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SEEDLING CHARACTERISTICS OF JHINJERA (*BAUHINIA RACEMOSA* LAMK.)

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ABSTRACT

Seedling characteristics of *Bauhinia racemosa* Lamk. are described. The seedling was of Phanerocotylar – Epigeal Reserve type. The total leaf area per seedling increased exponentially with age with relatively larger rate of leaf-area-increment by the 40^{th} day of seedling age. The major allocation of biomass in 60-day old seedlings was in leaves - 49.65% of the seedling total dry mass (190.77 ± 34.47 mg). Tap root had profuse laterals. Cotyledons were obovate large, green fleshy and food laden. They were wholly consumed within around 50 days after emergence. From base to apex, first internode was the largest one and internodal size of subsequent internodes reduced to nearly half of the first internode. The hypocotyl was pale green, terete. Epicotyl hairy. The primary leaves were simple alternate, bilobed, pubescent ventrally. Each leaf had small, green and linear-lanceolate stipule. Leaf apex obcordate and leaf base cordate – embayed in sinus. Midrib extension (≤ 1mm) in the apical notch. Leaves and cotyledons showed photonastic movement. Epicotyl was longer than hypocotyl but hypocotyl was thicker (generally twice) than epicotyl. The total leaf area of 60-day old seedlings was (2256.57 ± 193.74 mm^2). Cotyledons were 5-6(7)-nerved and leaves were 9-nerved. The cotyledonary and foliar venation was brachidodromous type. The cotyledons and leaves were amphistomatic. The number of subsidiary cells associated with different types of stomata varied from two to eight. Paracytic, anisocytic, anisotricytic, anomocytic and staurocytic types of stomata were found on leaves and cotyledons (*sensu* Prabhakar, 2004). Abnormal stomatal types included a staurocytic type with two abutting pores and other included a group of contiguous anisotricytic type of stomata with variously shaped subsidiaries and the one anisotricytic stomata with two abutting pores. The epicotylar stomata were of paracytic type. Stomata were comparatively smaller on leaf (c 13 μm) than on the cotyledons (c 18 μm). Seedling characteristics are compared with available data for other *Bauhinia* species.

Key Words: *Bauhinia racemosa Lamk.*, seedling characteristics, Cotyledonary expansion, Seedling leaf area, stomatal types.

INTRODUCTION

To quote Paria (2014), "seedling morphology, … , is a less explored but emerging domain in plant science", which documents the morphological characters and the changes that occur during development from early stages to adult (Fogliani *et al*, 2009). In this domain, Burger (1972), Vogel (1980), Smith (1981,1983), Nenggan (1983-84), Smith and Scott (1985), Compton (1912), Deb and Paria (1986), Wright *et al.* (2000), Lack *et al*. (2008), Garwood (1996, 2009), Miller and Miller (2011), Sinjushin and Akopian (2011), Barbosa *et al.* (2014), etc. are some of the very important publications; several of which dealt with Family Leguminosae. *Bauhinia* (Caesalpiniaceae) is very important genus in tropics with around 300 species (Willis, 1977). Seedling morphology of some taxa of this genus has been studied by Lubbock (1892), Compton (1912), Burger (1972), Smith (1981, 1983), Smith and Scott (1985), Das and Paria (1999), etc. Das and Paria (1999) have described seedling morphology of nine Indian species of *Bauhinia* viz. *B. acuminata, B. diphylla, B. malabarica, B. purpurea, B. retusa, B. rufescens, B. tomentosa, B. vahlii*, and *B. variegata*. Eight species of *Bauhinia* are known from Pakistan (Ali, 1973). In the present paper, seedling characteristics of *Bauhinia racemosa* Lamk. [Vern. Jhinjera, Jhinjheri, Bidi leaf tree) is presented which is distributed in Punjab, and Sindh (Karachi, Dadu and Thana Bullah Khan). It appears to be pertinent in view of the fact that seedlings related studies are not only important taxonomically but also from conservation and restoration viewpoint particularly in tropical dry forests (Khurana and Singh, 2001). *B. racemosa* is a drought resistant plant, ornamentally attractive and medicinally useful (Kesavan and Chellaram, 2011). The seeds are potential fire-resistant and may germinate from soil depth of 5 cm in fire treated beds (Ratnayke and Jayasekhera, 2011) and thus useful for fire-prone areas.

MATERIALS AND METHODS

The seeds of *B. racemosa* were collected from its tree growing in the Campus of University of Karachi. The taxonomic identification was confirmed by Professor Dr. Surraya Khatoon, Department of Botany, University of Karachi. Most species of Fabaceae produce seeds with physical dormancy (Alderete-Chávez *et al.*, 2011). Therefore, the seeds stored for around a year were scarified with conc. H_2SO_4 for 10 minutes and then washed under running water. One hundred scarified seeds were germinated in pots filled with garden loam soil maintained at 75% water holding capacity. Maximum germination of 40 % was achieved within 10 days. The seedlings emerging on different dates were tagged to facilitate their age comparison. The seedlings were studied for their morphological characters including stomatal types and biomass allocation into various seedling components. Germination type was described according to Garwood (1996). This scheme is based on the characters of cotyledonary position (epigeal or hypogeal), exposition (cryptocotylar or phanerocotylar) and texture (fleshy or foliaceous) during germination. Hickey (1973), LAWG (1999) and Vogel (1980) were followed for the seedling description. Aspect ratio of leaf was calculated according to Lu *et al* (2012) as lamina width / lamina length (midrib length from umbo to apical notch). Leaf epidermal impressions were made with clear nail polish (Wang *et al.*, 2006). Stomatal nomenclature suggested by Prabhakar (2004) being simple and based upon structure of stomata and not their ontogenetic pathways was adopted to ascertain stomatal types. This nomenclature does not recognize actinocytic and stephanocytic stomata and categorize them as anomocytic type. As a basic criterion, all the cells abutting the guard cells are considered distinct by Prabhakar (2004) from the other epidermal cells by virtue of their position (i.e. abutting nature to the guard cells). The area of cotyledons and leaves was determined graphically. The data was analyzed statistically (Zar, 2010).

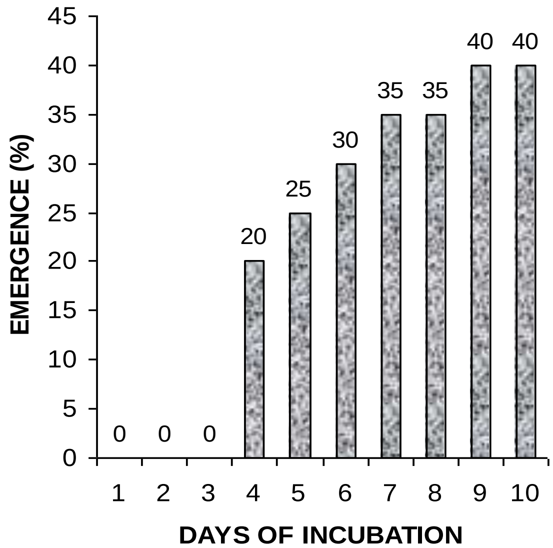

Fig.1. Seedling emergence from seeds *B. racemosa.*

Table 1. Some characteristics of 60-day old seedlings.

Parameter	60-day old seedlings	Parameter	60-day old seedlings
Shoot length (, SL cm)	8.17 ± 0.78	Leaf	
Epicotyl diameter (cm)	0.15 ± 0.02	Leaf base **	cordate-embayed in sinus
Number of leaves	7.0	Leaf apex	Bilobed; Obcordate
Hypocotyl length (cm)	0.81 ± 0.073	La	> zero; c 0.5 cm
Hypocotyl diameter (cm)	0.23 ± 0.013	Lb	> zero; c 0.6 cm
Root length (RL, cm)	10.1 ± 0.21	Mid vein	extension in apical notch
Root diameter (mm)	1.86 ± 0.20	Aspect ratio	2.33 ± 0.048 ***
Total Leaf Area (mm^2)	2256.57 ± 193.74	Leaf margin	Entire
Internodal length (Base to apex) (cm)		Petiole length	0.52 ± 0.038
I.	2.06 ± 0.233	Mean leaf size	338.5 ± 19.83
II.	1.4 ± 0.45	SL/RL ratio	0.81
III.	0.78 ± 0.15		
IV.	1.08 ± 0.21		
V.	0.87 ± 0.18		
VI.	0.90 ± 0.21		
VII.	1.0 ± 0.23		
Apex	0.16 ± 0.033		
Seedling Biomass			
Root Dry wt. (mg)	43.37 ± 6.44 (22.73%)*		
Stem dry wt (mg)	38.3 ± 10.50 (20.08%)*		
Hypocotyl dry wt. (mg)	14.30 ± 3.00 (7.50%) *		
Leaf dry wt. (mg)	94.67 ± 14.94 (49.65%)*		
Seedling dry wt. (mg)	190.77 ± 34.47		

La: Leaf apex extension i.e. distance on the perpendicular from the distal most point of the midrib to the distal most extension of the leaf tissue.
Lb: Distance on a perpendicular from the proximal most point of the mid vein to the proximal most extension of the leaf tissue.
*, percent proportion of the seedling weight.
**, If leaf base is embayed in a sinus with curved or straight sides and Lb > zero, the leaf base is cordate (LAWG, 1999).
***, W/L = lamina width / Lamina length (after Lu *et al.*, 2012).

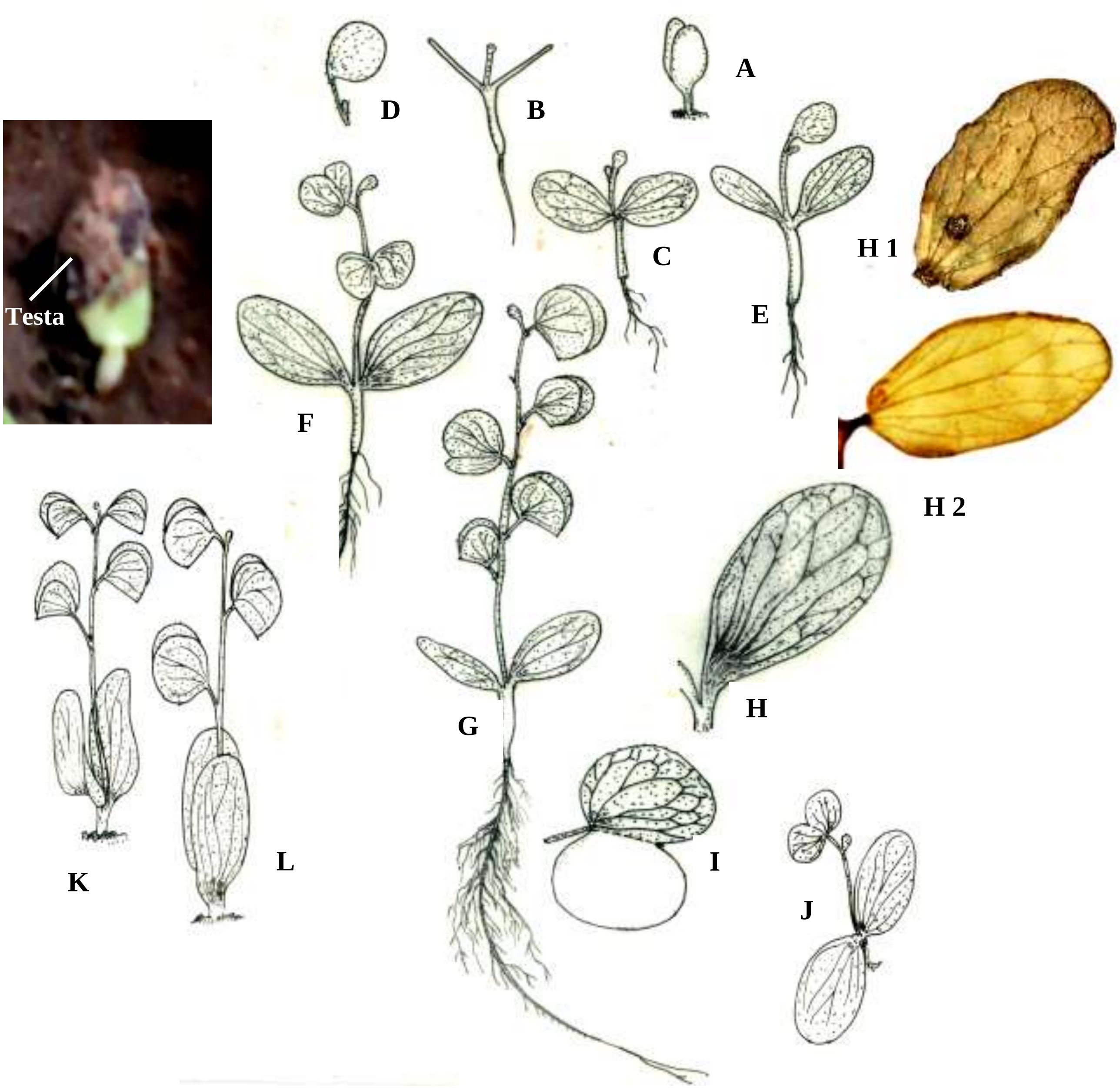

Figure 2. Seedling morphology of *Bauhinia racemosa* (Not drawn to scale). A, One day old seedling; B and C, Eight days old seedling seen from the lateral side and a tilted view, respectively; D, Apical part of seedling showing developing leaf and an apical bud beneath the leaf, E, Ten days old seedling; F, Twenty days old seedling; G, Forty day old seedling, H, H1 and H2, Cotyledonary venation (H1 and H2 are the photographs of cotyledons from dried seedling specimens) and I, Primary leaf venation. Note that hypocotyl is thicker than the epicotyl and the root. J, 15-day old at mid day ; K and L, 30-day old seedlings at evening showing photonasty. Inset shows the germinating seed.

RESULTS AND DISCUSSION

Seedling emergence

The seedlings of *B. racemosa* started emergence on fourth day of incubation (20%) which increased regularly to 40% on 10th day of incubation (Fig. 1). The seedling as per scheme of Garwood (1996) appeared to be phanerocotylar epigeal reserve type. Such type of seedling is also exhibited in *Bauhinia malabarica* and *B. rufescens* (Das and Paria, 1999). *Acacia nilotica*, *Azadirachta indica*, *Phaseolus vulgaris* and *Tamarindus indica* also show similar type of seedlings (Amritphale et al., 2008). In genus *Bauhinia*, four germination types (crypto-hypogeal, semicrypto-geal, Phanro-epigeal and Phanero-geal**)** are described by Das and Paria (1999).

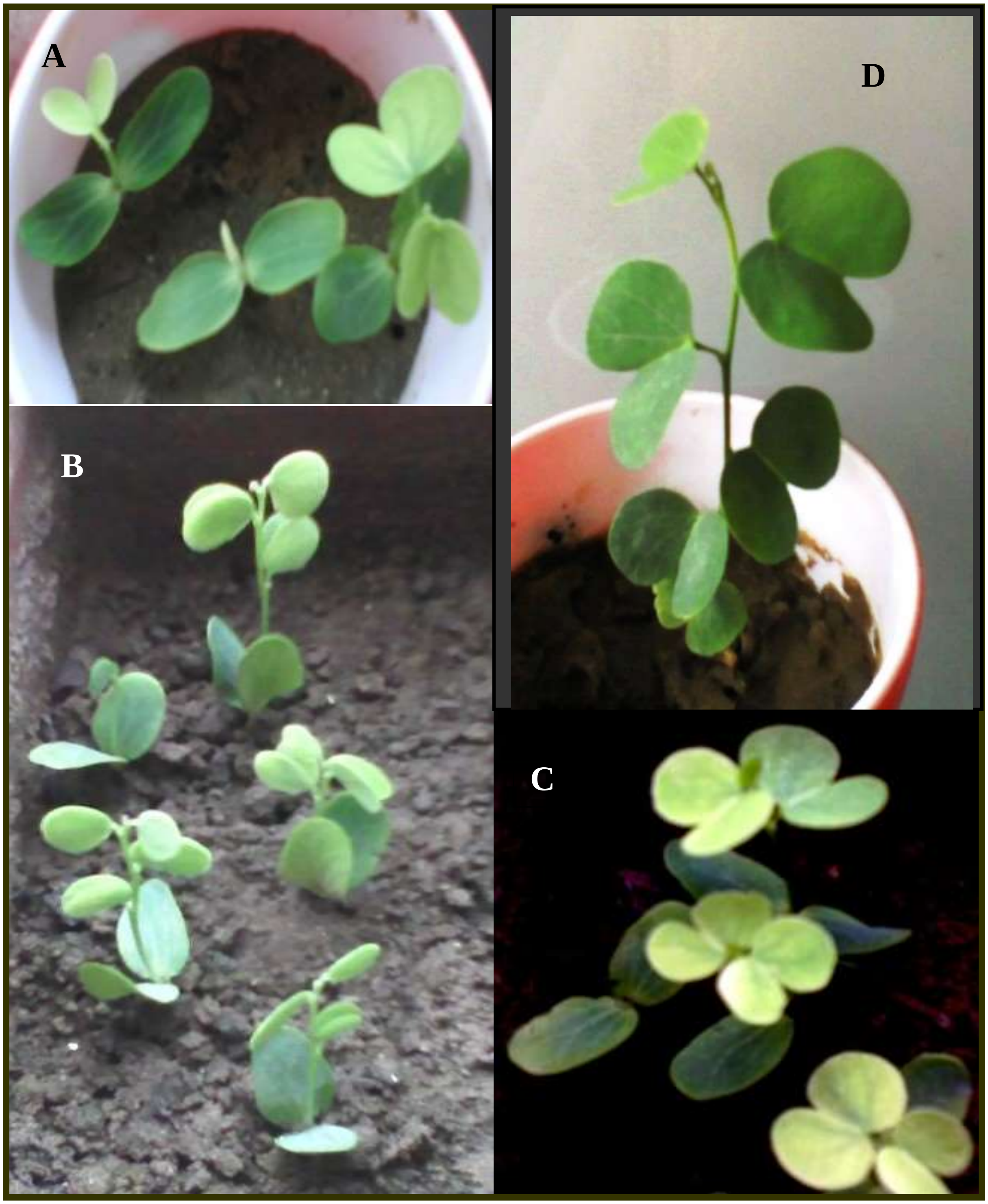

Plate 1. The seedlings of *Bauhinia racemosa*. A, Normal mid-day posture of one- to two leaved seedlings with fully open cotyledons; B, Evening posture of seedlings after sun set with cotyledons and leaves closed. C, Mid-noon photograph of two-leaf stage seedlings of *Bauhinia racemosa* raised in garden soil. Cotyledons are always darker green than the young recently-opening leaves which are pale yellow in colour. D, Fifty days old (six-leaved) seedling – Cotyledons have shriveled (brown remnants near the soil). Note that upper leaves are larger than the lower leaves.

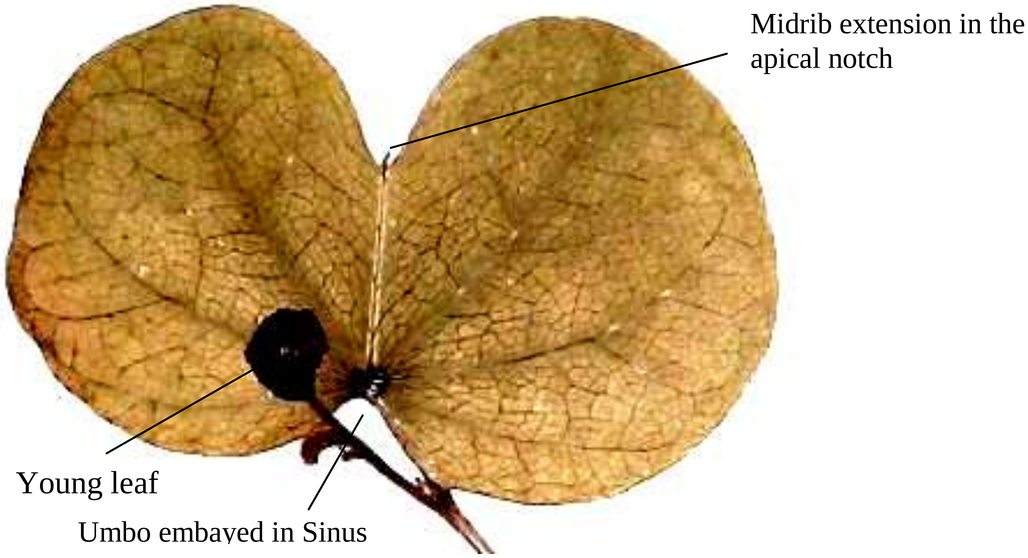

Plate 2. Photograph of a leaf of dry herbarium seedling specimen of *B. racemosa*.

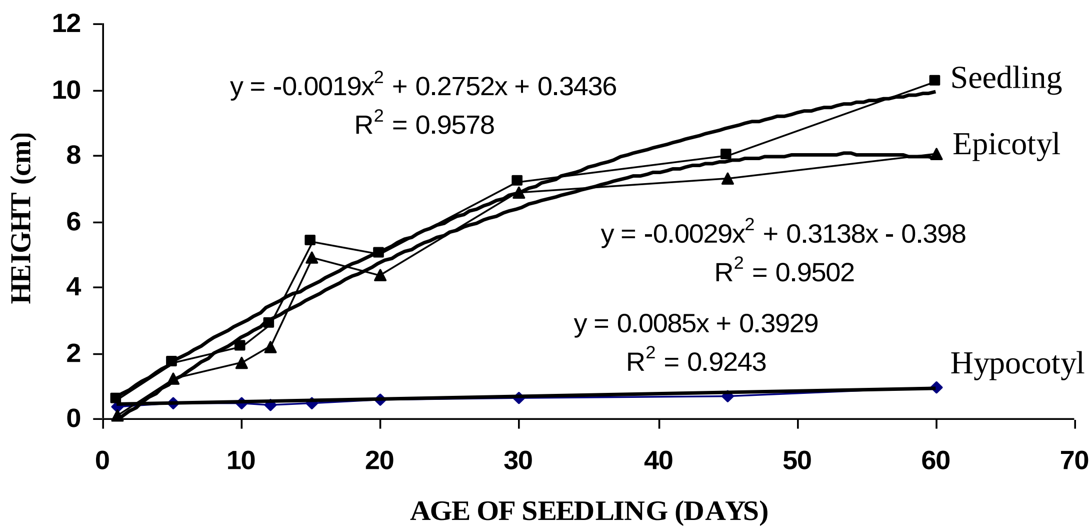

Fig. 3. Increment in height of hypocotyl, epicotyl and seedling of *B. racemosa* with age (days)

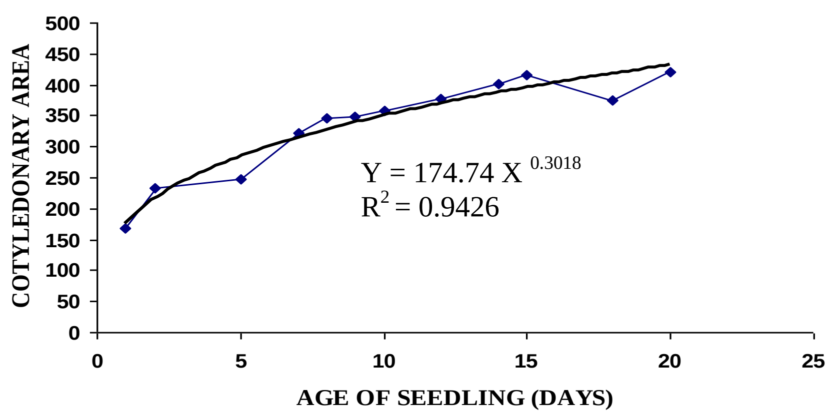

Fig. 4. Increment in total cotyledonary area (mm^2) of *B. racemosa* seedlings with age (days).

Table 2. Mean petiole length and area of the individual leaf of 2-month old seedlings (N=3) of *B. racemosa* as viewed from base to apex.

Leaf # (Base to apex)	Petiole Length (cm)	Leaf area (mm^2)	Area Based Proportion (%)
1	0.30 ± 0.06	190.0 ± 15.62	8.30 ± 1.06
2	0.38 ± 0.06	256.0 ± 16.60	11.25 ± 0.97
3	0.46 ± 0.035	356.3 ± 15.34	15.38 ± 0.34
4	0.50 ± 0.058	428.0 ± 50.50	18.30 ± 1.40
5	0.58 ± 0.109	396.3 ± 51.40	16.91 ± 1.32
6	0.67 ± 0.033	333.7 ± 14.40	14.53 ± 1.41
7	0.73 ± 0.037	363.0 ± 29.04	15.60 ± 0.313

*, *Per cent* Proportion of the area of a leaf to total leaf area of the seedling.

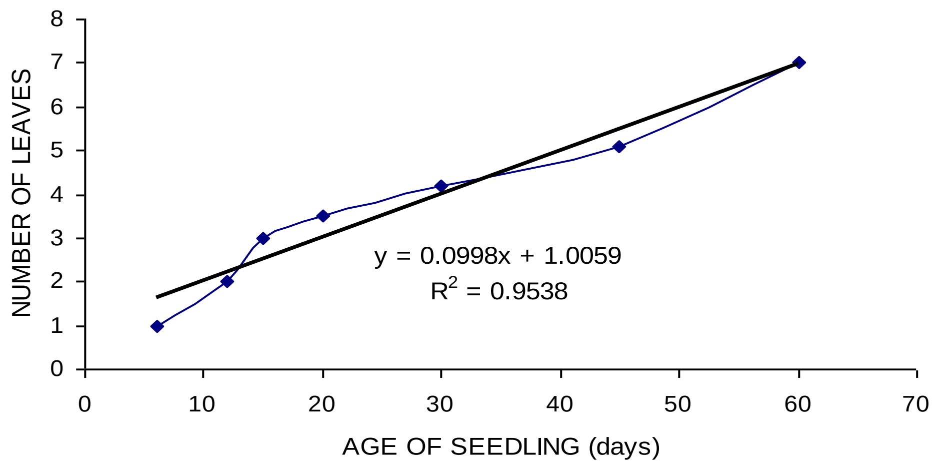

Fig. 5. Increment of number of leaves in seedlings as function of age.

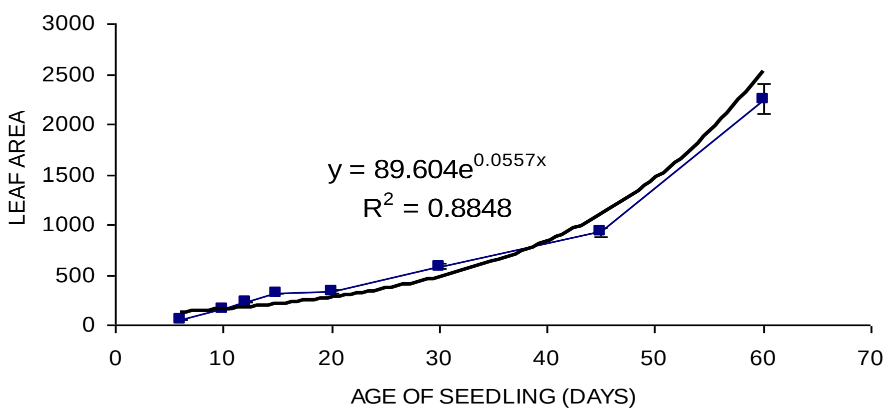

Fig. 6. Leaf area (mm^2) increment in seedling of *B. racemosa* as function of age.

Seedling description

Seedling is the final stage of the regenerative process of a plant from a seed. The use of this term is quite liberal. We have used this term as ecologists employ i.e. stage up to which the cotyledons are attached with the juvenile. In *B. racemosa,* cotyledons remained attached with seedlings up to 50-60 days. They started yellowing by around 45th days and abscized within 50-60 days. The overall growth of seedling was slow. The growth of hypocotyl was very slow which reached to 0.9 cm in 50 days with a rate of 0.0085 cm per day. Epicotyl on the other hand increased in length rapidly uo to 40th day and somewhat declined in growth afterwards, Thus major contribution to length of seedling came from epicotyl. Seedling growth with age was defined by a quadratic equation (Fig. 3). Seedling admeasured around 9.15 cm in length at 60-day age and nearly 6.0 cm at the age of 35 days. This resembled to the data on seedling height of *Bauhinia forficata* subsp. *pruinosa* reported by Souza and Valio (2003). The 34-day old seedling of this species was 5.0 ± 0.11 cm in length. The 60-day old seedling of *B. racemosa* had seven internodes and dry weight of 190.77 ± 34.47 mg. From base to apex, in *B. racemosa*, the first internode was the largest (2.06 ± 0.233 cm). The subsequent internodes were smaller and comparable in length (c 1 cm) (Table 1). First internode is highly elongated in *Bauhinia purpurea* and reduced in *B. variegata* (Das and Paria, 1999). There exists a great deal of diversity in seedling characteristics of genus *Bauhinia* as may be adjudged from the following description.

Root

Tap root system branched profusely.

Cotyledons

In *B. racemoasa*, seedling, on the fist day of its life, is slightly curved or straight and cotyleodns partially hidden in swollen and cracked testa. Very soon the cotyledons fully comes out of cracked testa. At this juncture of time cotyledons are straight lying closely appressed. Soon cotyledons unfold and and lie at 180^o but they remain near ground due to short hypocotyl (Fig. 1A, B and C). Cotyledons are equal in size obovate in form. Cotyledons and leaves both show photonastic movement (Plate 2A and B; Fig. 1 K and L).). Cotyledons close from a horizontal to a vertical position in the night and regain a horizontal position in the day time (Plate 1 A and B). Cotyledons green, photosynthesizing and somewhat thick and food-storing (paracotyledons of Vogel (1980). Fleshy (storage) cotyledons have also been reported from *Bauhinia vahlii, B. retusa, B. diphylla* and *B. purpurea* but not in all species of *Bauhinia (*Das and Paria, 1999*)*. Cotyledons are green and foliar in *B. acuminata*, *B. malabarica* and *B. rufescens* (Das and Paria, 1999). Mid-vein and veinlets of cotyledons are whitish-green and rest of cotyledonary lamina dark green in colour. In spite of it, venation is not as wholly and clearly visible as in dry herbarium seedlings' cotyledons. The mid vein of cotyledons bifurcates slightly above the mid of the fully grown cotyledon. Cotyledons are 5-6 (7) nerved. Two short veinlets arising from the cotyledonary base may sometimes be faintly seen (Fig. 1). The venation of cotyledons is brachidodromous type (Fig. 1 H, H1 and H2) as seen in dry seedling herbarium.

The total cotyledonary area at the fist day of seedling's life was 167.40 ± 7.20 mm^2 which after 20 days of growth attained an area of 420.18 ± 11.78 mm^2. On first day of emergence a single cotyledon had an area of 83.8 ± 7.17 mm^2. Cotyledonary expansion with age was given by a power model equation (Fig. 4).

Hypocotyl and Epicotyl

Hypocotyl stout, terete, yellowish green and glaucous. Hypocotyl is thicker than epicotyl. Hypocotyl is short and tetrangular in *Bauhinia malabarica* and *B. rufescens* and terete and long in *B. tomentosa* and *B. acuminata* (Das and Paria (1999). Epicotyl began to emerge on fifth day of emergence of seedling. It is hairy, around 1mm in diameter and grows more rapidly than hypocotyl and thus largely contributes to the shoot height,

Leaf

Leaf simple, petiolate (petiole hairy and Petiole length larger in the upper leaves, which appears to be due to fact that upper leaves are relatively larger in size than lower leaves (Table 2)), leaves alternate with tristichous phyllotaxy (third leaf above the first). In contrast, first two leaves are opposite in *Bauhinia vahlii* and *B. retusa* where as alternate in *B. variegata*, *B. diphylla*, *B. tomentosa*, *B. Malabarica* and *B. rufescens* (Das and Paria, 1999). Leaf lamina bilobed. The leaf lobes show photonastic movement – they close in the night. Lamina width (W) is larger than lamina length (L) i.e. midrib length from umbo to apical notch. The aspect ratio was, therefore, 2.33 ± 0.048 (Table 1). Midrib extension (≤ 1mm) in the apical notch (Plate 2). Such extension of midrib has also been shown in some species of *Bauhinia* (*B. tomentosa, B, malabarica, B, purpurea, B. variegata*, *B. rufescens* etc,) by Das and Paria (1999). Midrib extension beyond leaf lamina as an aristate tip (around 1mm long) is also reported in *Bauhinia monandra* (Australian Tropical Rianforest Plants; keys.trin.org.au/key-server/data ….html). Umbo is embayed in sinus and lamina base cordate. Leaf is hairy on both surface but densely hairy on ventral side. Midrib is more hairy than rest of the lamina. Hairs uni- to multicellular greatly varying in length. Few hairs are very large. Leaf stipulate (stipule green, hairy, 1 mm or lesser in size). First leaf appearing on 8^{th} day of seedling life and second leaf fifth day later of the first leaf in most of the even-aged seedlings. Epidermal cells of the leaf small and cuticularized. Primary as well as subsequent leaves exactly alike to the normal leaves of the adult plants. Leaf is nine-nerved generally as also in *Bauhinia monandra* (Australian Tropical Rianforest Plants; keys.trin.org.au/key-server/data ….html). The number of main veins radiating from lamina base in *Bauhinia purpurea* is reported to be 9-13 (Conner, 2003). Younger leaves are yellowish green in colour (low chlorophyll content) (Plate 2C). They slowly darken in green colour. The number of leaves present on the seedling increased with age in direct fashion (r =

0.9538). On any 6o-day old seedling the maximum number of leaves present was seven (Fig. 5). The total leaf area per seedling increased exponentially with age with relatively larger rate of leaf area increase after 40^{th} day of seedling. The 60-day old seedling had leaf area of 2256.57 ± 193.74 mm^2 (Fig.6). The venation of leaf is of brachidodromous type (Fig 1 I). Several species of *Bauhinia* from oligocene formation of Ningming formation of Guangxi, S. China, have been reported to bear brachidodromous venation (Wang *et al.*, 2014). Several living species of *Bauhinia* like *B. tomentosa, B, malabarica, B. rufescens, B. vahlii, B. retusa, B. diphylla* and others have also been shown to bear brachidodromuous venation (Das and Paria, 1999).

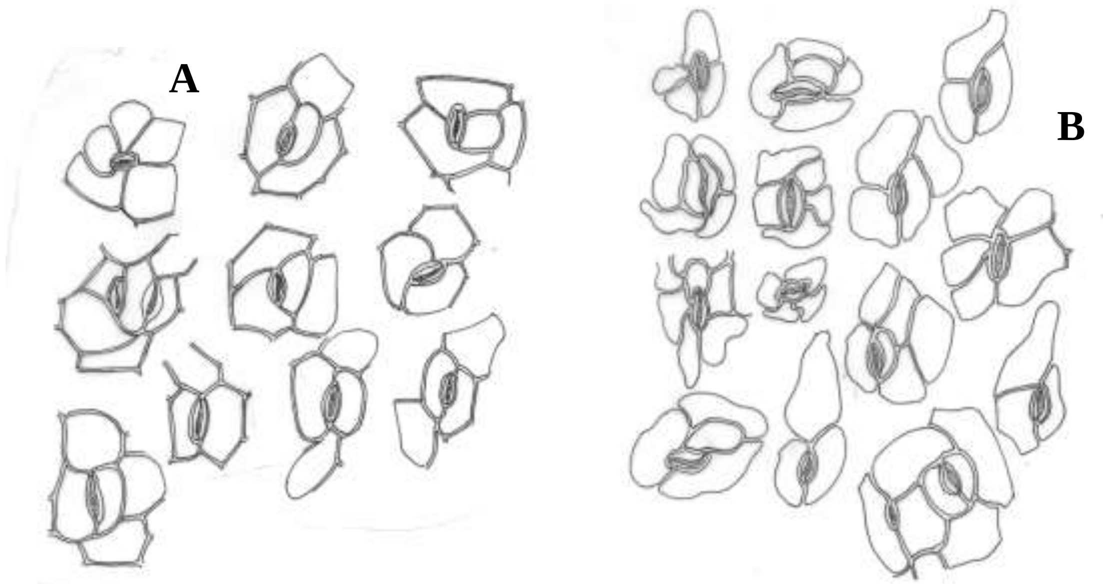

Fig.7. A variety of stomata on dorsal (A) and ventral (B) sides of leaf of seedlings of *B. racemosa*. A difference in number and shape of the subsidiary cells is explicit.

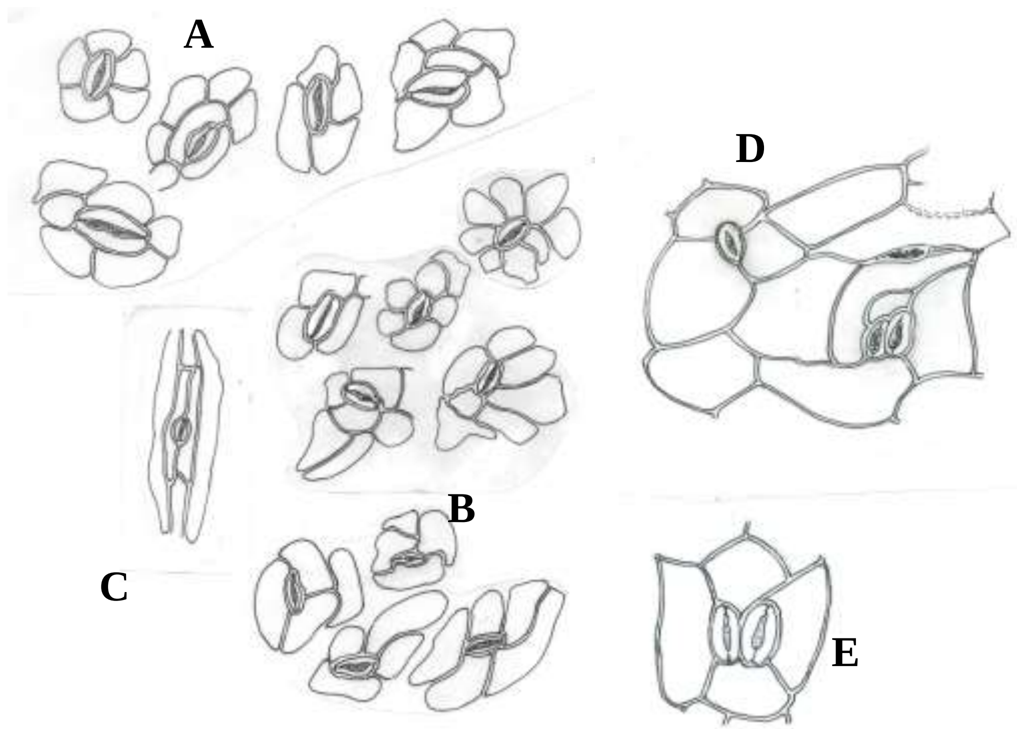

Fig. 8. A variety of stomata on upper (A) and lower (B) sides of cotyledons and the epicotyl stem (C). D and E are the abnormal stomata seen on the upper side of cotyledon. A difference in number and shape of the subsidiary cells is explicit.

Foliar, epicotylar and Cotyledonary stomata

Leaves, epicotyl and cotyledons all were provided with a number of stomatal types. Cotyledons and leaves both were amphistomatic (Fig. 7 and 8 and Plate 3). Metcalfe and Chalk (1979) have reported two types of stomata in Family Caesalpiniace (Parcytic and anomocytic). In the present studies with *B. racemosa*, we recorded a number stomata types on leaf, epicotyl and cotyledons.

On Dorsal surface of leaf paracytic, anomocytic, anisocytic, anisotricytic and contiguous paracytic types of stomata were recorded (Fig 7A). Contiguous stomata had two paracyutic stomata with common susidiary cell. On ventral surface paracytic stomata with sunsidiaries of equal or unequal sizes, anomocytic, anisotricytic, staurocytic and contiguous paracytic stomata with common subsidairy were seen (Fig. 7B). On epicotyl, only one type stomata were seen – paracytic occurring distantly. On dorsal (lower) surface of cotyledons anomocytic, paracytic and staurocytic stomata were present. On ventral (upper) cotyledonary surface, stomatal diversity was relatively high; anomocytic, staurocytic, anisoctic, anisotricytic, paracytic and abnormal stomata types were present (Fig.8). Abnormal stomatal types included a staurocytic type with two abutting pores (Fig. 8E) and other included a group of contiguous anisotricytic type of stomata with variously shaped subsidiaries and a stomata with two abutting pores (Fig. 8 D). The number of subsidiary cells associated with different types of stomata varied from two to eight. Stomata were oriented in varying directions (Plate 3). Of 45 species of order Leguminales, 31 species were reported to be amphistomatic and only 14 spp. hypostomatic by Tripathi and Mondal (2012). According to them, three stomata types of Leguminales were paracytic, anisocytic and anomocytic - found in various combinations. The most common stomata in legumes are of the paracytic type and paracytic and anomocytic types may although occur together in Caesalpiniaceae but never occur together in Family Fabaceae which is more diverse in stomata than Families Caesalpiniaceae and Mimosaceae (Tripathi and Mondal, 2012). Metcalfe and Chalk (1979) have reported several types of stomata in Papilionaceae – Anomocytic, Paracytic, and Parallelocytic restricted on adaxial surface or found on both surfaces singly or in groups. They have reported no anisocytic stomata in Papilionaceae. *Sensu* Prabhakar (2004), paracytic, anisocytic, anisotricytic, anomocytic, staurocytic and contiguous paracytic stomata types have been reported from *Erythrina suberosa* by Khan *et al.* (2014). The thirteen species of the family Fabaceae (Genus *Ademsia, Galega, Lotus, Lupinus, Melilotus*, *Parkinsonia, Senna, Trifolium* and *Vicia*) were reported to be characterized with anisocytic, anomocytic stomata. Stomata are predominantly paracytic in leaves of *Citrus* spp. (Obiremi and Oladele, 2001). They are extremely variable even in the members of a tribe and even within a genus (Metcalfe and Chalk, 1950) and in a species as well. That is more than one type of stomata frequently occur on the same leaf surface.

Paracytic stomata are most frequent in several papilionaceous plants (*Alysicarpus bupleurifolius, A. monilifer, A. rugosus, Arachis hypogea, Cajanus cajan, Canavalvia gladiata, Clitoria terneata, Erythrina cristagalli, E. indica, Lathyrus sativus, Lens esculentus, Medicago sativa*, and *Tephrosia purpurea*. The genus *Senna* has been reported to have paracytic stomata (Freire *et al.*, 2005). There are, however, anisocytic stomata in *Glycine soja*, *Pisum sativum* and *Sesbania sesban* and anomocytic stomata in *Sesbania grandiflora* and *Trigonella foenum-graceum.* The stomata on leaf of *Alhagi maurorum* (Fabaceae) are paracytic and anisocytic types and on stem anomocytic type (Bokhari and Dasti, 1991).

The locality of collection of specimens is known to influence the epidermal structure and show wide variation in stomatal types e.g., specimens of *Heliotropium europium* collected from Quetta had anomocytic, anisocytic, brachyparacytic, staurocytic, cyclocytic and actinocytic stomata as common types while specimens collected from Pishin have no anisocytic but has an additional brachyparatetracytic stomata which didn't occur in the specimens of Quetta (Dasti *et al.*, 2003). Contiguous stomata were also found *in Erythrina indica* but rarely. They were frequent in *L. sativus* (Shah and Gopal, 1969) and may be formed by budding. *Melilotus albus, Alysicarpus vaginallis, Aeschymonene indica, and Desmodium* spp. also reported to possess contiguous stomata (Kothari and Shah, 1975; Bora and Baruah, 1979). Aniesua and Silas (2012) have also reported un-open stomatal pores, two-stomata sharing one subsidiary cell, one guard cell, parallel contiguous and aborted guard cell in *Acalypha (Euphorbiaceae)*. Stomatal clustering on epidermis is reported in more than 60 species (Gan *et al.*, 2010).

Stomatal abnormalities are suggested to be the result of environmental perturbations as confirmed by Carr and Carr (1990) and environmental stress like drought and salinity (Gan *et al.*, 2010). Warming may significantly decrease the average nearest neighbour distance between stomata (Zheng *et* al. (2013). As structure, development and patterning of stomata on the leaf surface is the function of complex processes, they should be viewed from evolutionary, physiological, ecological and organ view-point (Croxdale, 2000). Great deal of research is needed with local flora from this view-point.

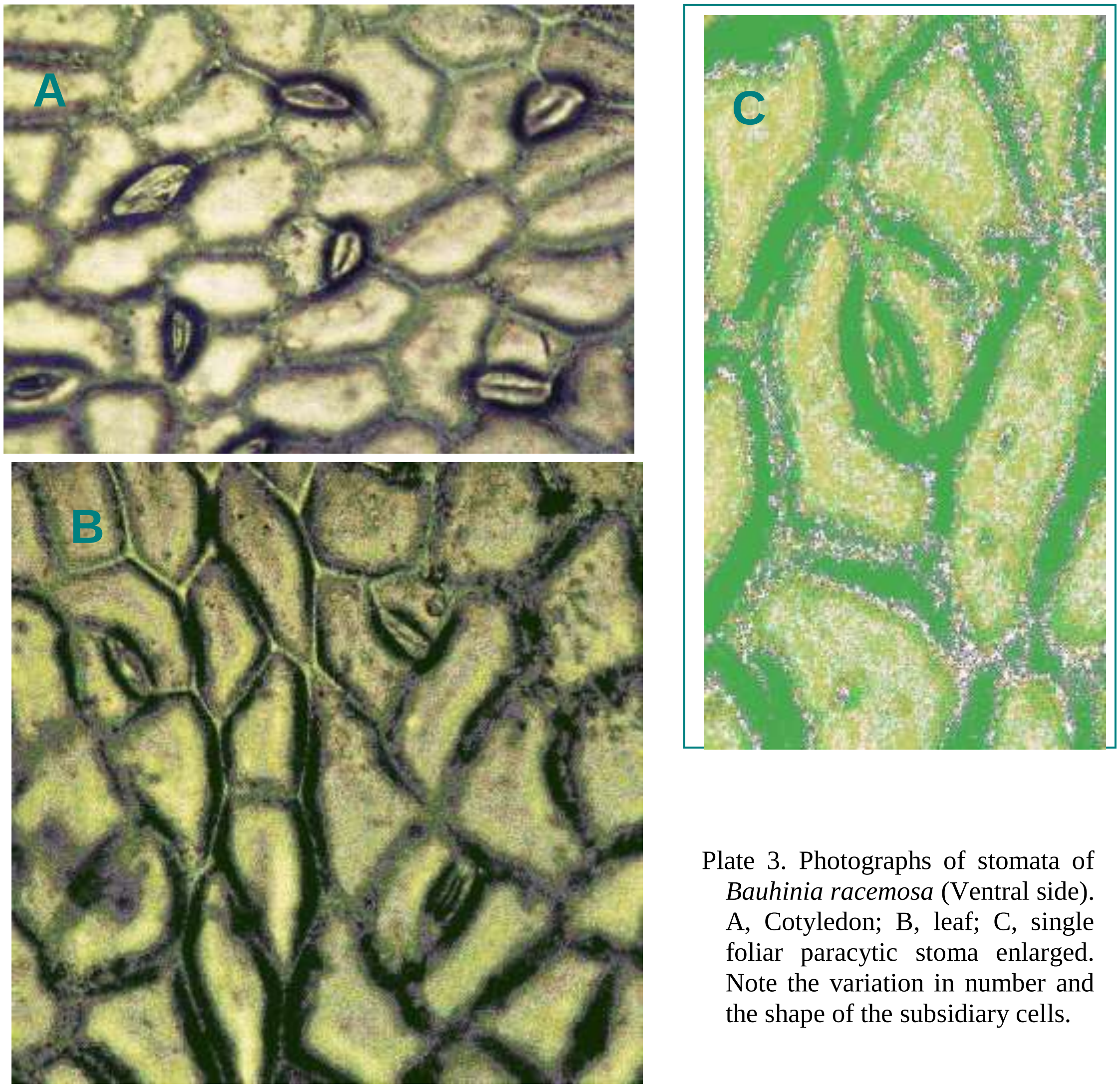

Plate 3. Photographs of stomata of *Bauhinia racemosa* (Ventral side). A, Cotyledon; B, leaf; C, single foliar paracytic stoma enlarged. Note the variation in number and the shape of the subsidiary cells.

Table.3. Stomatal size (length, µm) (N = 50).

Parameter	Leaf (Dorsal)	Leaf (Ventral)	Cotyledon (dorsal)	Cotyledon (Ventral)
Mean	13.216	12.926	18.112	17.952
SE	0.4356	0.2698	0.4466	0.4993
Median	12.80	12.80	18.40	17.60
CV (%)	23.31	14.076	17.43	19.67
Minimum	8.0	8.0	11.20	11.20
Maximum	24.0	17.60	24.0	28.80
Mean difference	t = 0.566 (NS)		t = 0.239 (NS)	

Stomatal size

The stomatal size, in terms of length, was little larger on cotyledons (17-18 µm) than that of the foliar stomata (c 13 µm). The size of stomata on the dorsal surface (Outer) of the cotyledons was not statistically different from the ventral surface (t = 0.239, NS). Stomata on foliar dorsal or ventral surfaces were also not different in size statistically (t = 0.566, NS) (Table 3). Stomata size of *B. racemosa* resembled to that of leguminous herbs such as *Vicia faba, Melilotus indica, Lathyrus aphaca* having smaller stomata (13 -14 µm) (Ahmad *et al.*, 2009). The stomata of tree legume species are, however, generally reported to be larger than that of herbs (Tripathi and Mondal, 2012).

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