermal cuticle thick (+) or thin (-)	+	+	_
3	Leptocentric bundle present (+) or absent (-)	_	_	+
4	Druses crystal in ground tissue present (+) or absent (-)	+	+	_
5	Number of xylem cluster	7	8	9
6	Medulla present (+) or absent (-)	+ (smaller)	+ (larger)	_

Table 3.4: Some similarities of anatomical structures among the three fig species

SL. no	Charateristics	Wild (*F. hispida*)	Joggo (*F. racemosa*)	*Teen* (*F. carica)*
1	Sclerenchyma cells present (+) or absent (-)	+	+	+
2	Druses crystal in pith present (+) or absent (-)	+	+	+
3	Xylem present as single (+) or clusters (-)	_	_	_
4	Cortex present (+) or absent (-)	+	+	+

Anatomical structural difference were found in some parameters such as epidermal hair or trichome, cuticle, leptocentric bundle, number of xylem cluster, druses crystal in ground tissue, medulla or cavity. There were also some similarities found in sclerenchyma cells, druses crystal in pith, Cortex, Xylem etc.

Epidermal layer may be a key defense against biotic and abiotic stresses. Laanisto and Niinemets [35], reported shade as a abiotic stress. From the current study, it was also observed that the longer shade period enhanced sprouting in teen while rooting was delayed in short period of shading. Such circumstance signifies its ability to its adaptive capacity in abiotic stress condition which is related to its epidermal layer as described by Ali *et al.,* [36].

Thick epidermal cuticle was observed in wild fig and joggo fig. On the other hand, thin cuticle was found in teen stem. In stem samples from Teen (*Ficus carica*), thin trichomes were observed. In joggo fig, a random mixture of thick and thin trichomes was also found (*Ficus recemosa*). In addition to small and thin trichomes, a lot of long and small, thick trichomes were found in wild fig (*Ficus hispida*) (Table 3.3). From the findings of the study, teen enhanced number of sprout and length observed in long period shading than in wild fig.

Sclerenchymatous cells were also present in stem of all fig species [6]. Similarly, here xylem was present both as single and clusters. Wild fig (*Ficus hispida*) stem showed the lowest amount of xylem cluster (Table 3.3). Ali *et al.,* [36], also reported variation in number of xylem clusters in several *Ficus carica* cultivars. Sprouting and rooting performance enhanced in teen in long period shading while delayed rooting in short time shading and unshaded condition. No rooting performance observed in wild fig.

Another one is leptocentric bundles which is present in the stem of *Ficus carica* only where no druses crystals were observed in ground tissue but were present in the pith (Table 3.3).

Though Ali *et al.,* [36], reported the presence of druses crystals in the ground tissue in several cultivars of *F. carica* in stems (Table 3.3), in the current study druses crystals were observed in only pith and absent in ground tissue and collateral type leptocentric bundle is present in all types of fig. On the other hand, it was seen that leptocentric bundle is absent in wild fig and joggo fig (Table.3.1). Below the epidermal layer several layers of collenchyma followed by parenchyma cells are present. This finding is also similar with the findings reported by Ali *et al.,* [36].

Cortex was observed in all three cultivars below the epidermal layer. Wide Medulla or cavity was noticed in the joggo fig and small medulla was in wild fig. There was no medulla found in teen which favored sprouting and rooting performances (Table 3.3).

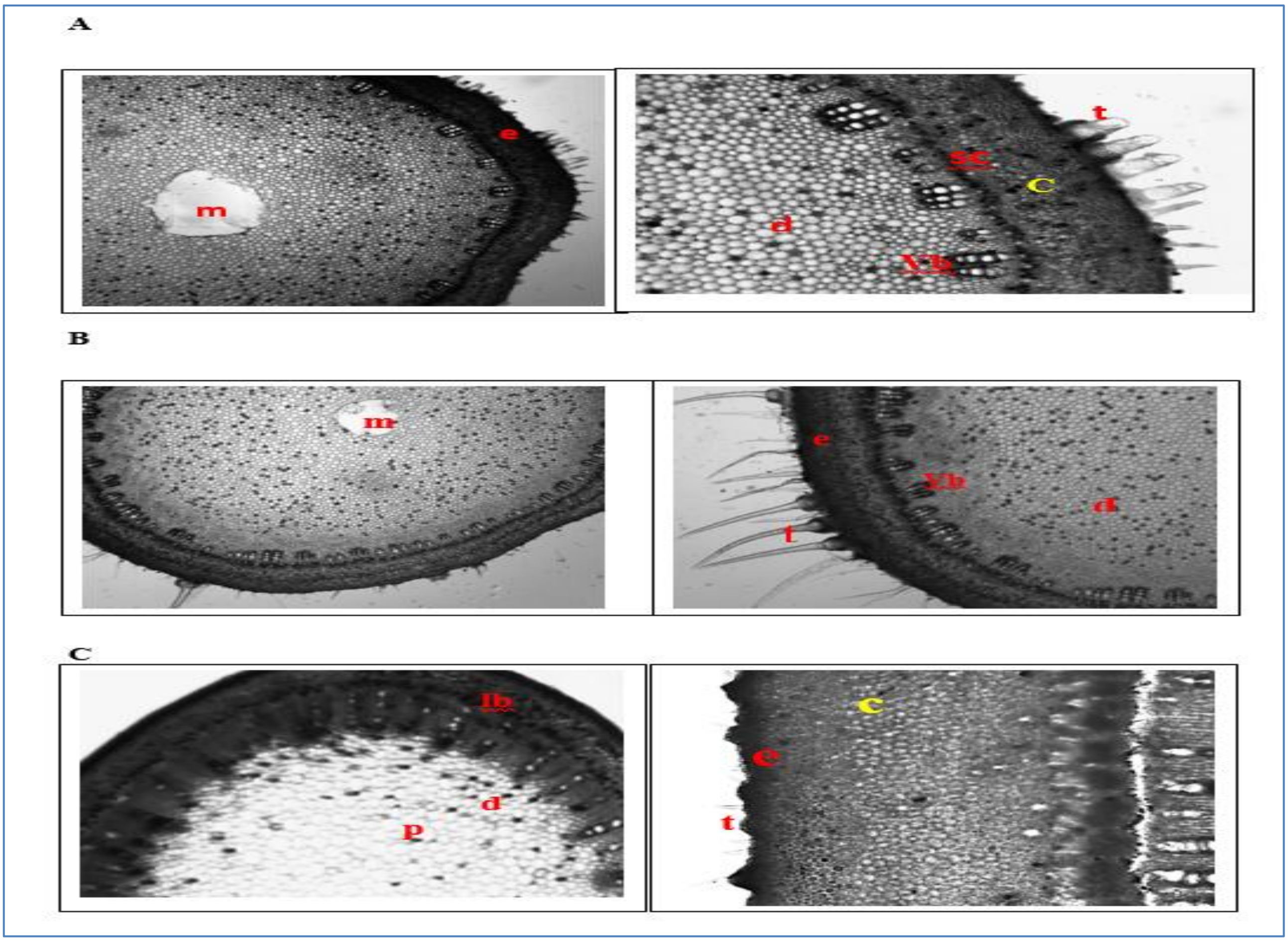


Plate 3.1: Stem anatomical structures of three fig species. A: Stem anatomy *of Ficus hispida*, B: Stem anatomy of *Ficus racemosa* C: Stem anatomy of *Ficus carica*.vb- vascular bundle, m- medulla, lb- leptocentric bundle, e-epidermis, t- trichome, p-pith, d- druses crystal, sc- sclerenchyma and c-cortex

Table 3.5: Different structural parameters of the anatomy of stem cuttings of three fig species

Characteristics	Wild *(F. hispida)*	Joggo *(F. racemosa)*	Teen *(F. carica)*
Epidermal hair or tricome	It is unicellular which enhance evaporation rate. Thus sprout number observed less than teen.	Multicellular. Thus more evaporation is occurred [37]. Sprouting is less than other two cultivars.	It is Usually absent or very few in teen. Thus less evaporation occurs. Due to small and less trichome which promotes better sprouting [37].
Epidermal cuticle	Thick cuticle supports the plants growing in dry situation. Less number of sprout observed than teen because of water loss [37].	Same as wild fig	It is found quite thin in plants with the presence of adequate water due to less evaporation [37].
Druses crystal in ground tissue	Its Presence can increase toxicity in plant. Druses crystals may function as main irritant in toxic organs of the plants [38]. Through metabolism, oxalate is metabolized very slowly or not at all in many plants. Plant crystal idioblasts may serve as a mechanism for eliminating the oxalate that would otherwise build in toxic amounts [38].	It is also Present in joggo fig. It can produce toxic qualities in plant.	It is Absent in this cultivar. Thus toxic qualities cannot produce and promote better sprouting,
Leptocentric bundle	It is absent in this cultivar.	Absence of this type of vascular bundle hamper sprouting and rooting response of stem cutting.	It is present in this cultivar. Here, Phloem lies at the center and xylem surrounds it. Adequate water and

Characteristics	Wild *(F. hispida)*	Joggo *(F. racemosa)*	Teen *(F. carica)*
			nutrient transfer to the cutting promotes early sprouting.
Medulla	Smaller medulla is present. Parenchyma tissue present where found druses crystal of calcium oxalate. Large Parenchymatous tissue extending from pith to cortex between primary vascular bundles became known as a medullary ray or pith ray [39].	larger medulla is found which inhibit the sprouting responses and rooting performance.	Medulla or cavity in the ground tissue cannot be found.
Cortex	Thick cortex delays sprouting. Cortex also contains resin-ducts, laticifers, oil cavities, sclereids etc [24].	Thick cortex present, so no sprouting.	Thin cortex. Rapid sprouting can occur.

Relationship between anatomical characteristics of stem and cutting and rooting performances have been discussed below under headings and sub headings –

3.2.1 Effect of Stem Anatomy on Days Required for Sprouting

From T2 to T4, the days require for sprouting is decreased. T4 showed the minimum day requirement for sprouting and given better performance in rooting in T3 and T4 (Fig. 3.1).

Thick cuticle was responsible of late sprouting such as in wild fig. On the other hand, Thin cuticle was observed to promote early sprouting in teen (V1) [37] (Table 3.5).

Thin cortex could also be responsible for early sprouting in case of teen. Wild fig have shown thick cuticle in the epidermal layer where the sprouting delayed (Table 3.5).

Besides, epidermal hair or trichome was absent or very thin in teen. As transpiration happens through trichome, so the presence on thin layer of trichome reduces evaporation of water from the cutting and promotes sprouting [37] (Table 3.5).

3.2.2 Effect of Stem Anatomy on Number and Length of Sprout

Thick epidermal hair or trichome observed in the wild and joggo fig but thin in teen cultivar. Trichomes are generally divided into single-celled or multicellular, branched or unbranched, and glandular or non-glandular based on different characteristics and functions [40]. Due to the presence of trichomes, the epidermis becomes thicker and has a higher concentration of long-chain fatty acids than other epidermal cells, which helps to control temperature and lessen evaporation [40], (Table 3.5). Number of sprout was counted less in wild fig than in teen. In case of teen; less evaporation occur due to small and less trichome promotes better sprouting. It favored the sprout length there. On the other hand, in teen, was noticed increasing length in T3 [37]. The shading may influence sprouting behavior by resisting the water loss from stem cutting) (Table 3.5).

In wild and joggo figs, the epidermal cuticle was thick while teens had a thin layer. It is quite thin in teen and causes little water loss [37]. A thin cuticle layer aids in water supply to the plant. Therefore, teen has a better response on sprouting than the other two cultivars (Flowchart 3.4 B). As a result, teen have a better sprout length result in shading than wild figs (Flowchart 3.4 A). In T3, sprout length is observed more than in the wild.

Druses crystal is present in the pith of all three cultivars but is absent in the ground tissue of teen. Druses crystals may be the primary irritant in plant toxic organs [38], (Fig. 3.4 B). Its presence in the ground tissue of wild and joggo figs has reduced sprouting, but it was increased in teen. Besides, sprout length also noticed more than in the wild as a result of 6 and 9 days of shedding (Flowchart 3.4 A). More sprout length was also observed in teen at T1 and T2 but not in wild fig**.**

The medulla or cavity was observed in the wild and joggo varieties because calcium oxalate is found there but was absent in the teen variety. Ground tissue was observed to be devoid of druses crystals in teen. So teen sprouted better than the other two varieties (Flowchart 3.4 B). The thin cortex layer observed in teen which aids in evaporation and photosynthetic activities, as the cortex's outermost layer contains chloroplasts. The cortical cells of the stem have been found to be smaller than those of the hypocotyl as seen in transverse sections [41], (Table 3.5). The sprout length was longer and number was more in the teen was also longer than in the wild fig in long period of shading. No sprout number was counted in wild fig at un-shaded condition (Flowchart 3.4 A).

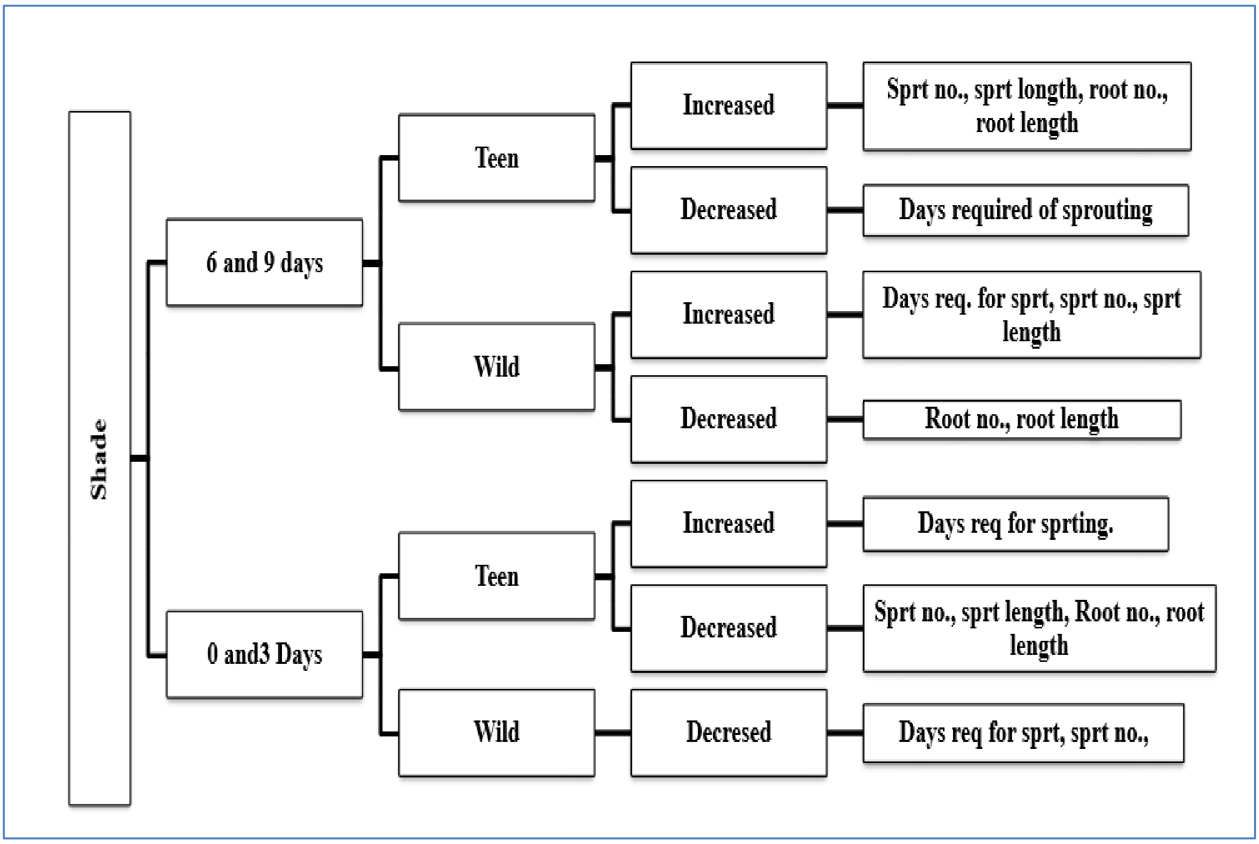
3.2.3 Effect of Stem Anatomy on Number and Length of Root from Cutting

Adventitious root initiation from the cambial region has been reported for many plants [42]. According to Lionakis [43], a new xylem ring is normally formed in woody species after the resumption of cambial activity. Lionakis [43], also told that primary and secondary xylem exist in the vascular bundle after rooting from cuttings.

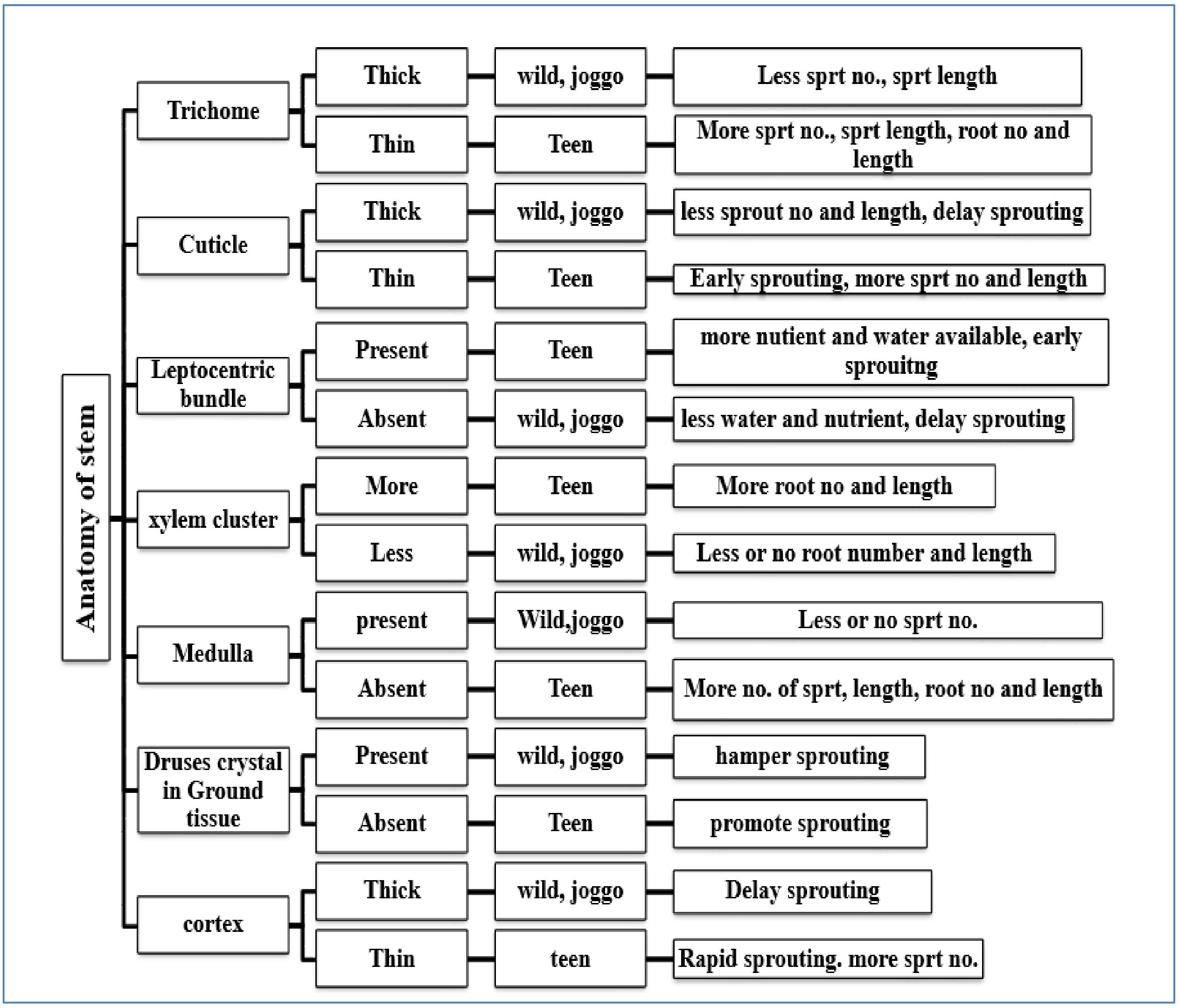
The most important prerequisite for the successful development of cutting propagation is the creation of adventitious roots [44]. Delayed auxin treatment promoted adventitious roots and callus formation on basal stem cuttings [45]. In the current study, teen showed less sprouting in T4. Thus activation of auxin is delayed in longer shade period which is supported by the findings of Lodama *et al.*, [45]. Rooting of cutting was mostly observed in teen. Wild fig showed very few or no rooting (Flowchart. 3.4 A).

Scelenchyma cell ring was noticed broken after root initiation from cutting [43]. In the study, teen performed better in rooting. The new root emerged through the ruptured sclerenchyma ring to pass through split in the epidermis in successful cutting [46].

According to Moussa *el al.*, [47], more water treatment reduces thickness of stem, stem diameter, thickness of vascular bundle. But, cortex becomes thick in more water treatment. Thus vascular bundle could transfer water and nutrient by root in case of teen where the cortex and cuticle were found thin which enhanced better rooting performance than wild fig (Table 3.5). Though Pacholczak *et al.*, [48], observed that when rooting inducers are applied after shading, cuttings experience the best rooting effects. Shading causes anatomical changes that make it easier for auxin or biostimulator to be absorbed by roots and promote their development.



Flow chart. 3.4: (A) Schematic presentation of the relationship between duration of shading and anatomical structures on performance of cutting of figs



Flow chart. 3.4: (B) Schematic presentation of the relationship between duration of shading and anatomical structures on performance of cutting of figs

4. CONCLUSION AND RECOMMENDATION

The results of this study leads to the conclusion that the effects of shade duration and anatomical structure on rooting performance of teen and wild fig are different. Teens performed and responded better than wild fig. Superior results were recorded in the number and length of sprouts and roots in teen under long period of shade conditions. Besides, days required for sprouting were less for longer shade in teen which results early sprouting. After being treated in a shaded environment, it was evident that the stem cutting of teen will behave more appropriately for propagation. This study was done in one season only. Before making a final recommendation for farmers additional trials in various parts of Bangladesh under various shade durations are required.

REFERENCES

1. Gani, G., Fatima, T., Qadri, T., Beenish Jan, N., & Bashir, O. (2018). Phytochemistry and pharmacological activities of fig (Ficuscarica): A review. *Inter J Res Pharm Pharmaceut Sci*, *3*, 80-82.
2. Mehraj, H., Sikder, R. K., Haider, M. N., Hussain, M. S., & Jamal Uddin, A. F. M. (2013). Fig (Ficus carica L.): a new fruit crop in Bangladesh. *International Journal of Business, Social and Scientific Research*, *1*(1), 1-5. http://www.ijbssr.com. Accessed 13 Dec 2022
3. Yoon, J. (2022). What Is a Fig? Plus, How to Eat Figs. Retrieved December 22, 2022, from https://www.eatingwell.com
4. Veberic, R., & Mikulic-Petkovsek, M. (2016). Phytochemical composition of common fig (Ficus carica L.) cultivars. In *Nutritional composition of fruit cultivars* (pp. 235-255). Academic Press.
5. Washburn, C., & Brennand, C. (2010) Preserve the harvest, FN/Harvest/2005-06pr, Utah State University, USA. https://extension.usu.edu. Accessed 13 Dec 2022

6. Ara, R., Kamal Uddin Khan, S. A., Adhikary, S. K., Fazlay Rabby, M., & Shawkat, S. (2022, August). Potentials of Teen (Ficus carica) as a Fruit Crop in Coastal Bangladesh. In *Transforming Coastal Zone for Sustainable Food and Income Security: Proceedings of the International Symposium of ISCAR on Coastal Agriculture, March 16–19, 2021* (pp. 201-215). Cham: Springer International Publishing. Doi . 10.1007/978-3-030-95618-9_16.
7. Brien, J. (2002). Fig growing in NSW. Agfact H3.1.19, first edition. NSW Agriculture. www.agric. nsw.gov.au. Accessed Dec 2022.
8. Banglapedia, (2015). Fruits, the national encyclopedia of Bangladesh. Available from http://en.banglapedia.org. Accessed 15 December, 2022
9. Pasha, M. K., & Uddin, S. B. (2019). Minor edible fruits of Bangladesh. *Bangladesh Journal of Plant Taxonomy*, *26*(2).
10. BBS, (Bangladesh Bureau of Statistics). (2015). Year Book of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Government of the Peoples" Republic of Bangladesh, Dhaka
11. Vangelisti, A., Zambrano, L. S., Caruso, G., Macheda, D., Bernardi, R., Usai, G., ... & Natali, L. (2019). How an ancient, salt-tolerant fruit crop, Ficus carica L., copes with salinity: a transcriptome analysis. *Scientific Reports*, *9*(1), 2561.
12. Salimpour, A., Shamili, M., Dadkhodaie, A., Zare, H., & Hadadinejad, M. (2019). Evaluating the salt tolerance of seven fig cultivars (Ficus carica L.). *Advances in Horticultural Science*, *33*(4), 553-566. https://doi.org/10.13128/ahsc8191
13. Banglapedia, (2021). Fruits, the national encyclopedia of Bangladesh. Available from http://en.banglapedia.org. Accessed 22 December, 2022.
14. Boliani, A. C., Ferreira, A. F. A., Monteiro, L. N. H., Silva, M. S. A. C. D., & Rombola, A. D. (2019). Advances in propagation of Ficus carica L. *Revista Brasileira de Fruticultura*, *41*, e-026. Doi. 10.1590/0100-29452019026.
15. BetülÖzer, K. (2022). CABI Digital Library. Retrieved December 22, 2022, from https://www.cabidigitallibrary.org/doi/abs/10.1079/9781789242492.0006
16. Souza, J. M. A., Leonel, S., de Souza Silva, M., Júnior, M. D. A. O., Martins, R. C., Bolfarini, A. C. B., & Ataíde, E. M. (2019). Carbohydrate content and season collection of cuttings from 'Roxo de Valinhos' fig tree. *Comunicata Scientiae*, *10*(1), 125-131.
17. Shamsuddin, M. S. (2020). Early growth and fruit development of fig (*Ficus carica L.)* | IIUM Student Repository. Retrieved on December 15, 2022, from http://210.48.222.250/handle/123456789/10054
18. Dias, J. P. T., Takata, W. H. S., & Ono, E. O. (2013). Propagação de figueira com estacas de diferentes diâmetros. *Revista Trópica: Ciências Agrárias e Biológicas*, *7*(1).
19. Singh, K. K., Sharma, P. K., Rana, M. K. & Sing, D. (2022). Vegetative Propagation of Fig (*Ficus carica* L.)-A Review. *Dizhen Dizhi Journal 14* (11), (17-24).
20. Rajkumar, R., Gora, J. S., Kumar, R., Singh, A., Kumar, A., & Gajender, G. (2017). Effect of different growing media on the rooting of pomegranate (Punica granatum L.) cv.'Phulearakta'cuttings. *Journal of Applied and Natural Science*, *9*(2), 715-719.
21. Achigan-Dako, E. G., N'Danikou, S., Tchokponhoue, A. D., Assogba-Komlan, F., Larwanou, L., Vodouhe, S. R., & Ahanchede, A. (2014). Sustainable use and conservation of Vitex doniana Sweet: unlocking the propagation ability using stem cuttings. *Journal of Agriculture and Environment for International Development*.
22. Bharti, D. (2016). Study of Tissue Systems in Plants | Plant Anatomy. Retrieved on December 12, 2022, from https://www.biologydiscussion.com
23. Bercu, R., & Popoviciu, D. R. (2014). Anatomical study of Ficus carica L. leaf. *Annals of the Romanian Society for Cell Biology*, *19*(1), 33-37. (DOI: 10.ANN/RSCB-2014-0002).
24. Yeung, E. C. (1999). The use of histology in the study of plant tissue culture systems—some practical comments. *In Vitro Cellular & Developmental Biology-Plant*, *35*, 137-143.
25. IRRI, (2013). STAR-statistical tool for agricultural research. International Rice Research Institute. Philippines, www.bbi.iri.org. Accessed 27 December, 2022
26. Ruchi, C., & Handa, A. K. (2009). Effect of shade on growth and productivity of stem cutting of Pongamia pinnata. *Annals of Biology*, *25*(2), 151-153.
27. Ferreira, L., Souza, A., & Silva, I. (2014). Effect of Shading and Subsequent Sampling days on Eucalyptus Mini-Stump Sprouting and Mini-cutting Rooting. *Australian Journal of Basic and Applied Sciences*, *8*(18), 521-527.
28. Khan, S. R., Rose, R., Haase, D. L., & Sabin, T. E. (2000). Effects of shade on morphology, chlorophyll concentration, and chlorophyll fluorescence of four Pacific Northwest conifer species. *New forests*, *19*, 171-186.
29. Dombroskie, S. L., Tracey, A. J., & Aarssen, L. W. (2016). Leafing intensity and the fruit size/number trade-off in woody angiosperms. *Journal of Ecology*, *104*(6), 1759-1767. https://doi.org/10.1111/1365-2745.12622
30. Gonzalez, N., De Bodt, S., Sulpice, R., Jikumaru, Y., Chae, E., Dhondt, S., ... & Inzé, D. (2010). Increased leaf size: different means to an end. *Plant physiology*, *153*(3), 1261-1279.

31. Caplan, D., Stemeroff, J., Dixon, M., & Zheng, Y. (2018). Vegetative propagation of cannabis by stem cuttings: effects of leaf number, cutting position, rooting hormone, and leaf tip removal. *Canadian Journal of Plant Science*, *98*(5), 1126-1132.
32. Wu, Y., Gong, W., & Yang, W. (2017). Shade inhibits leaf size by controlling cell proliferation and enlargement in soybean. *Scientific reports*, *7*(1), 1-10.
33. Safeer, P. M., Sreekumar, S., Krishnan, P. N., Biju, C. K., & Seeja, G. (2013). Influence of stem cuttings, spacing, group planting, light, irrigation and harvesting period on yield in Plectranthus vettiveroides (KC Jacob) NP Singh & BD Sharma. *IOSR Journal of Agriculture and Veterinary Scienc. e*, *6*, 47-53.
34. Maynard, B. K., & Bassuk, N. L. (1985). Etiolation as a tool for rooting cuttings of difficult-to-root woody plants. In *Combined Proceedings of International Plant Propagators Society* (pp. 448-495).
35. Laanisto, L., & Niinemets, Ü. (2015). Polytolerance to abiotic stresses: how universal is the shade–drought tolerance trade-off in woody species?. *Global Ecology and Biogeography*, *24*(5), 571-580.
36. Ali, Z. A., Mustafa, N. S., Abdel-Raouf, H. S., El-Shazly, S. M., & El-Berry, I. M. (2013). Characterization of some fig cultivars by anatomical traits on both leaves and stems. *World Applied Sciences Journal*, *24*(8), 1065-1071. (DOI: 10.5829/idosi.wasj.2013.24.08.13259).
37. Kumar, S. (2015). The Epidermal Tissue System of Plants (With Diagrams). Retrieved December 12, 2022, from https://www.biologydiscussion.com
38. Tütüncü Konyar, S., Öztürk, N., & Dane, F. (2014). Occurrence, types and distribution of calcium oxalate crystals in leaves and stems of some species of poisonous plants. *Botanical studies*, *55*(1), 1-9. Doi. 10.1186/1999-3110-55-32.
39. Larson, P. R., & Larson, P. R. (1994). Rays. *The vascular cambium: development and structure*, 363-452. https://doi.org/10.1007/978-3-642-78466-8_8
40. Wang, X., Shen, C., Meng, P., Tan, G., & Lv, L. (2021). Analysis and review of trichomes in plants. *BMC plant biology*, *21*(1), 1-11. https://doi.org/10.1186/s12870-021-02840-x
41. Islam, M.T. (2002). Anatomy of country bean. M.Sc. Thesis, Bangladesh Agriculture University, Mymensingh, Bangladesh.
42. Hartmann, H. T., & Kester, D. E. (1975). *Plant propagation: principles and practices*. Prentice-Hall..
43. Lionakis, S. M. (1984). Anatomy of root initiation in stem cuttings of the kiwifruit plant (Actinidia chinensis Planch.). *Fruits*, *39*(3), 207-210.
44. Ghimire, B. K., Kim, S. H., Yu, C. Y., & Chung, I. M. (2022). Biochemical and physiological changes during early adventitious root formation in chrysanthemum indicum linné cuttings. *Plants*, *11*(11), 1440.
45. Lodama, K. E., du Toit, E. S., Steyn, J. M., Araya, H. T., Prinsloo, G., Du Plooy, C. P., & Robbertse, P. J. (2016). Improving rooting of Lobostemon fruticosus L. cuttings with delayed auxin treatment. *South African Journal of Botany*, *105*, 111-115.
46. Gad, M. M., & Attia, F. A. Z. K. (2017). Does Anatomical Structure of Stem Cuttings Affect Root Formation?. *Assiut Journal of Agricultural Sciences*, *48*. DOI: https://dx.doi.org/10.21608/ajas.2017.5545.
47. Moussa, S. A., Taia, W. K., & Al-Ghamdy, F. G. (2012). Acclimation of Dipterygium glaucum Decne grown in the Western Coastal part of Saudi Arabia to different water supplies. *Int J Res Chem Environ*, *2*(1), 301-9.
48. Pacholczak, A., Jędrzejuk, A., & Sobczak, M. (2017). Shading and natural rooting biostimulator enhance potential for vegetative propagation of dogwood plants (Cornus alba L.) via stem cuttings. *South African Journal of Botany*, *109*, 34-41.