3. Result and Discussion

3.1. Caryopses anatomy

Caryopsis anatomy

Both cross and longitudinal sections were taken serially and observed. Observations for the characteristic features were noted from the sections passing through the central portion of the embryo located in the caryopsis.

General anatomy of grass caryopsis reveals that it can be distinguished into three distinct parts/regions (Diagram 1); (1) the caryopsis coat which includes the pericarp, the seed coat, and the nucellus (2) the endosperm (3) and the embryo.

Few caryopses were free from the pericarp, for example *Sporobolus, Eleusine* while few caryopses were permentley enclosed the lemma and palea, for example members of tribe Paniceae, *Aristida* and *Stipa* (which were members of group Pooideae). In the tribe Andropogoneae members, glumes permently enclose the caryopsis along with a pedicel and a section of the rachis. The grain may enlarge during development and ripening exceeding the size of the glumes, lemma and palea.

1. **Caryopsis coat:** There are several layers of cells in caryopsis coat and it can be differentiated into pericarp, integuments and nucellus. Pericarp is generally defined as the fruit wall developed from the ovary wall. Seed coat is the protective covering of the seed formed from integuments. In grasses, the pericarp and the remains of the integuments of the single seed are completely fused.

   During development the expansion of the caryopsis causes these cells to become crushed and form a complex caryopsis coat. Pericarp layer can be further distinguished into five different layers: the outer epidermis, the hypodermis, a zone of thin walled cells, cross cells, tube cells.

   The outer epidermis and the hypodermis together form the exocarp. The cells of the exocarp are elongated in a direction parallel to the longitudinal axis of the caryopsis and they become compressed and their walls thicken considerably so that when the caryopsis is ripe, cell lumina cannot easily be distinguished in them.

   Cross cells are found below the parenchymatous layer and they have thick walls with pits which are elongated transversely to the cell. The longitudinal axis of these cells is at right angles to that of the exocarp cells. The tube cells constitute the inner epidermis of the pericarp and they occur on the inside of the cross walls. There are large intercellular spaces between the tube cells, the walls of which are pitted and thinner than those of cross walls. The longitudinal axis of these cells is parallel to that of exocarp cells.

   Seed coat which is united with the pericarp, is crushed in the mature caryopsis and hence difficult to discern cells in this zone. A fully mature seed coat consists only of the inner integument, the outer being completely crushed.

   Nucellus is discernible as one to two layers of thin walled cells between aleurone layer and the seed coat. In a complete mature seed these nucellar cells are crushed and appear as thin glassy zone which is bright and colourless.

   Depending upon the number of distinguishable layers in the pericarp it can be categorized into four different types.

   1. Type – A: (Fig. 1, A):
      Pericarp differentiated into five layers:
      First: Epidermis- made up of square/rectangular flat or broad cells

Second: Subepidermal/hypodermis- made up of rectangular/square cells
Third: Thin walled cells which are crushed
Fourth: Cross cells
Fifth: Nucellus- made up of rectangular cells

2. Type – B: (Fig. 1, B):
   Pericarp differentiated into four layers:
   First: Epidermis- made up of square/rectangular flat or broad cells
   Second: Subepidermal/hypodermis- made up of rectangular/square cells
   Third: Cross cells
   Fourth: Nucellus- made up of rectangular cells
3. Type – C: (Fig. 1, C):
   Pericarp differentiated into three layers:
   First: Epidermis- made up of square/rectangular flat or broad cells
   Second: Cross cells
   Third: Nucellus- made up of rectangular cells
   Other layers like hypodermis and crushed parenchyma may be crushed during development.
4. Type – D: (Fig. 1, D):
   Pericarp differentiated into three layers:
   First: Epidermis- made up of square/rectangular flat or broad cells
   Second: crushed parenchyma cells
   Third: Nucellus- made up of rectangular but either they are flat or broad
   Layer of cross cells not develop from beginning and hypodermis may be crushed during development.

Embryo: The grass embryo is highly specialized and appears as an oval depression on the flat side of the caryopsis next to lemma. On the opposite side of the grain to the embryo is the hilum; a line (e.g. *Lolium perenne*, *Avena fatua*) or dot (*Holcus lanatus*, *Briza media*) marking the point of attachment of the seed to the pericarp. The embryo includes primordia of one, two, or more foliage leaves and the primary root, and primordia of several adventitious roots. The scutellum is a haustorial organ, equivalent to the single cotyledon, and functions in enzyme secretion and absorption of nutrients from the endosperm. Also in the embryo is the coleoptiles (part of the single cotyledon, an open sheath with a pore at tip, homologue of first foliage leaf), the epiblast (an outgrowth of the coleorhiza), and the coleorhiza (the first part of the plant to emerge on germination, producing a tuft of anchoring hairs, protecting the radicle; the primary root emerges through it); all are peculiar to the grass embryo. The embryonic shoot is known as the plumule, and the embryonic primary root as the radicle. The mesocotyl is a vascular trace in the scutellum extending down into the coleorhiza and up into the coleoptile. Endosperm occurs as a large elliptical structure in the seed formed from the fusion of two polar nuclei of the embryo sac and a sperm nucleus.

The endosperm provides nutrition for the embryo and developing seedling, and is usually solid and starchy (liquid in some including *Koeleria*, *Trisetum*, and all Aveneae). Variation in embryo structure is related to the presence or absence of the mesocotyl, the epiblast, the scutellum cleft (i.e. whether or not the scutellum is fused to the coleorhiza), and whether the first leaf is rolled or folded, and allows an evolutionary sequence of embryo types to be recognized (Renvoize 2002). It is the new immature plant, developing from the zygote. Embryo is placed dorsally and is surcirculared by caryopsis coat on its dorsal surface and crushed cells which composed depletion layer on its ventral surface from where the scutellum comes in contact with the endosperm.

It contains two major parts: (i) embryo axis and (ii) scutellum. Embryo axis represents coleorhiza, radicle, mesocotyl, plumule, coleoptiles. (Fig. 2, A, B).

Embryo is placed at different angles with respect to anterior-posterior position of caryopsis. Taking this as a characteristic feature of variation caryopsis are categorized as:

A: less than 130°: (Fig. 1, E): embryo placed almost nearly to the right angle of the anterior-posterior axis of the caryopsis.

B: 130°- upto160°: (Fig. 1, F)

C: 160°- upto190°: (Fig. 1, G)

With an increase in the angle position of embryo becomes more parallel to the anterior-posterior axis and with a decrease in the angle; the position of embryo is almost at right angle and placed perpendicular to the axis.

Embryo axis is an imaginary line drawn longitudinally through the embryo, comprising of the following parts:

1. Root axis: It comprises of coleorhiza and radicle.

- **Coleorhiza** is a cone shaped protective a sheath covering the radicle, at the terminal end of the embryonic axis. On the side nearest the scutellum it extends to the level of the subapical meristem of the radicle. On opposite side it extends, as a thin sheet 4-5 cells thick, to the top of the radicle. Coleorhiza shows outer and inner epidermis. Epidermal cells are square shaped (Fig. 2, C, arrowhead) and in between two epidermises, loosely arranged columnar to isodiametric cells are present, which are thin walled (Fig. 2, C).

  Coleorhiza shows two variations. Sometimes it extends towards the dorsal surface and forms the epiblast. Epiblast is produced laterally from the embryo away from the scutellum and forming a small extension of the coleorhiza, while in others coleorhiza is directly connected to the mesocotyl with an absence of epiblast.

  Epiblast distinguished in many caryopses is a small projection of tissue of the embryonic axis opposite the scutellum. Based on the length and sharpness of the tip different types of epiblast are present among the studied caryopses (Fig. 2, H–L).

  Type -I: Epiblast as a small outgrowth form colerhiza with blunt end (Fig. 2, H).

Type - II: Epiblast in form of small outgrowth with sharp pointed end (Fig. 2, I).

Type - III: Epiblast long reaching upto half length of plumule, thin with a pointed (like a needle) end (Fig. 2, J).

Type – IV: Epiblast long, thick and pointed (blunt) end (Fig. 2, K).

Type – V: Epiblast long, nearly reaching upto entire length of plumule and with pointed end (Fig. 2, L).

- **Radicle:** It has a closed apical organization typical of grasses, surcirculared by a densely stained layer and terminates at a root cap. Cells of the root cap at the tip of the radicle are closely adherent to the cells of coleorhiza (Fig. 2D, arrowhead). It has a thick birefringent cell wall on its lateral surfaces. Cells are isodiametric to penta-hexagonal and compactly arranged. Cells are arranged in radial tiers one above the other (Fig. 2, D). Differentiation into a distinct epidermis and other layers are not prominent.

2. Shoot axis: It comprises of coleoptile and plumule.

- **Coleoptile** is a cone shaped sheath like protective covering over the upper end of the embryonic axis. It is two to three layers thick and is a flattened cone surcircularing the first leaves and shoot apex. Coleoptile shows outer epidermis and inner epidermis. Outer epidermal cells are rectangular, long and flat. Inner epidermal cells are broad, rectangular cells. Between two epidermis, 3-4 layers are present, and cells are square to rectangular shaped cells (Fig. 2, F).
- **Plumule** is present at the upper end of the axis under the coleoptiles; which is compactly arranged a terminal bud. Plumule have embryonic leaf. Generally three leaves are there, namely, first leaf, second leaf and third leaf. Third leaf is inner most leaf and it is very small. Cells of plumule are similar to that of coleoptiles i.e. squarish to rectangular, but they are smaller in size compared to the coleoptiles cells, and cells are arranged in row (Fig. 2, G). In plumule, no such differentiation in epidermis and any other layers are seen. All cells are rectangular to square shaped, arranged one above the other and compactly arranged.
- **The anatomical features of coleorhiza, radicle, coleoptiles and plumule are similar in all the studied species, and hence are not described individually in the description of the embryo axis of each species.**

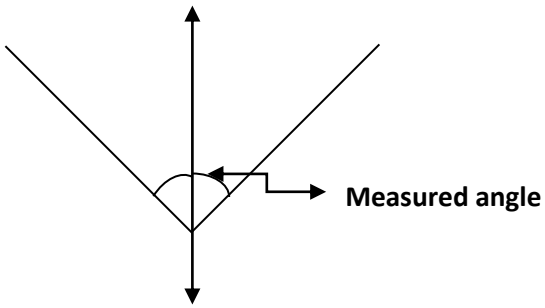
3. Mesocotyl: Mesocotyl is an undifferentiated zone of compact internodes and meristematic initials present between the radicle and plumule. It extends downward to the radicle. The mesocotyl cells are procambial cells from where radicle and plumule originates. It also vascularise rhizome and embryos. Mesocotyl is differentiated into the following layers: an outer and inner epidermis and in between them few cells are present. Outer epidermal cells are square to rectangular cells. Inner epidermal cells are square shaped compactly arranged one above the other. In between radially arranged rectangular, flat radial cells are present, which are arranged one above the other and are compactly arranged. But in few species they are loosely arranged. (Fig. 2, E).

- **Anatomical features of mesocotyl similar for all studied species, so that it will not described again in description of plants.**

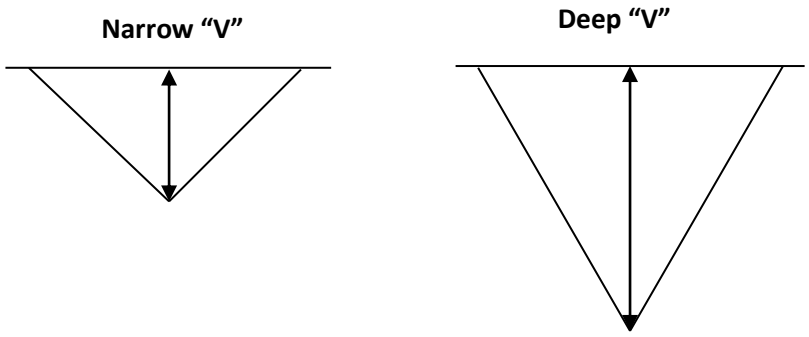
4. Scutellum is considered as the single cotyledon of grasses. It is shield like, and attached to the embryo axis functioning in absorbing food stored in the endosperm by secreting enzymes and transporting the food back to the embryo via vascular strands. It partially surcirculars the embryo axis and is continuous with coleorhiza. In between scutellum and coleorhiza a small gap is present which is known as scutellum slit or cleft. Cleft may or may not be present in all the caryopsis. The outer most layer of the scutellum consists of short, uniformly columnar cells known as scutellar epithelium. Scutellum extends to the apical portion of the embryonic axis.

When viewed in cross section, scutellum is "V" or "U" or "Δ" shaped.

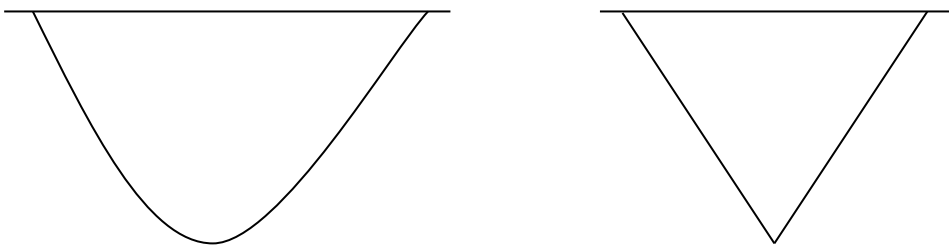
(I) "V" shaped: It is further classified into different categories: V1-V9: (Fig. 3, A-R). Depending on the angle of the arms of "V" measured as shown below:



Further the depth of the scutellum has been categorized as narrow and short on the basis of the distance (measurement) of anterior-posterior axis as shown below:



Similarly the base of the scutellum may be circular or tapering as shown below



Microphotographs of the different types of scutellum based on the above mentioned characteristic features have been represented in Fig. 3.

V1: deep "V" shaped with flat anterior side and having circular base.

Based on angle of arms of "V", this is again divided into two categories:

V1-1: angle is 63.2±4.72 (Fig. 3, A).

V1-2: angle is 75.6±5.83 (Fig. 3, B).

V2: deep "V" shaped with flat anterior side and having pointed base, at an angle of 52.1±4.27 (Fig. 3, C).

V3: deep "V" shaped with convex anterior side and having circular base.

Based on angle of arms of "V", this is again divided into six categories:

V3-1: arms of "V" at an angle of 89.4±6.48 (Fig. 3, D).

V3-2: arms of "V" at an angle of 68.9±3.46 (Fig. 3, E).

V3-3: arms of "V" at an angle of 63.9±5.37 (Fig. 3, F).

V3-4: arms of "V" tapering having angle 53.4±5. 42 (Fig. 3, G).

V3-5: arms of "V" broad arm end with angle 82.23±3.46 (Fig. 3, H).

V3-6: having angle 43.2±7.38 (Fig. 3, I).

V4: deep "V" shaped with convex anterior side and having pointed base.

Based on angle of arms of "V", type V4 can be categorized into:

V4-1: angle is 27.2±4.39 (Fig. 3, J).

V4-2: angle is 45.3±6.78 (Fig. 3, K).

V5: deep "V" shaped with concave anterior side and having circular base with angle 52.9±3.78 (Fig. 3, L).

V6: narrow "V" shaped with flat anterior side and having circular base with angle 61.2±6.24 (Fig. 3, M).

V7: narrow "V" shaped with convex anterior side and having circular base with angle 69.5±7.46 (Fig. 3, O).

V8: narrow "V" shaped with convex anterior side and having pointed base.

Based on angle of arms of "V", this is again divided into three categories:

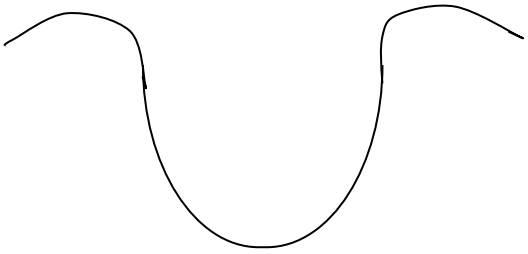
V8-1: angle is 55.6±9.67 (Fig. 3, P).

V8-2: angle is 69.9±2.47 (Fig. 3, Q).

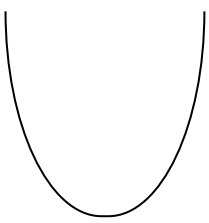
V8-3: angle is 63.7±3.21 (Fig. 3, R).

V9: narrow "V" shaped with concave anterior side and having circular base with angle 64.9±2.58 (Fig. 3, N).

(II) "U" shaped: It is divided into two categories as shown below: (Fig. 4, A-E).



Type U1: Arms of "U" overarches cover the embryo



Type U2:Arms of "U" extend only upto embryo surface

Type U1: arms of "U" overarch and cover the embryo (Fig. 4, A-B). On the basis of the angle of arms and shape, it is further divided into two categories.

U1-1: deep "U" with concave anterior side having an angle 41.9±5.73 (Fig. 4, A). The arms of extend out giving a horse shoe shaped form to the embryo.

U1-2: deep "U" with convex circular anterior side and having an angle 65.7±8.31 (Fig. 4, B).

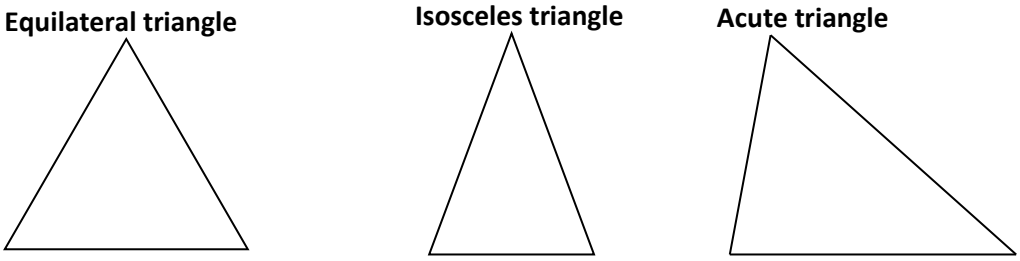
Type U2: The arms of "U" extend only upto the embryo surface, not extending further (Fig. 4, C-E). On the basis of the angle of arms and shape, it is divided into three categories.

U2-1: narrow "U" with flat anterior side having an angle 59.3±4.84 (Fig. 4, C).

U2-2: deep "U" with concave anterior side having an angle 55.3±2.39 (Fig. 4, D).

U2-3: narrow "U" with convex anterior side having an angle 62.1±4.83 (Fig. 4, E).

(III): "Δ" shaped: It is divided into seven categories: (Fig. 4, F-L).



Δ1: isosceles with flat base having angle 35.8±3.74 (Fig. 4, F).

Δ2: isosceles with flat base having angle 52.4±5.51 (Fig. 4, G).

Δ3: isosceles with circular base having angle 38.2±5.37 (Fig. 4, H).

Δ4: acute triangle with circular base having angle (Fig. 4,I).

Δ5: equilateral with circular base having angle 58.9±2.93 (Fig. 4, J).

Δ6: equilateral with flat base having angle 58.7±4.73 (Fig. 4, K).

Scutellum cells are circular to oval in shape but sizes varies from species to species. The scutellum extends downwards to blend with the ventral portion of the coleorhiza.

Vascularisation: Vascular strand of the embryo extends lengthwise through the embryo, and splits at one point with one strand going into the scutellum and the other going to the coleoptiles. Vascular bundle connecting the embryonal axis with the scutellum traves from the mesocotyl. In grass caryopses, most striking feature is the curvature of the embryo, which is so strong that the inner faces of plumule and the radicle are contiguous. It is evidently due to this condition that no trace of an epiblast

is seen. According to Schlickum (1896), the coleoptiles of the grasses differes essentially from the leaves following it in the absence of stomata and the presecence of only two vascular bundles. The vascular system which comes from spikelet it divereted into florets through rachilla.

Reeder (1957) analyzed the structure of caryopsis in detail, especially structure of embryo which helps in grass systematics. Characteristic features described by Reeder have been considered to differentiate and characterize caryopses of grasses in the present study. Reeder concentrated on the following four characteristic features of embryo which are having taxonomic significance:

1. The course of the vascular system which may be

   a). Panicoid (denoted as P): The trace to the scutellum and embryonic leaves diverge at approximately the same point.

   b). Festucoid (denoted as F): The trace to the scutellum and embryonic leaves are separated by a more or less elongated internode.

2. The presence or absence of epiblast.

   Epiblast as described earlier is an erect flap, long or short, with an absence of vascular tissue and located on the opposite side of the embryonic axis from the scutellum. Depending on its presence or absence it has been denoted as '+' when present and '-' when absent.

3. The presence or absence of a cleft.

   Cleft means the space present between scutellum and coleorhiza i.e. lower part of scutellum whether free from the coleorhiza or fused to it. (If distinct cleft present than denoted as "P" and if absent than denoted as "F").

4. In the cross section of the embryonic leaf the vasculature has been observed. The vasculature whether has many bundles and overlapping margins or few bundles and margins which merely meet. (If overlapping margins present than denoted as "P" and if margins merely meet than denoted as "F").

On the basis of above four characters, nine different formulas of grass caryopsis have been listed. These nine different formulas categorized into six different groups. Out of which Oryzoid-olyroid group have three formulas and true festucoids have two forumulas while other groups have single formula. Diagrammatic representation of the different types has been described in Diagram 2.

Characteristic features of the six groups are as given below:

(1). True festucoids: The species having embryo with the formula **"F+FF"**. These are characterized by festucoid vascularization, presence of epiblast, no cleft between the scutellum and coleorhiza and in cross section the primary leaf is

seen to have relatively few bundles and margins which do not overlap. Few species having the formula **"F-FF"** are also true festucoid but they showed absence of epiblst.

(2). True panicoids: The genera in which the embryo has the formula **"P-PP"**. The embryos are characterized by having panicoid vascularization, no epiblast, a distinct cleft between the scutellum and coleorhizae, and in transverse section the primary leaf with its numerous vascular bundles has overlapping margins.

(3). Chloridoid-Eragrostoid type: The embryo has the formula **"P+PF"**. These embryos are basically panicoid in that they are characterized by that type of vascularization and lower part of the scutellum free from the coleorhiza. They resemble festucoids in that they have an epiblast and in transverse section, the margins of the leaves do not ordinarily overlap.

(4). Bambusoid type: The embryo has the formula **"P+PP"**. These are basically panicoid but differing principally in the presence of a more or less developed epiblast.

(5). Oryzoid-Olyroid type: In these combination of genera in which embryos of the formulae **"F-PP", "F+PP"** and **"F+FP"**. All have a festucoid type of vascularization and panicoid embryonic leaf. In most of genera shows presence of epiblast and there is usually a cleft between the coleorhiza and scutellum.

(6). Arundinoid-Danthonioid type: Those genera having embryos of the formula **"P-PF"**. They are basically panicoid and differ only in that the embryonic leaf has few vascular bundles and margins which merely meet rather than numerous bundles and overlapping margins.

Two types of vascularizations are present (shown in longitudinal section):

1. Panicoid (Fig. 4, L)
2. Festucoid (Fig. 4, M)

In the cross section, embryonic leaf shows two different types of arrangement:

1. P-type: overlapping margins with many bundles (Fig. 5, A)
2. F-type: margins merely meet with few bundles (Fig. 5, B)

Angle of vascularization: i.e. vascular bundle which come from the radicle and goes into the plumule. It is classified into different classes:

Type - A: less than 130° (Fig. 5, C)

Type - B: 130°- upto 150° (Fig. 5, D)

Type - C: 150°- upto 170° (Fig. 5, E)

Type - D: 170° and above (Fig. 5, F)

Endosperm: Endosperm is major reserve food storage of caryopsis. It is source of feed for embryo when it germinates and cells may be multinucleate. It has polygon i.e. isodiametric storage cells which contain starch grains, the type of which varies in different species. Starch grains may be simple, elliptic to circular, hexagonal, pentagonal or rectangular or may be mixture of simple and compound grains with few granules.

Generally the endospermal cells which are present towards the pericarp are smaller, flattened next to the aleurone layer and the cells which are present towards the center are bigger in size (Fig. 6, H). The cells which are interior contain mostly starch while those toward the periphery contain mostly protein. Seed which were contain were storage starch i.e. starch grians designed for long term storage of energy produced in the amyloplast of seed, roots, tubers, corms, fruits and rhizomes. And the morphology which is genetically contrlloed (Reichert, 1913).

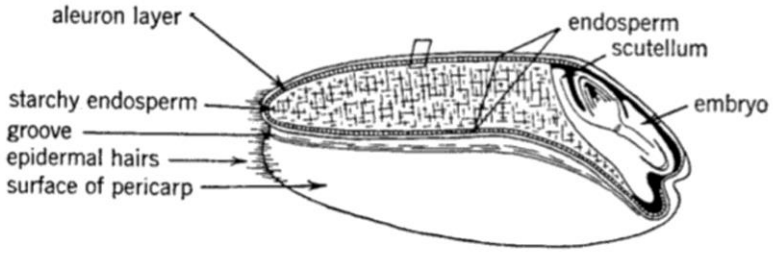
ISCN (2011) described the international code for starch nomenclature. On the bais of which in present study four different types of starch grains were observed:

1. Simple grains (i.e. grains form single) with elliptic to circular shape (i.e. appearing as a circle in which all radii are of equal length) (Fig. 6, A).
2. Simple grains with polygon shape (Fig. 6, B).
3. Simple starch grains having circular and polygon (i.e having more than four sides) shape grains (Fig. 6, C).
4. Mixture of starch grains i.e simple and compound grains (grains that formin aggregates or grains that have more than one center of formation within or single amyloplast, Fahn, 1990) both are present together (Fig. 6, D,E).

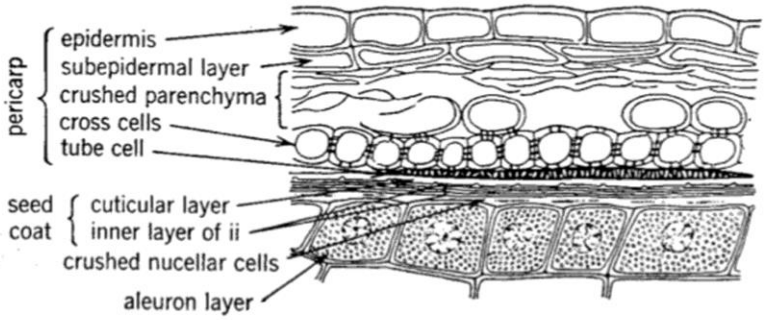
Aleurone layer: It is single layered structure present after pericarp. It is uniseriate and continuous acircular the entire endosperm. The alerurone layer is lacking at the scutellum adaxial apex above its ventral scale downwards to the place where the caryopsis comes in contact with the basal scutellum.

Aleurone cells are of different shapes:

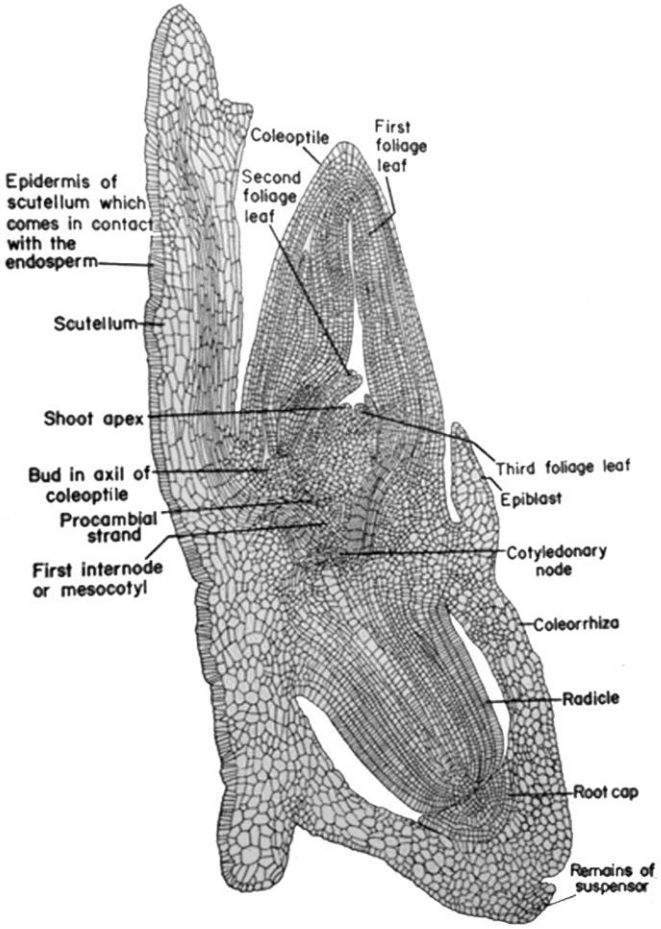
- Vertically elongated rectangular shaped (Fig. 6, G)
- Both types i.e. square and rectangular of cells present together (Fig. 6, H).
- Tangentailly elongated rectangular shaped (Fig. 6, I)
- Square shaped (Fig. 6, J)



A: Caryopsis of Wheat



B: Pericarp of Wheat caryopsis



C: Longitudinal section of Wheat caryopsis

Diagram 1: General anatomy of grass caryopsis (Easu(1953) Plant anatomy)

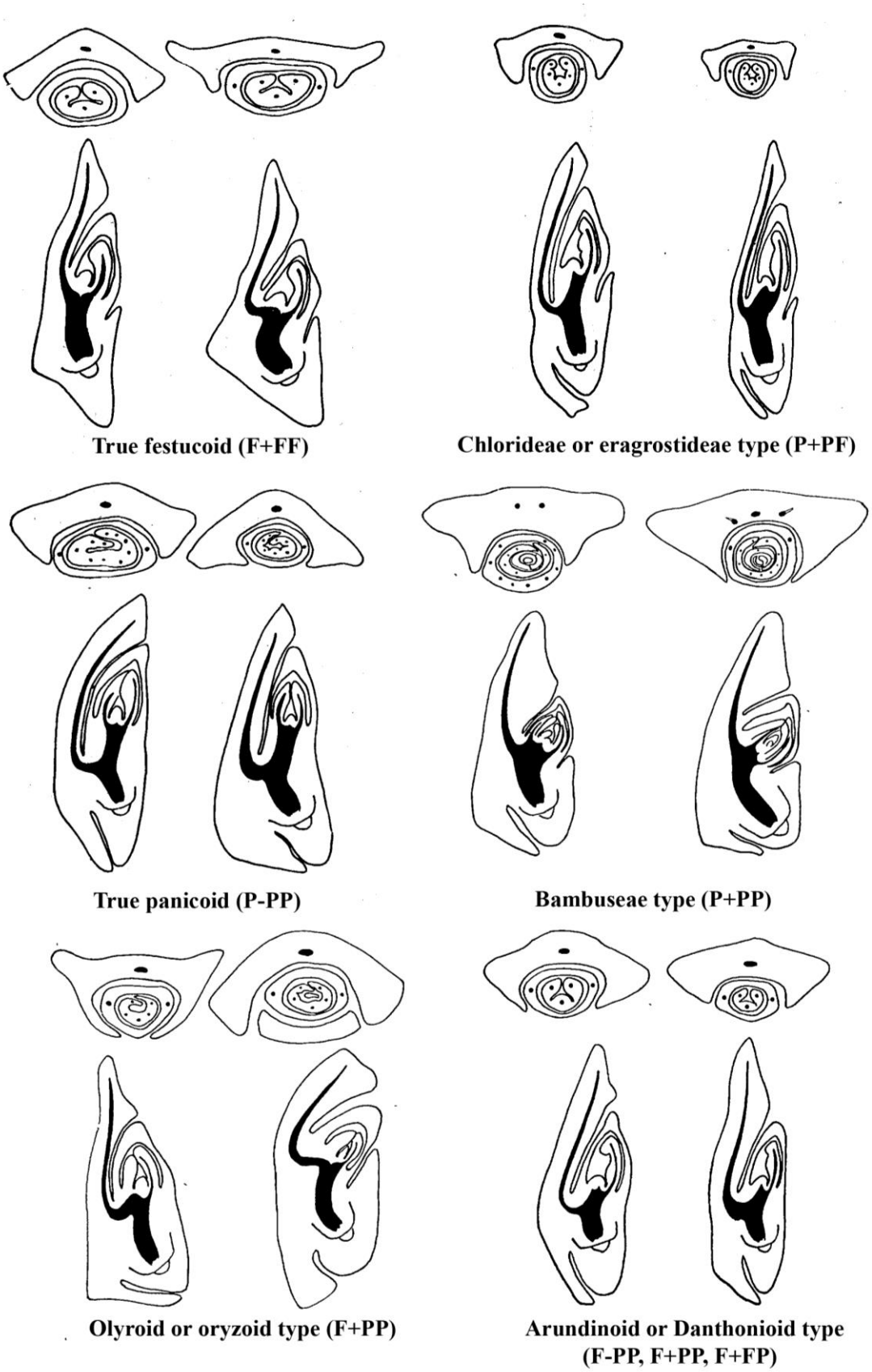


Diagram 2: Different types of embryo (Adapted from Rheeder (1957))

Moprhometric analysis / Histoarchitechtural analysis of caryopsis

Abbrevations used in figures

Cole- coleorhiza

r- radicle

me- mesocotyl

pl- plumule

Coleo- coleoptiles

Sl- scutellum slit

ep- epiblast

S- scutellum

e- endosperm

St- starch grain

a-aleurone layer

p- Pericarp

d- depletion layer

em- embryo

Fig. 1: Different types of pericarp in caryopsis and angles of embryo

A-D: Different types of pericarp

A: Type – A (arrow-epidermis, squiggle arrow-hypodermis, semicircle arrow-cross cells, arrowhead- nucellus)

B: Type – B (arrow-epidermis, squiggle arrow-hypodermis, semicircle arrow - cross cells, arrowhead- nucellus)

C: Type – C (arrow-epidermis, semicircle arrow - cross cells, arrowhead-nucellus)

D: Type – D (arrow-epidermis, semicircle arrow - crushed parenchyma, arrowhead- nucellus)

E-G: Different angles of embryo with respect to anterio-posterior axis caryopsis (line shows angle of embryo)

E: Type – A

F: Type – B

G: Type – C

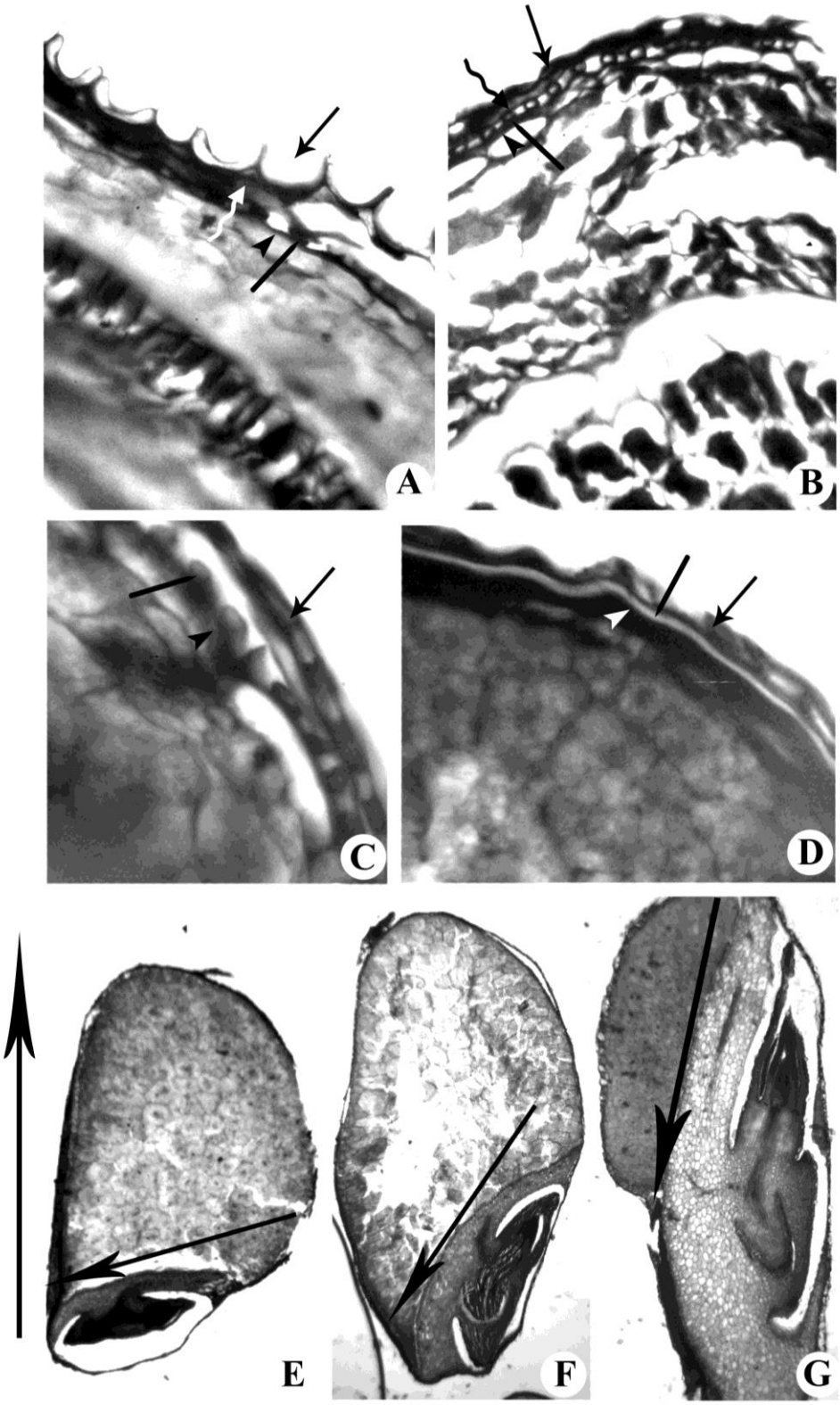


Fig. 1

Fig. 2: Different parts of embryo and types of epiblast

A-G: Different parts of embryo

A: Different parts of embryo (Coleorhiza, coleoptile, plumule, mesocotyl)

B: Enlarge view of embryo showing coleorhiza (square), radical (arrowhead), mesocotyl (arrow)

C: Coleorhiza showing compactly arranged cells (arrow)

D: Isodiametric cells of radicle (arrow)

E: Mesocotyl showing compactly arranged rectangular, flat cells (arrow)

F: Coleoptiles showing squarish to rectangular cells (arrow)

G: Square/rectangular cells of plumule (arrow)

H- L: Different types of epiblast (arrow shows epiblast)

H: Type - I

I: Type - II

J: Type - III

K: Type - IV

L: Type - V

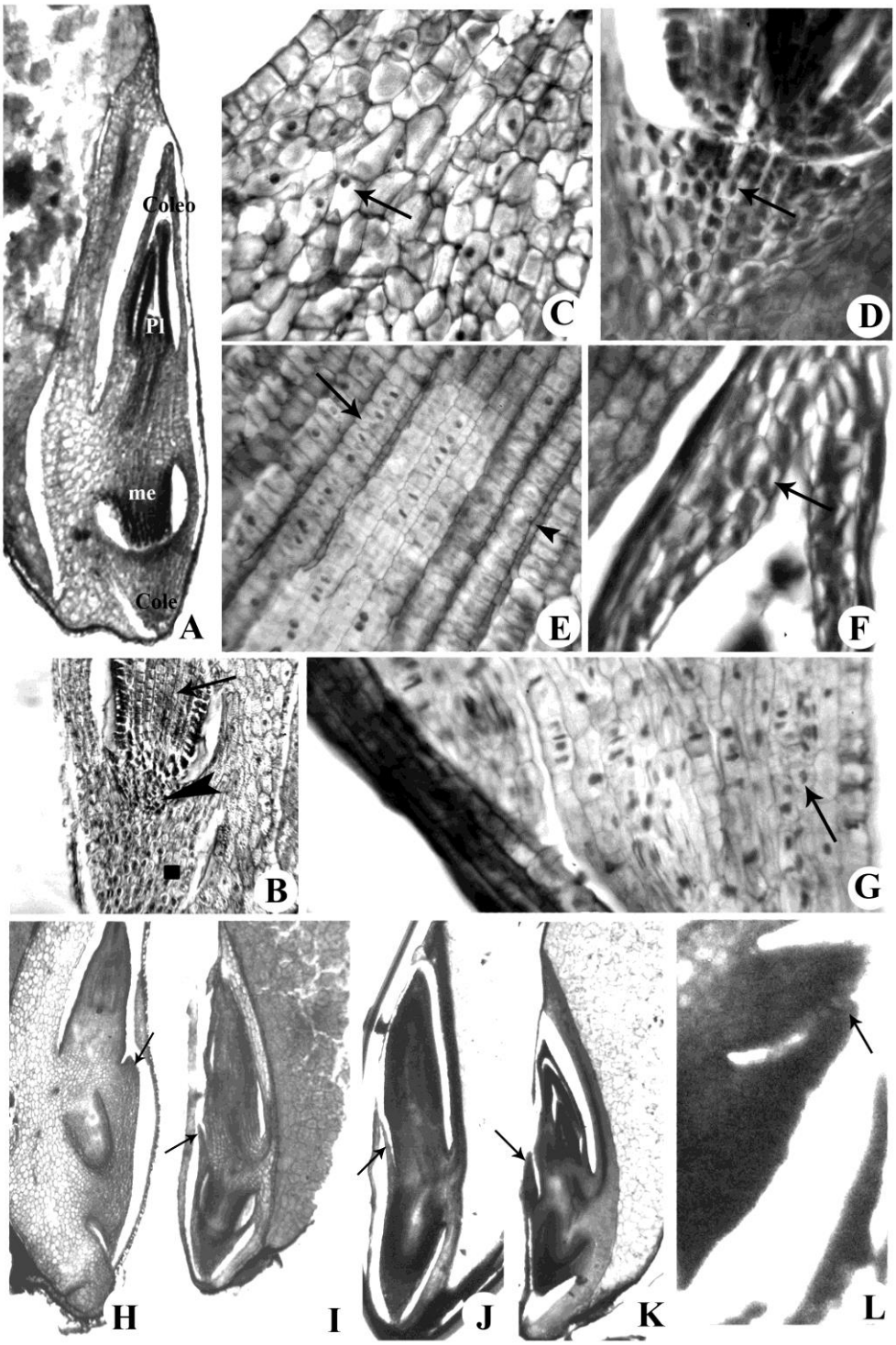


Fig. 2

Fig. 3: Different types of "V" shaped scutellum

A,B: Type V1- Deep "V" with flat anterior side and round base

A: Type V1-1 (angle 63.2±4.72)

B: Type V1-2 (angle 75.6±5.83)

C: Type V2- Deep "V" with flat anterior side and pointed base (52.1±4.27)

D-I: Type V3- Deep "V" with convex anterior side and round base

D: Type V3-1(angle 89.4±6.48)

E: Type V3 -2(angle 68.9±3.46)

F: Type V3-3(angle 63.9±5.37)

G: Type V3-4(angle 53.4±5. 42)

H: Type V3-5(angle 82.23±3.46)

I: Type V3-6(angle 43.2±7.38)

J,K: Type V4- Deep "V" with convex anterior side and pointed base

J: Type V4-1 (angle 45.3±6.78)

K: Type V4-2 (angle 27.2±4.39)

L: Type V5- Deep "V" with concave anterior side and round base (angle 52.9±3.78)

M: Type V6- Narrow "V" with flat anterior side and round base with angle (angle 61.2±6.24)

N: Type V9- Narrow "V" with concave anterior side and round base (angle 64.9±2.58)

O: Type V7- Narrow "V" with convex anterior side and round base (angle 69.5±2.46)

P-R: Narrow "V" with convex anterior side and pointed base

P: Type V8-1 (angle 55.9±3.67)

Q: Type V8-2 (angle 61.8±2.47)

R: Type V8-3 (angle 65.7±3.21)

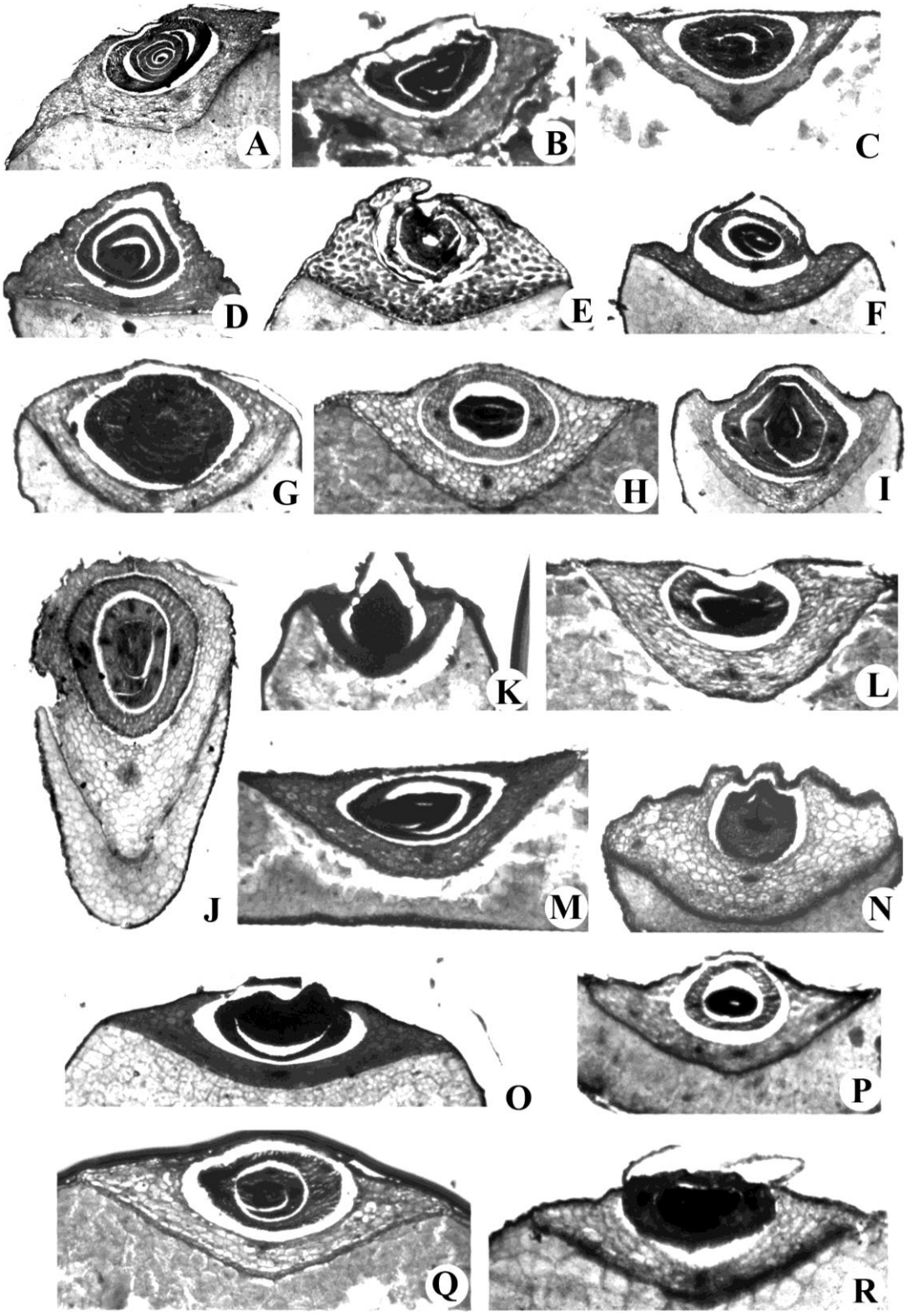


Fig. 3

Fig. 4: Different types of "U" and "Δ" shaped of scutellum, different types of vascularization

A-E: "U" shaped of scutellum

A,B: Type – U1- Deep "U"with concave anterior, arms of "U" overarch and cover the embryo

A: Type – U1-1- Deep "U" with concave anterior side (angle 41.9±5.73)

B: Type – U1-2- Deep "U" with convex round anterior side (angle 65.7±8.31)

C-E: Type – U2- Arms of "U" extend only upto the embryo surface, not extending further

C: Type – U2-1- Narrow "U" with flat anterior side angle (59.3±4.84)

D: Type – U2-2- Deep "U" with concave anterior side (angle 55.3±2.39)

E: Type – U2-3- Narrow "U" with convex anterior side (angle 62.1±4.83)

F-L: "Δ" shaped scutellum

F: Type - Δ1- Isosceles with flat base (angle 35.8±3.74)

G: Type - Δ2- Isosceles with flat base angle (52.4±5.51)

H: Type - Δ3- Isosceles with round base (angle 38.2±5.37)

I: Type - Δ4- Acute triangle with round base (angle 80.2±3.53)

J: Type - Δ5- Equilateral with round base (angle 58.9±2.93)

K: Type - Δ6- Equilateral with flat base (angle 58.7±4.73)

L, M: Types of vascularization

L: Fetucoid type of vascularization

M: Panicoid type of vascularization

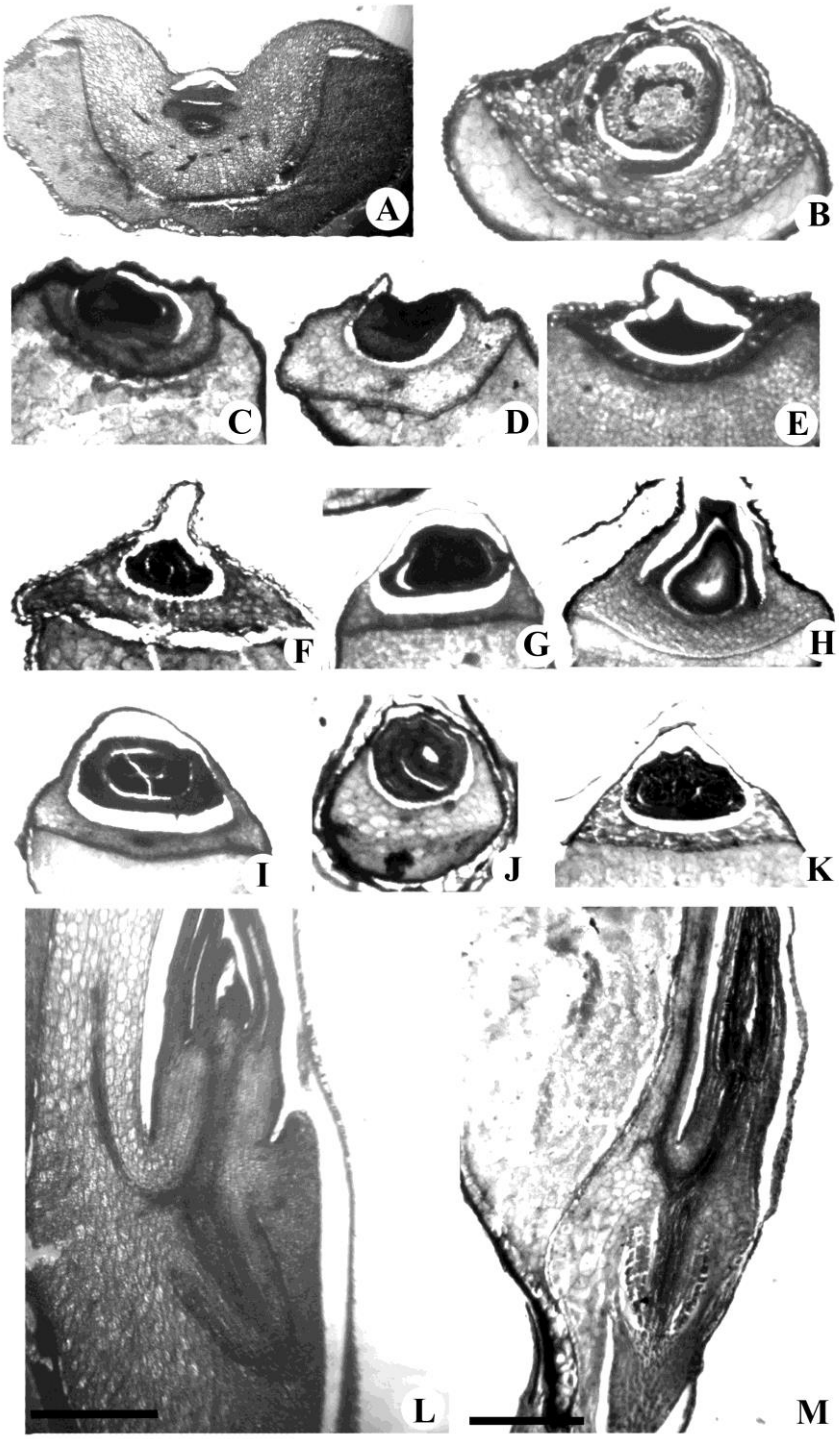


Fig. 4

Fig. 5: Different arrangements of embryonic leaf and different angles of vascularization

A, B: Arrangements of embryonic leaf

A: Panicoid type of arrangment

B: Festucoid type of arrangement

C – F: Different angles of vasculrization

C: Type – A

D: Type – B

E: Type – C

F: Type – D

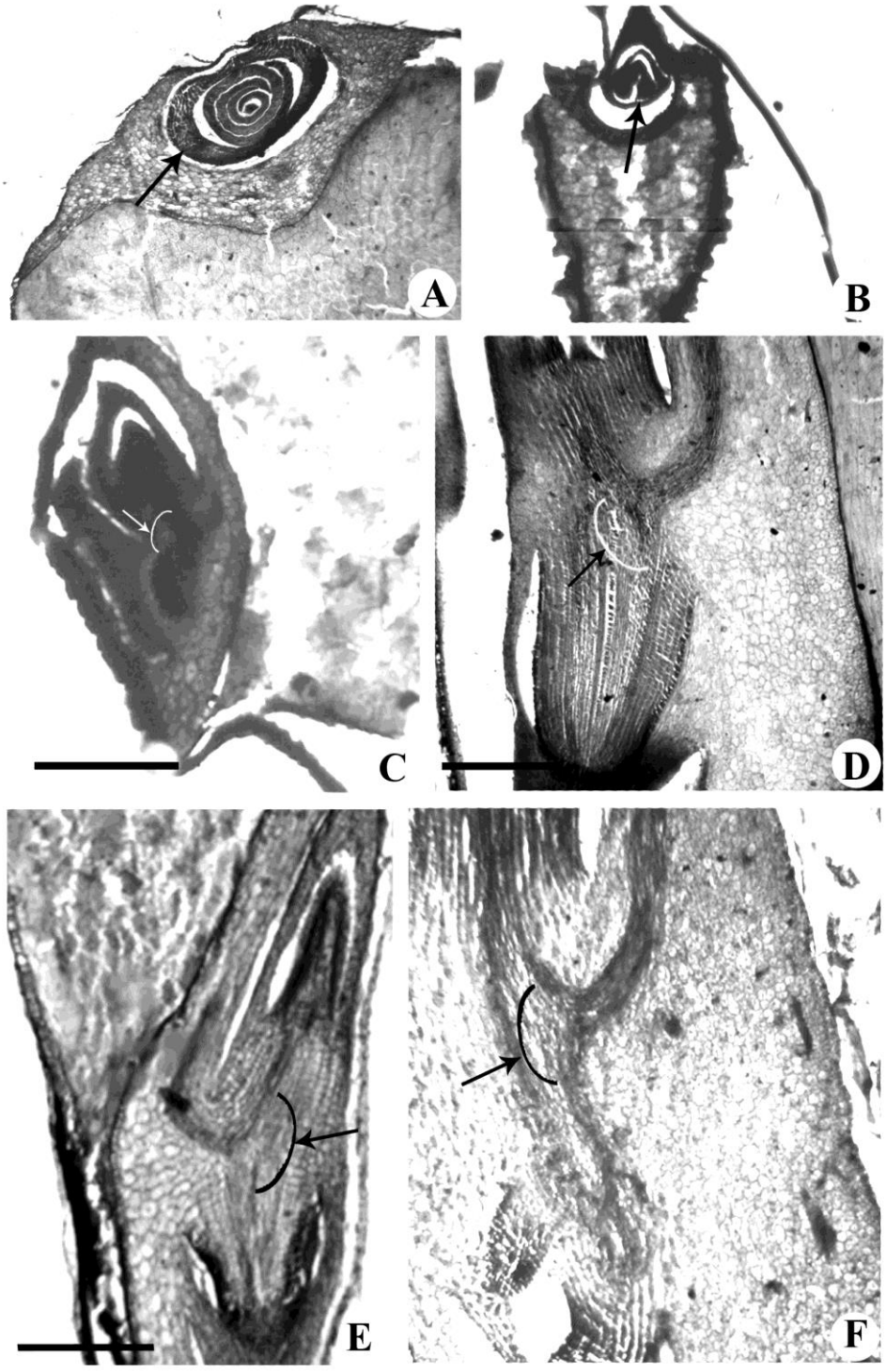


Fig. 5

Fig. 6: Different types of starch grain and aleurone layer

A-F: Types of starch grains

A: Simple with round to elliptic shape

B: Simple with penta to hexagonal shape

C: Simple starch grains- having round (arrowhead) and penta to hexagonal (arrow) shape

D,E: Mixed starch grains- simple and compound starch grains (arrow shows compound starch grains)

F: Towards aleurone layer (denoted as A) small starch grains (arrowhead) and towards embryo larger starch grains (arrow) present

G-J: Types of aleurone layer

G: Vertical rectangular aleurone cells

H: Mixed shaped aleurone cells- square (arrow) and rectangular (arrowhead) shaped

I: Horizontal and rectangular aleurone cells

J: Square shaped aleurone cell

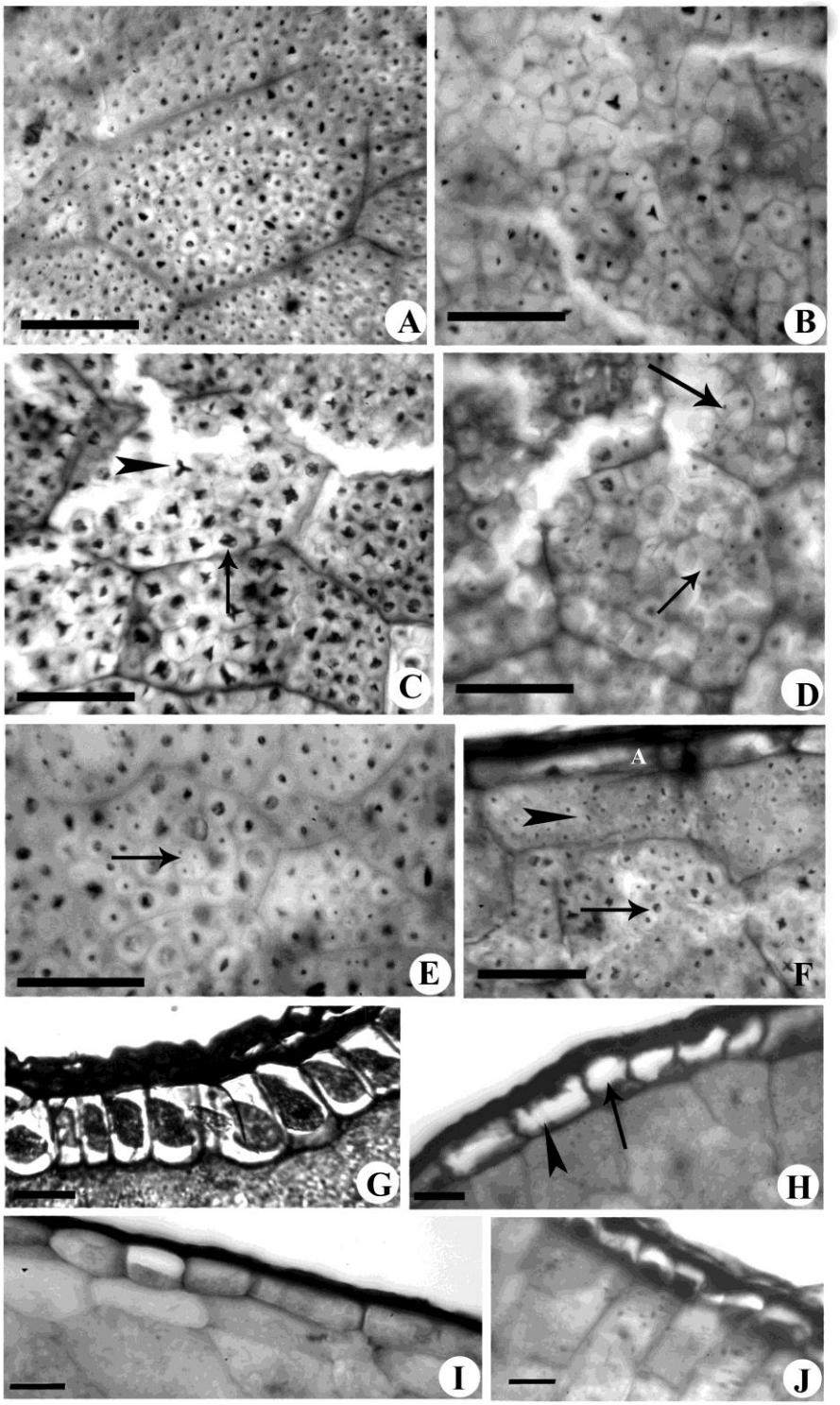


Fig. 6

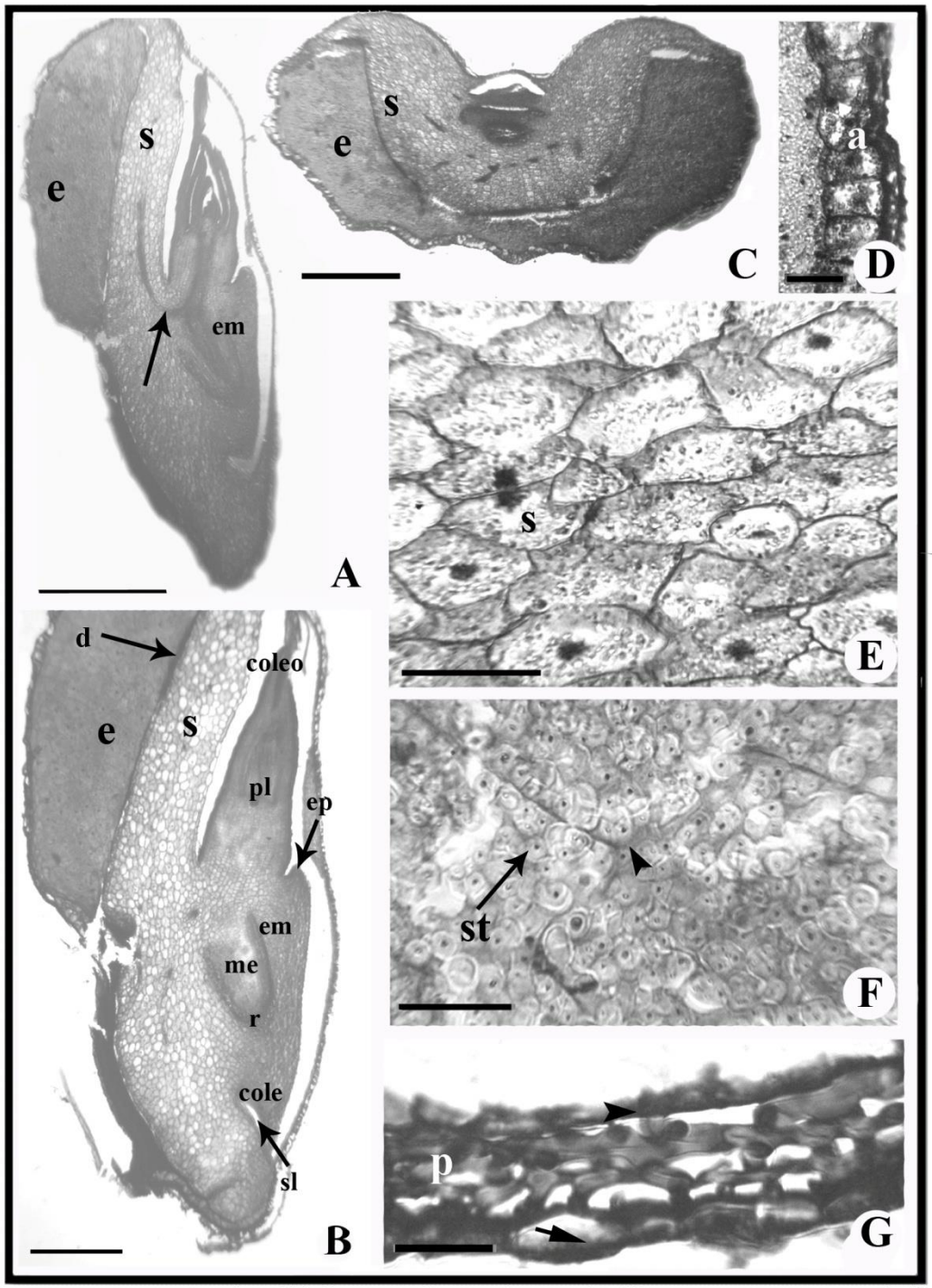
MORPHOMETRIC / HISTOARCHITECHTURAL ANALYSIS OF CARYOPSIS ANATOMY

1. *Chionachne koenigii* (Fig. 7(1) A-G)

Shape: Kidney shaped in transaction and having size 1.39 (L) X 3.34 (B) mm (Fig.C).
Pericarp: Type B (Fig. G; epidermis (arrowhead), nucellus (arrowhead)).
Embryo: Type C - Embryo placed an angle of 172.3°. Type I epiblast (Fig. A, B).
Scutellum: "U" shaped: Type U1-1, having an angle of 41.9°. Scutellum cleft/slit is present.Oval shaped scutellum cells. Depletion layer is present (Fig. C, E).
Vascularisation: Type of vascularisation: Festucoid (Fig. A)
Angle of vascularisation: 165.6°**,** Type – C.
Pattern of embryonic leaf: P- type
Endosperm: Polygon shaped endospermic cells.
Starch grain: Some cells have simple circular shaped starch grains, some cells have simple circular shaped and compound starch grains are present together (Fig. F).
No. of starch grains per endosperm cell: 63±4 **Starch grain size:** 2.09±0.73 (µm)
Aleurone layer: Vertically elongated rectangular shaped aleurone cells (Fig. D).
Caryopsis type and formula: Oryzoid-Olyroid type and having formula F+PP.
Bar Size: A & C=125 µm, B= 85.5 µm, D-G=12.5 µm

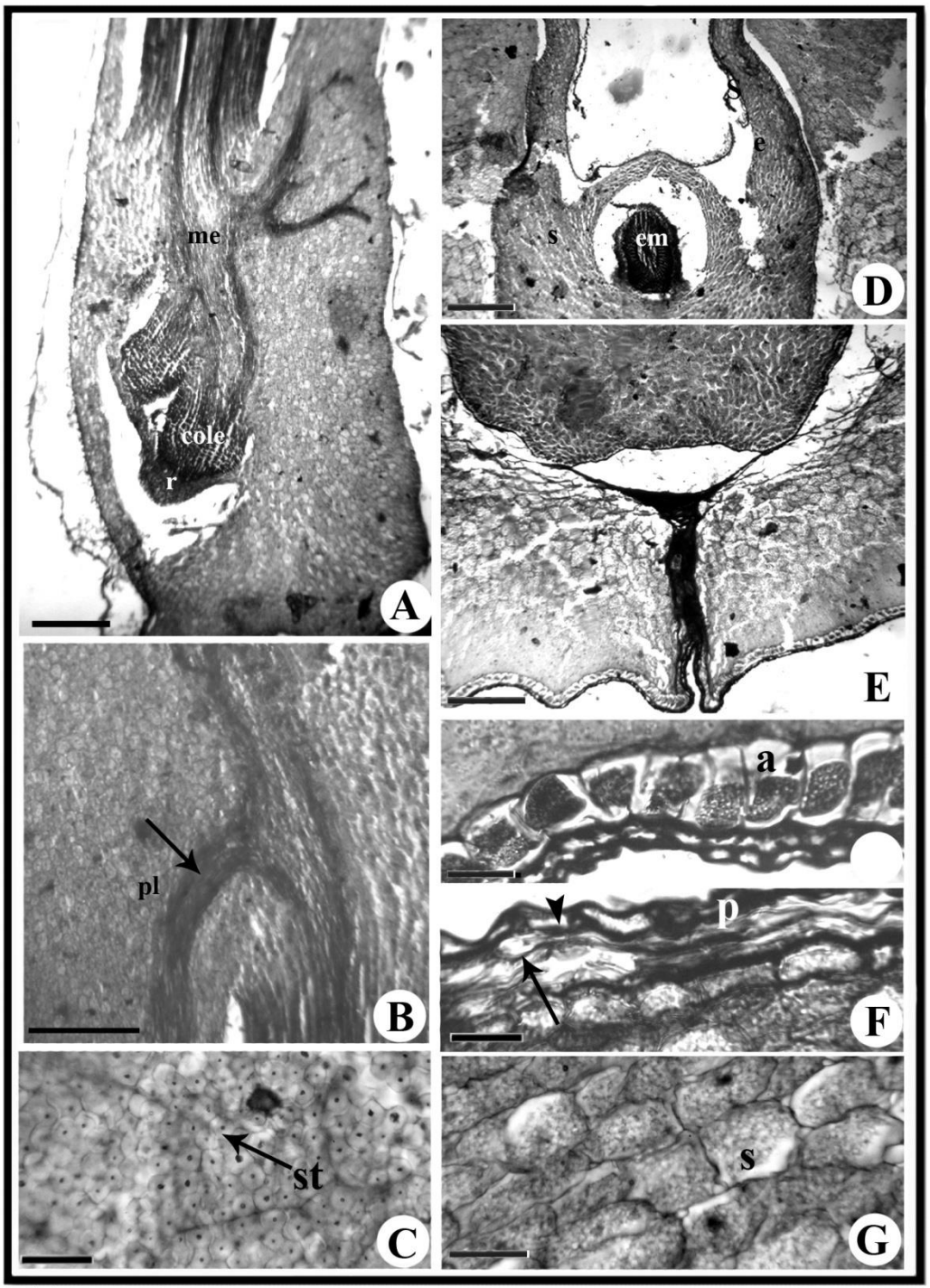
2. *Coix lachryma-jobi* (Fig. 7(2) A-H)

Shape: Oblong to circular in transaction with wavy anterior and posterior end and having size 2.57 (L) X 4.38 (B) mm (Fig. D, E).
Pericarp: Type B (Fig.G; epidermis (arrowhead), hypodermis (arrow)).
Embryo: Type C - Embryo placed an angle of 163.9°. Epiblast is absent (Fig. D).
Scutellum: "U" shaped: Type U1-1, having an angle of 35.82°. Scutellum cleft/slit is present (Fig. A). Oval shaped scutellum cells .Depletion layer is present (Fig. D, H).
Vascularisation: Type of vascularisation: Panicoid (Fig. B)
Angle of vascularisation: 177.9°**,** Type – D.
Pattern of embryonic leaf: P- type
Endosperm: Polygon shaped endospermic cells.
Starch grain: Simple circular and polygon shaped starch grains (Fig. C).
No. of starch grains per endosperm cell: 87±7 **Starch grain size:** 5±2.54 (µm)
Aleurone layer: Vertically elongated rectangular shaped aleurone cells (Fig. F).
Caryopsis type and formula: True panicoids type and having formula P-PP.
Bar Size: A, B, D, E =125 µm, C, E-G=12.5 µm



1. *Chionachne koenigii*

Fig. 7



2. *Coix lachryma-jobi*

3. *Andropogon pumilus* (Fig. 8(3) A-E)

Shape: Rectangular to oval shaped in transaction and having size 0.27 (L) X 0.45 (B) mm (Fig. B).

Pericarp: Type C.

Embryo: Type C - Embryo placed an angle of 167.7°. Epiblast is absent.

Scutellum: "V" shaped: Type V3-4, having an angle of 52.67°. Scutellum cleft/slit is present. Oval shaped scutellum cells. Depletion layer is present (Fig. D).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 167.5°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple polygon shaped starch grains (Fig. E).

No. of starch grains per endosperm cell: 48±5 **Starch grain size:** 7.29±3.72 (µm)

Aleurone layer: Tangentially elongated rectangular shaped alerurone cells (Fig. C).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C- E=12.5 µm

4. *Apluda mutica* (Fig. 8(4) A-G)

Shape: Circular to oval shaped in transaction and having size 0.54 (L) X 0.39 (B) mm.

Pericarp: Type C (Fig. G; epidermis (arrowhead), hypodermis (arrow)).

Embryo: Type B - Embryo placed an angle of 154.4°. Epiblast is absent (Fig. A).

Scutellum: "V" shaped: Type V3-2, having an angle of 66.93°. Scutellum cleft/slit is present .Oval shaped scutellum cells. Depletion layer is present (Fig. D).

Vascularisation: Type of vascularisation: Panicoid (Fig. C)

Angle of vascularisation: 141.3°**,** Type – B.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

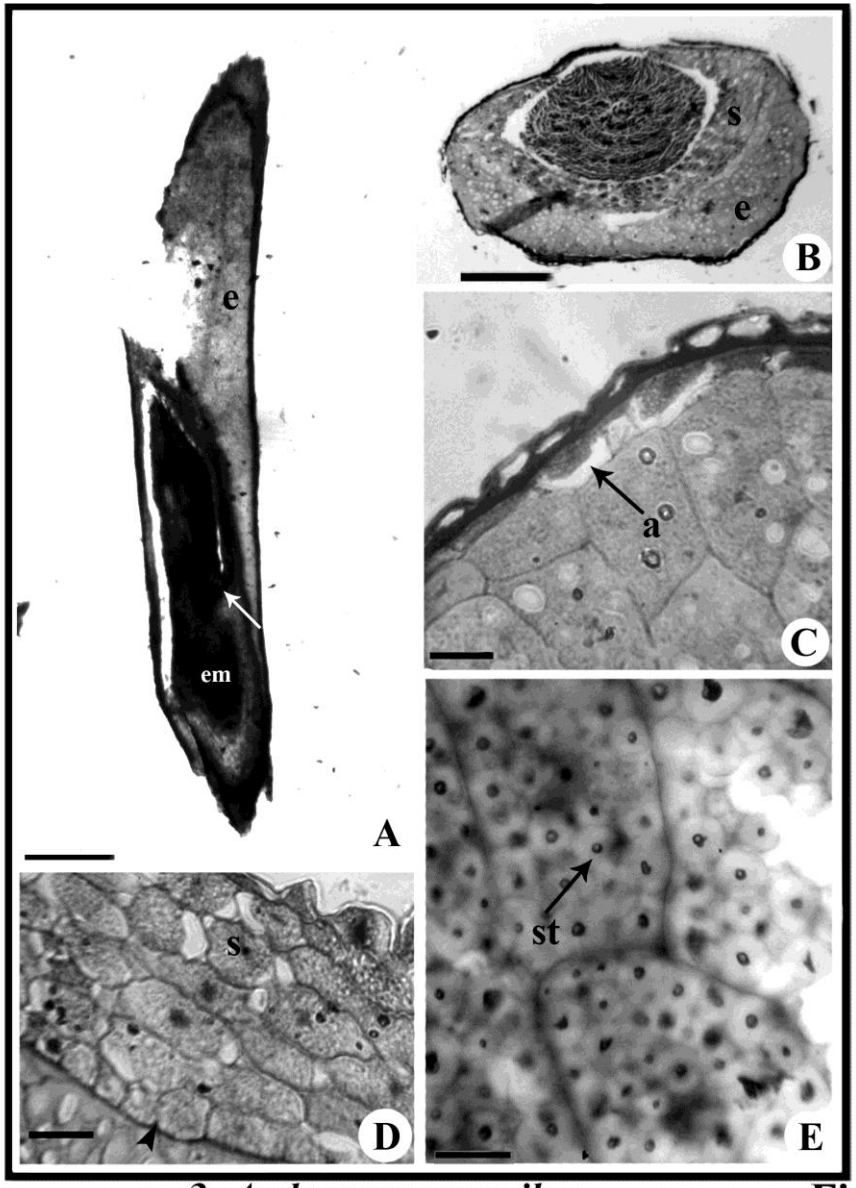
Starch grain: Simple circular and polygon shaped starch grains (Fig. F, arrow).

No. of starch grains per endosperm cell: 43±3 **Starch grain size:** 5±1.50 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. F).

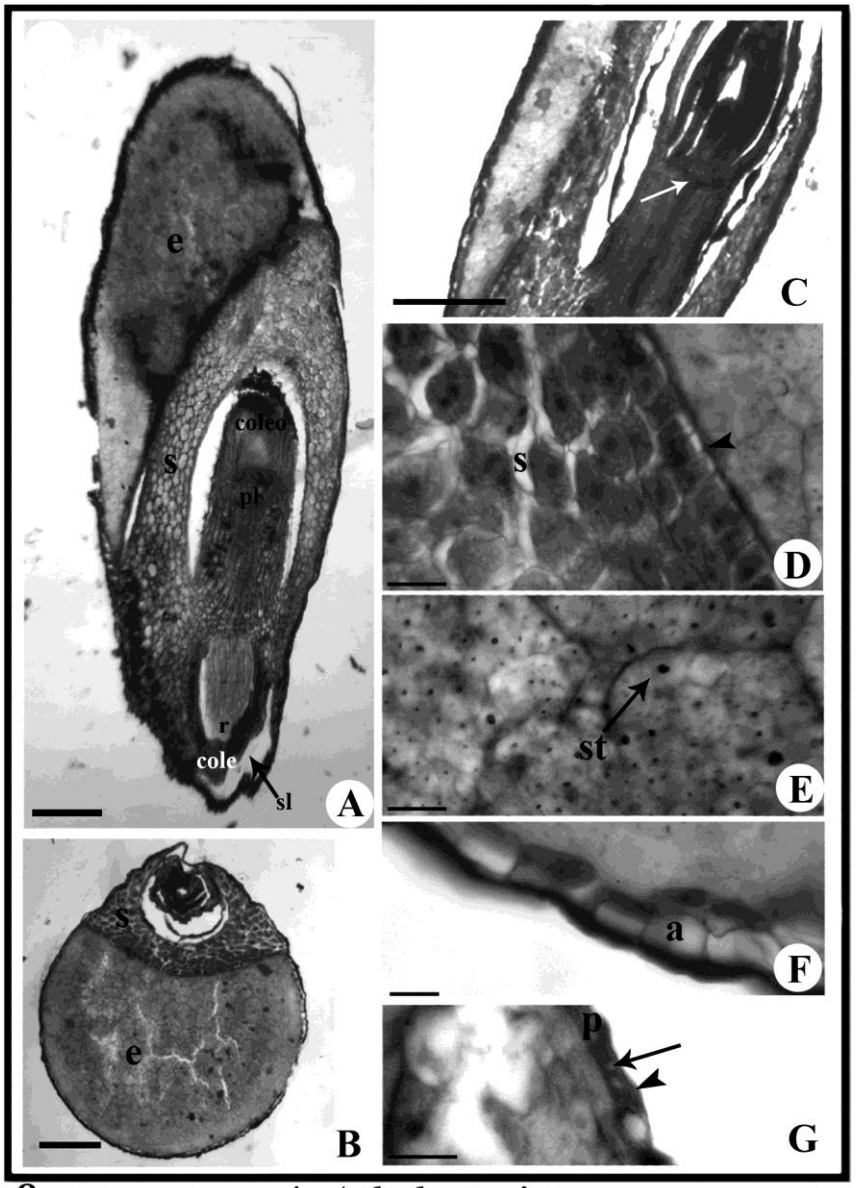
Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C= 85.5 µm, D- E=12.5 µm



3. *Andropogon pumilus*

Fig. 8



4. *Apluda mutica*

5. *Arthraxon lanceolatus* (Fig. 9(5) A-F)

Shape: Kidney shaped in transaction and having size 0.38 (L) X 0.31 (B) mm (Fig.B).

Pericarp: Type C (Fig. F; epidermis (arrowhead), hypodermis (arrow)).

Embryo: Type C - Embryo placed an angle of 170.5°. Epiblast is absent (Fig. A).

Scutellum: "V" shaped: Type V8-3, having an angle of 63.1°. Scutellum cleft/slit is present .Oval shaped scutellum cells. Depletion layer is present (Fig. C).

Vascularisation: Type of vascularisation: Panicoid (Fig. A)

Angle of vascularisation: 168.5°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple polygon shaped starch grains (Fig. E).

No. of starch grains per endosperm cell: 38±6 **Starch grain size:** 4.55±0.64 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. D).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F=12.5 µm

6. *Bothriochloa pertusa* (Fig. 9(6) A-G)

Shape: Oval shaped in cross section, convex anterior side and having size 0.35 (L) X 0.67 (B) mm (Fig. C).

Pericarp: Type C (Fig. G; cross cells (arrowhead), nucellus (arrow)).

Embryo: Type C - Embryo placed an angle of 172.3°. Epiblast is absent (Fig. B).

Scutellum: "V" shaped: Type V8-1-, having an angle of 52.5°. Scutellum cleft/slit is present and it is small, present above the coleorhiza and it covers colerorhiza .Oval shaped scutellum cells .Depletion layer is present (Fig. D).

Vascularisation: Type of vascularisation: Panicoid (Fig. B)

Angle of vascularisation: 156.5° with Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

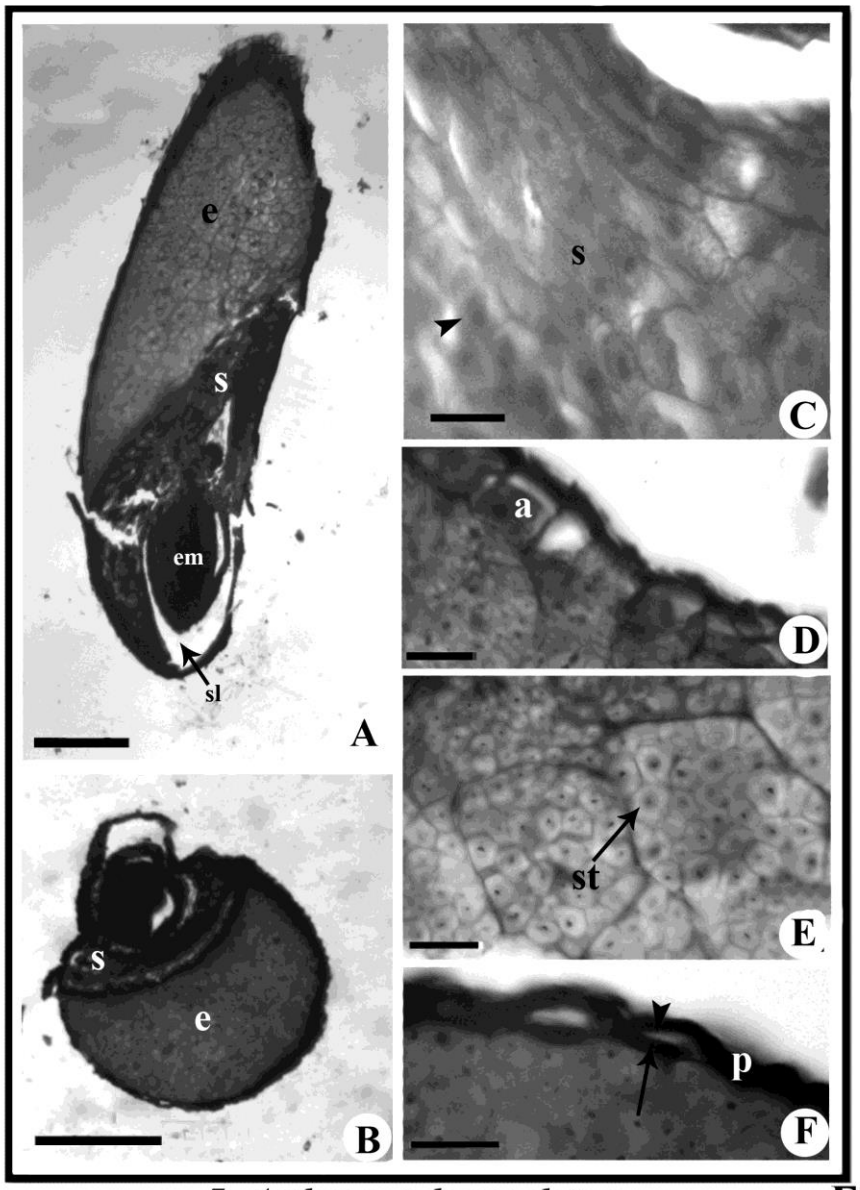
Starch grain: Some cells have simple circular shaped starch grains and some cells have simple circular shaped and compound starch grains are present together (Fig. E; simple (arrow), compound (arrowhead)).

No. of starch grains per endosperm cell: 49±11 **Starch grain size:** 3.41±0.42 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells.

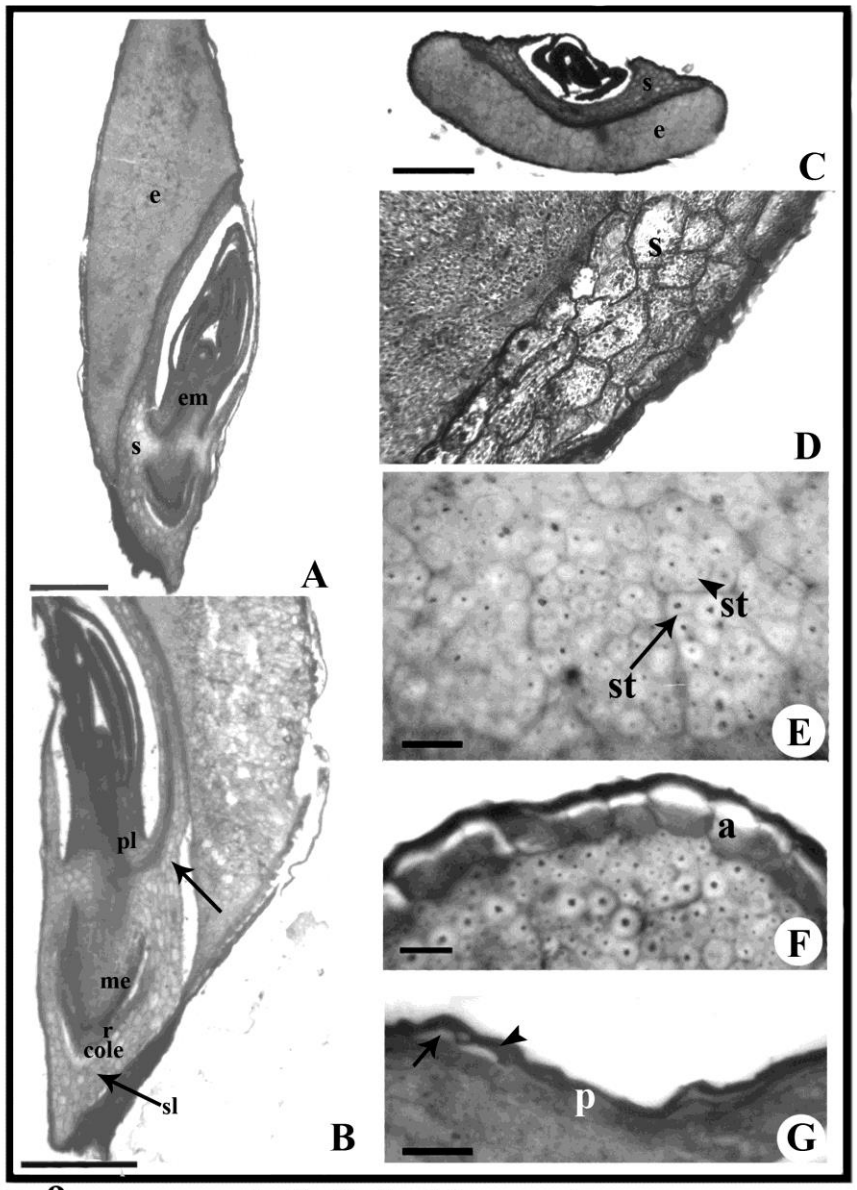
Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A-C =125 µm, D- G=12.5 µm



5. *Arthraxon lanceolatus*

Fig. 9



6. *Bothriochloa pertusa*

7. *Capillipedium hugelii* (Fig. 10(7) A-F)

Shape: Oval to oblong in cross section, convex dorsal surface and having size 0.42 (L) X 0.70 (B) mm (Fig. C).

Pericarp: Type C (Fig. F).

Embryo: Type B - Embryo placed an angle of 172.3° (Fig. A). Epiblast is absent.

Scutellum: "U" shaped: Type U2-3, having an angle of 64.5°. Scutellum cleft/slit is present (Fig. B) and it is present above the coleorhiza and it covers colerorhiza .Oval shaped scutellum cells (Fig. E). Depletion layer is present (Fig. E, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 167.0° with Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: simple circular and polygon shaped starch grains are present together (Fig. E, arrow).

No. of starch grains per endosperm cell: 29±7 **Starch grain size:** 3.75±1.64 (µm)

Aleurone layer: Tangentially elongated rectangulae shaped aleurone cells (Fig. D).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A-C =125 µm, B= 85.5 µm, D- F=12.5 µm

8. *Chrysopogon fulvus* (Fig. 10(8) A-F)

Shape: Inverted triangular shaped in transaction and having size 1.14 (L) X 0.59 (B) mm (Fig. C).

Pericarp: Type D (Fig. E).

Embryo: Type C - Embryo placed an angle of 173.1° (Fig. A). Epiblast is absent.

Scutellum: "V" shaped: Type V4-1 (Fig. C), having an angle of 26.8°. Scutellum cleft/slit is present .Oval shaped scutellum (Fig. F). Depletion layer is present (Fig. F, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 149.9°**,** Type – B.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

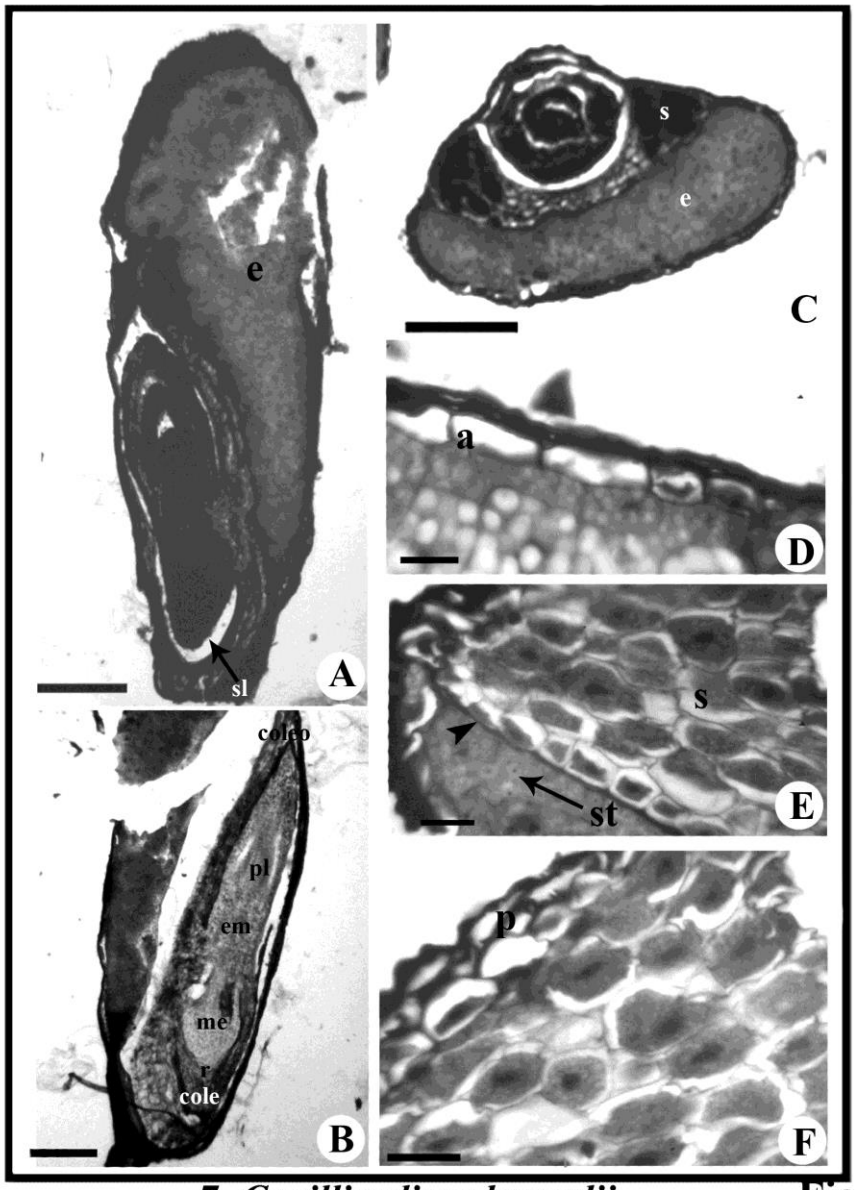
Starch grain: Simple circular (arrow) and polygon shaped starch grains (Fig. D).

No. of starch grains per endosperm cell: 15±4 **Starch grain size:** 6.82±2.49 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells.

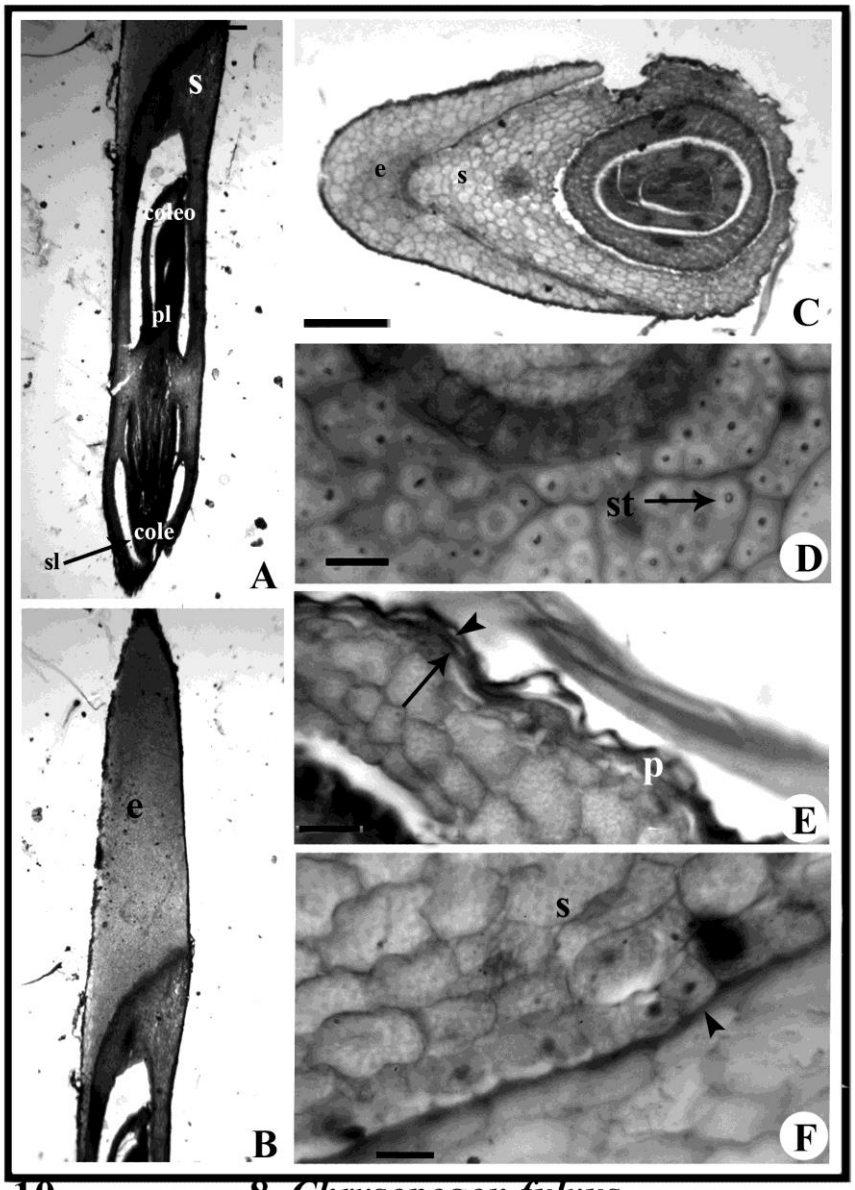
Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A-C =125 µm, D- F=12.5 µm



7. *Capillipedium huegelii*

Fig. 10



8. *Chrysopogon fulvus*

9. *Cymbopogon martini* (Fig. 11(9) A-F)

Shape: Oval shaped in cross section, convex dorsal surface and concave ventral surface, having size 0.36 (L) X 0.69 (B) mm (Fig. B).

Pericarp: Type D (Fig. C).

Embryo: Type C - Embryo placed at an angle of 172.6° (Fig. A). Epiblast is absent.

Scutellum: "V" shaped: Type V3-3 (Fig. B), having an angle of 61.7°. Scutellum cleft/slit is present and it is seen towards scutellum side. Oval shaped scutellum cells (Fig. E) and depletion layer is also present (Fig. E, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: Type – C with 164.2°.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: simple circular starch grains (Fig. F).

No. of starch grains per endosperm cell: 40±6 **Starch grain size:** 9.38±3.72 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. D).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F=12.5 µm

Dichanthium

10. *Dichanthium annulatum*

11. *Dichanthium caricosum*

10. *Dicanthium annulatum* (Fig. 11(10) A-F)

Shape: Oblong shaped in transaction and having size 0.47 (L) X 0.71 (B) mm (Fig. C).

Pericarp: Type B (Fig. E; epidermis (arrowhead), nucellus (arrow)).

Embryo: Type B - Embryo placed an angle of 159.4° (Fig. A). Epiblast is absent.

Scutellum: "V" shaped: Type V3-3 (Fig. C), having an angle of 58.4°. Scutellum cleft/slit is present. Oval shaped scutellum cells. Depletion layer is present.

Vascularisation: Type of vascularisation: Panicoid (Fig. B)

Angle of vascularisation: 177.5°**,** Type – D.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

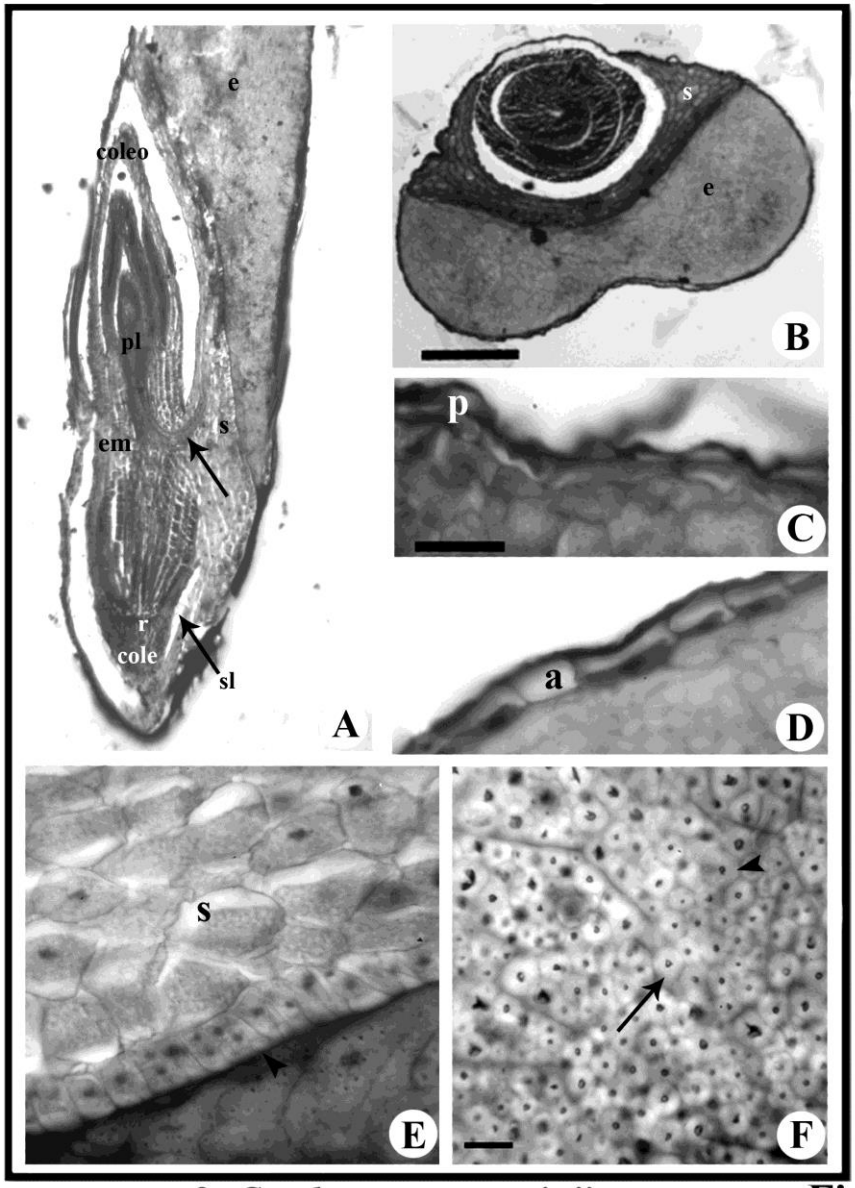
Starch grain: Some cells have simple circular shaped starch grains and some cells have simple circular shaped and compound starch grains are present together (Fig. F).

No. of starch grains per endosperm cell: 29±8 **Starch grain size:** 5.56±1.48 (µm)

Aleurone layer: Vertically elongated rectangular shaped aleurone cells (Fig. D).

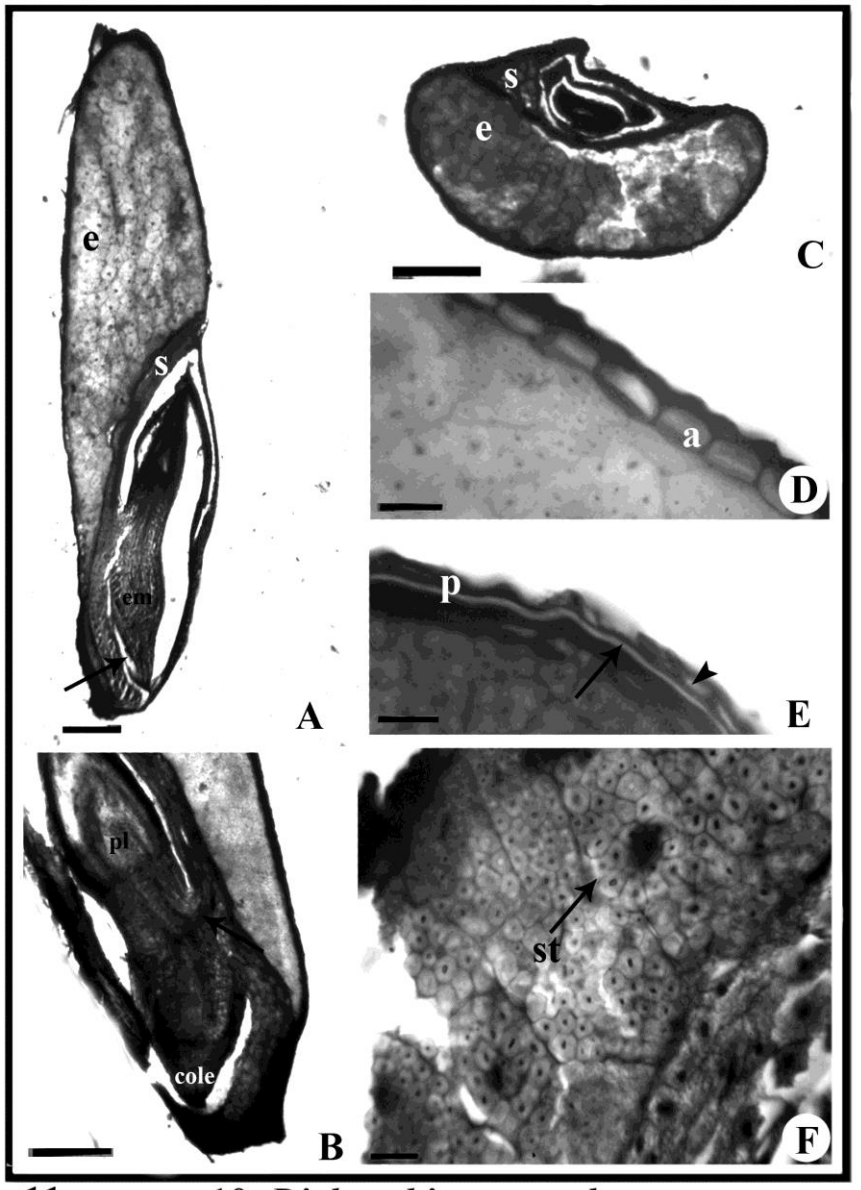
Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A-C =125 µm, D-F=12.5 µm



9. *Cymbopogon martinii*

Fig. 11



10. *Dichanthium annulatum*

11. *Dichanthium caricosum* (Fig. 12(11) A-F)

Shape: Oval shaped in transection, convex dorsal surface, having size 0.47 (L) X 0.93 (B) mm (Fig. B).

Pericarp: Type D (Fig. D).

Embryo: Type C - Embryo placed an angle of 161.42° (Fig. A). Epiblast is absent.

Scutellum: "U" shaped: Type U2-3 (Fig. B), having an angle of 67.1°. Scutellum cleft/slit is present (Fig. A). Oval shaped scutellum cells (Fig. E) and depletion layer is also present (Fig. E, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 169.9°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple polygon starch grains (Fig. F).

No. of starch grains per endosperm cell: 22±5 **Starch grain size:** 5±2.84 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. C).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C- F=12.5 µm

Differentiating features:

Angle of vascularisation- Type D, vertically elongated aleurone cells, embryo type- B. ……..……..*D. annulatum*

Angle of vascularisation- Type C, tangential elongated aleurone cells, embryo type- C ……..……..*D. caricosum*

12. *Hackelochloa granularis* (Fig. 12(12) A-E)

Shape: Oblong to circular shaped in transaction and having size 0.19 (L) X 0.72 (B) mm (Fig. B).

Pericarp: Type C (Fig. E).

Embryo: Type B - Embryo placed an angle of 158.6° (Fig. A). Epiblast is abssent.

Scutellum: "V" shaped: Type Δ5 (Fig. B), having an angle of 41.9°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. D). Depletion layer is present (Fig. D, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 152.5°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

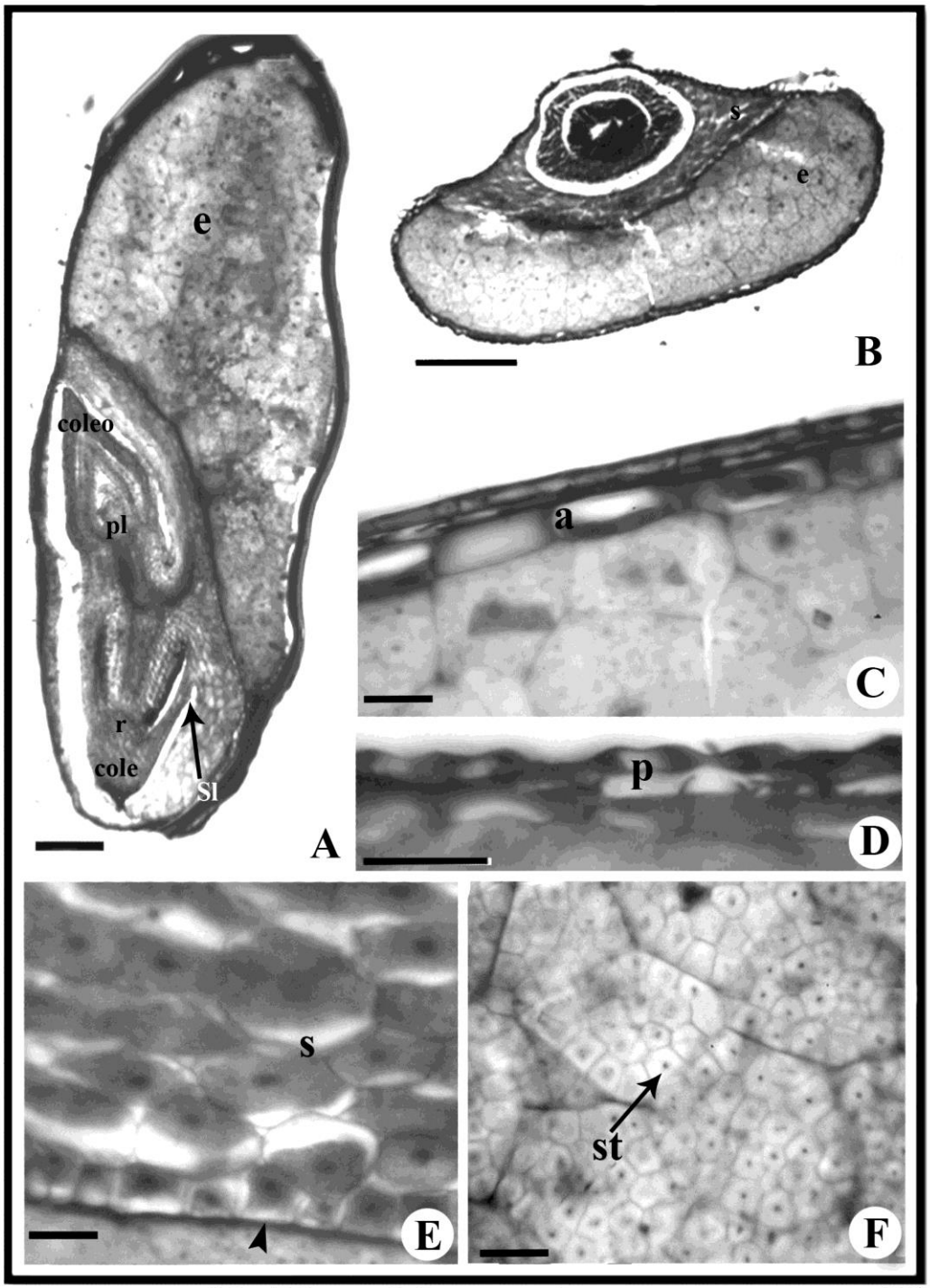
Starch grain: Simple circular shaped and polygon shaped starch grains (Fig. C).

No. of starch grains per endosperm cell: 11±4 **Starch grain size:** 4.17±1.33 (µm)

Aleurone layer: Tangentially elongated rectangular shaped alerurone cells (Fig. E, arrow).

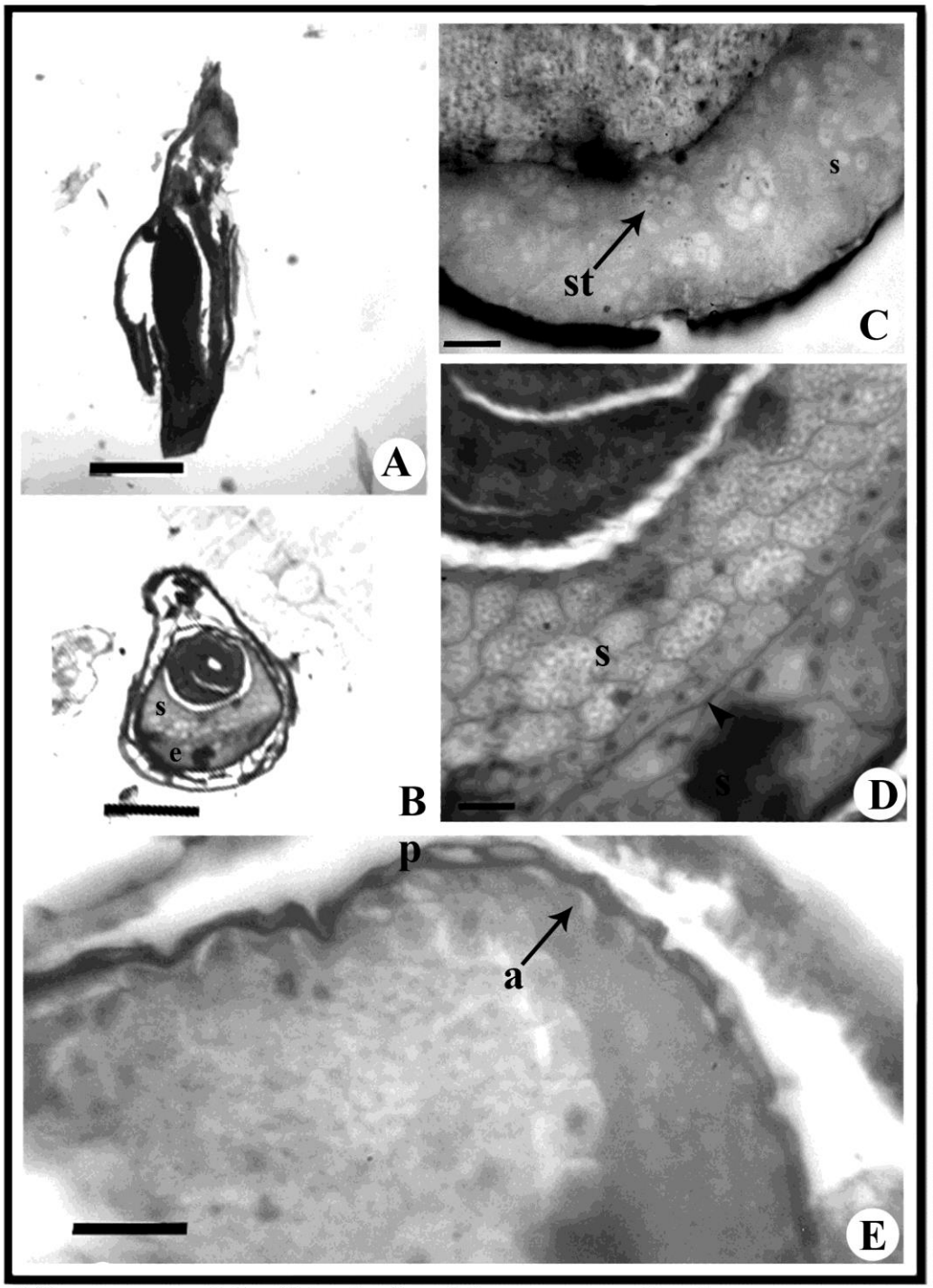
Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C- E=12.5 µm



11. *Dicanthium caricpsum*

Fig. 12



12. *Hackelochloa granularis*

Heteropogon

13. *Heteropogon contortus var. genuinus sub var. typicus*

14. *Heteropogon contortus var. genuinus sub var. hispidissimus*

15. *Heteropogon ritcheii*

16. *Heteropogon triticeus*

13. *Heteropogon contortus* var. *genuinus* sub var. *typicus* (Fig. 13(13) A-G)

Shape: Crock (Matka) shaped in transaction with convex anterior side and having size 0.54 (L) X 0.60 (B) mm (Fig. C).

Pericarp: Type B (Fig. E; epidermis (arrowhead), nucellus (arrow)).

Embryo: Type C - Embryo placed an angle of 178.8° (Fig. A). Epiblast is absent.

Scutellum: "V" shaped: Type V3-6 (Fig. C), having an angle of 43.7°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. F). Depletion layer is present (Fig. F, arrohead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 177.9°**,** Type – D.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells (Fig. B).

Starch grain: Simple circular to polygon shaped starch grains (Fig. G).

No. of starch grains per endosperm cell: 25±3 **Starch grain size:** 4.69±1.68 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. D).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A-C =125 µm, D-G =12.5 µm

14. *Heteropogon contortus* var. *genuinus* sub var. *typicus* (Fig. 13(14) A-F)

Shape: Crock (Matka) shaped in transaction with convex anterior side and having size 0.75 (L) X 0.83 (B) mm (Fig. B).

Pericarp: Type D (Fig. F; epidermis (arrowhead), nucellus (arrow)).

Embryo: Type C - Embryo placed an angle of 175.7° (Fig. A). Epiblast is absent.

Scutellum: "U" shaped: Type U1-1 (Fig. B), having an angle of 41.9°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. C). Depletion layer is present (Fig. C, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 178.4°**,** Type – D.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

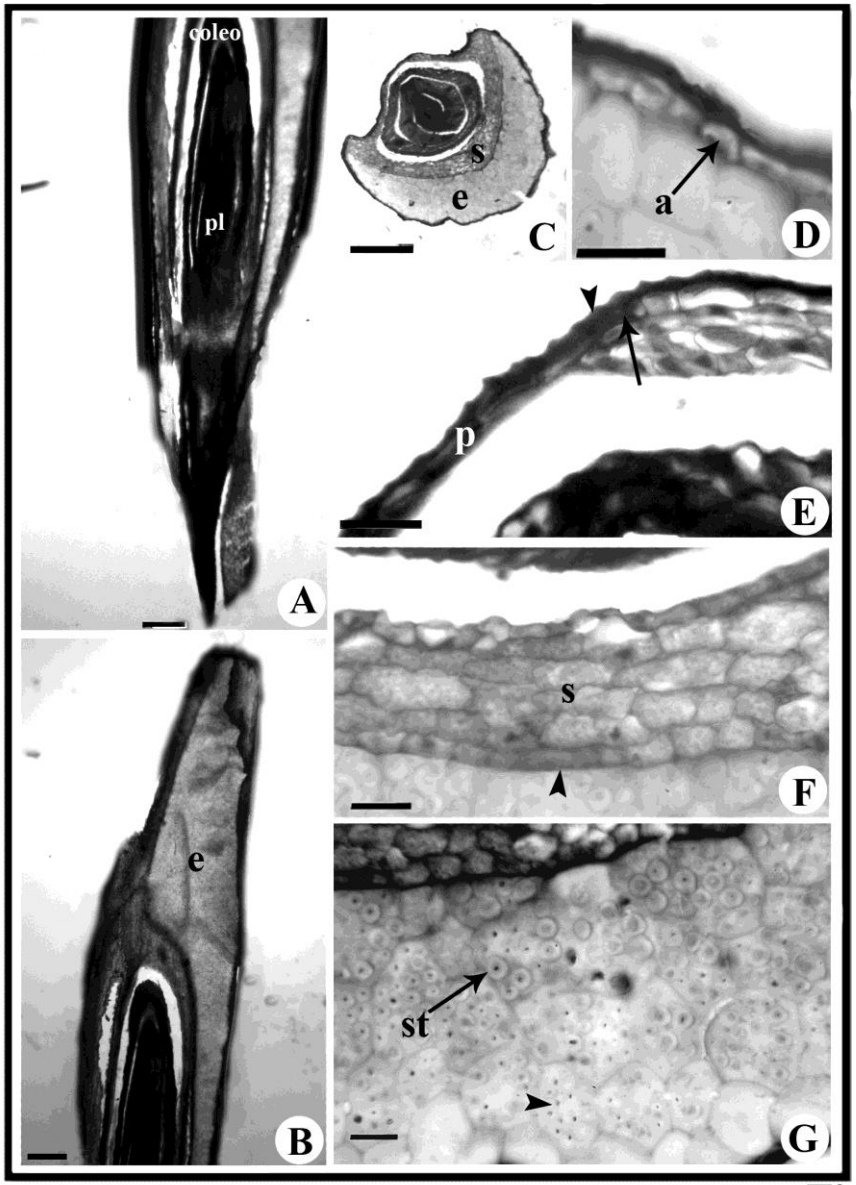
Starch grain: Simple circular (arrow) to polygon shaped (arrowhead) starch grains (Fig. E).

No. of starch grains per endosperm cell: 21±5 **Starch grain size:** 6.94±2.38 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. D).

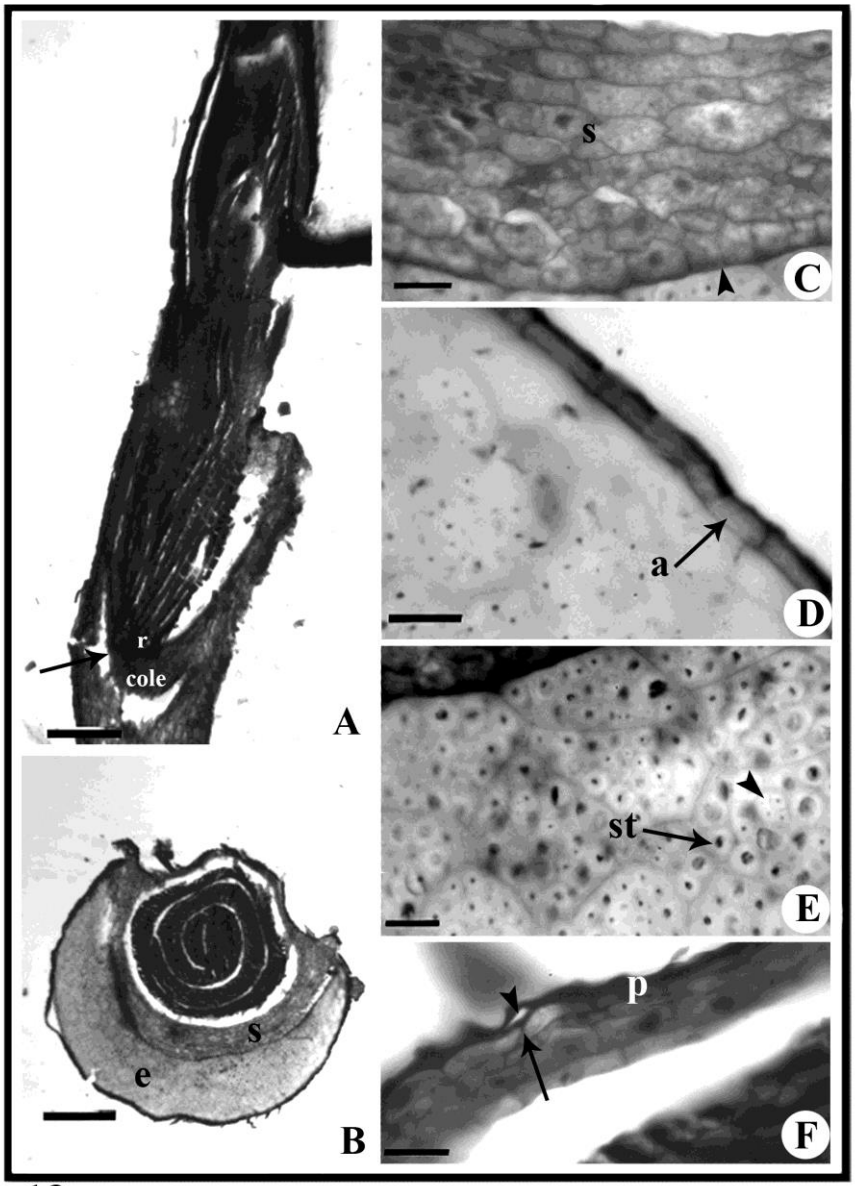
Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C- F=12.5 µm



13. *Heteropogon contortus var. genuinus sub var. typicus*

Fig. 13



14. *Heteropogon contortus var. genuinus sub var. hispidissimus*

15. *Heteropogon ritchiei* (Fig. 14(15) A-G)

Shape: Crock (Matka) shaped in transection, concave from ventral surface and having size 0.52 (L) X 0.51 (B) mm (Fig. C).

Pericarp: Type D (Fig. G).

Embryo: Type C - Embryo placed an angle of 176.9° (Fig. A). Epiblast is absent.

Scutellum: "U" shaped: Type U1-2 (Fig. C), having an angle of 57.7°. Scutellum cleft/slit is present and it is seen towards scutellum side, it is becoming broad towards the proximal end. Oval shaped, compactly arranged scutellum cells (Fig. E).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 177.8°**,** Type – D.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells (Fig. B).

Starch grain: simple circular and polygon shaped starch grains (Fig. D).

No. of starch grains per endosperm cell: 19±6 **Starch grain size:** 5.68±2.13 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. F).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A-C =125 µm, D-G=12.5 µm

16. *Heteropogon triticeus* (Fig. 14(16) A-H)

Shape: Crock (Matka) shaped in transection, concave from ventral surface and having size 1.25 (L) X 1.23 (B) mm (Fig. B).

Pericarp: Type A (Fig. G; cross cells (arrowhead), epidermal cell (arrow)).

Embryo: Type C - Embryo placed an angle of 169.9° (Fig. A). Epiblast is absent.

Scutellum: "U" shaped: Type U1-1 (Fig. B), having an angle of 57.7°. Scutellum cleft/slit is present and it is seen towards scutellum side, it is becoming broad towards the proximal end. Oval shaped, compactly arranged scutellum cells (Fig. H) and depletion layer is present.

Vascularisation: Type of vascularisation: Panicoid (Fig. D)

Angle of vascularisation: 146.4°**,** Type – B.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells (Fig. C).

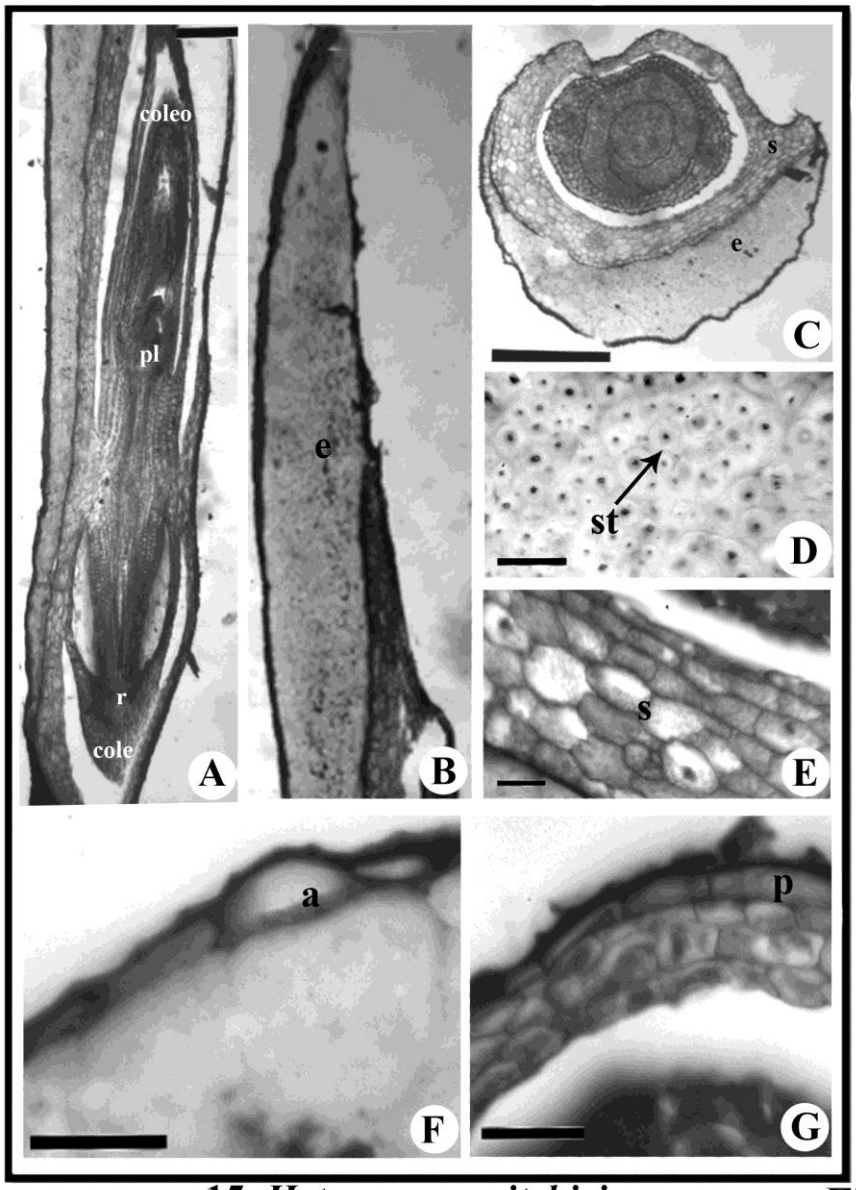
Starch grain: Some cells have simple polygon shaped, some have simple circular shaped, and compound starch grains present together (Fig. E).

No. of starch grains per endosperm cell: 20±5 **Starch grain size:** 8.75±3.48 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. F).

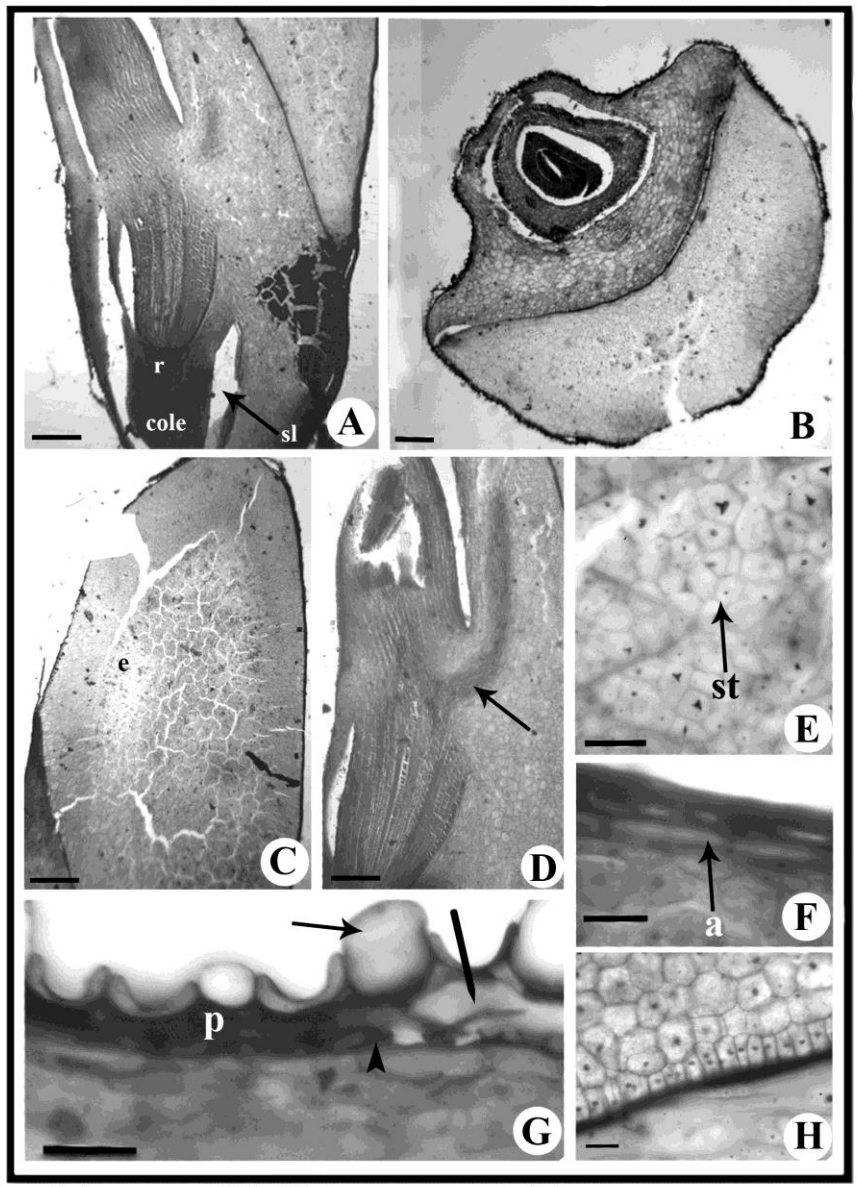
Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A-D =125 µm, E-H =12.5 µm



15. *Heteropoogn ritchiei*

Fig. 14



16. *Heteropogon triticeus*

Differentiating features:

Angle of vascularisation- Type B…….*H. triticeus*

Angle of vascularisation- Type D

Scutellum Type- V3-6..…….. *H. contortus* var. *genuinus* sub var. *typicus*

Scutellum Type- U1-1……. *H. contortus var. genuinus sub var. hispidissimus*

Scutellum Type- U1-2……. *H. ritchiei*

17. *Imperata cylindrica* (Fig. 15(17) A-F)

Shape: Oblong shaped in transaction with convex anterior side and having size 0.19 (L) X 0.24 (B) mm (Fig. C).

Pericarp: Type D (Fig. F; epidermis (arrowhead), nucellus (arrow)).

Embryo: Type C - Embryo placed an angle of 163.7° (Fig. B). Epiblast is absent.

Scutellum: "Δ" shaped: Type Δ5 (Fig. C), having an angle of 58.9°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. E). Depletion layer is present (Fig. E, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 152.3°**,** Type – B.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple polygon shaped starch grains (Fig. D).

No. of starch grains per endosperm cell: 12±2 **Starch grain size:** 3.47±1.26 (µm)

Aleurone layer: Vertically elongated rectangular shaped aleurone cells.

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, C =125 µm, B= 85.5 µm, D- F=12.5 µm

Ischaemum

18. *Ischaemum indicus*

19. *Ischaemum molle*

20. *Ischaemum pilosum*

21. *Ischaemum rugosum*

18. *Ischaemum indicus* (Fig. 15(18) A-F)

Shape: Oval to rectangular shaped in transaction and having size 0.41 (L) X 0.71 (B) mm (Fig. C).

Pericarp: Type C (Fig. F; epidermis (arrowhead), nucellus (arrow)).

Embryo: Type C - Embryo placed an angle of 171.2° (Fig. A). Epiblast is absent.

Scutellum: "V" shaped: Type V3-2 (Fig. C), having an angle of 72.64°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. D). Depletion layer is present (Fig. D, arrowhead).

Vascularisation: Type of vascularisation: Panicoid (Fig. B)

Angle of vascularisation: 167.3°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

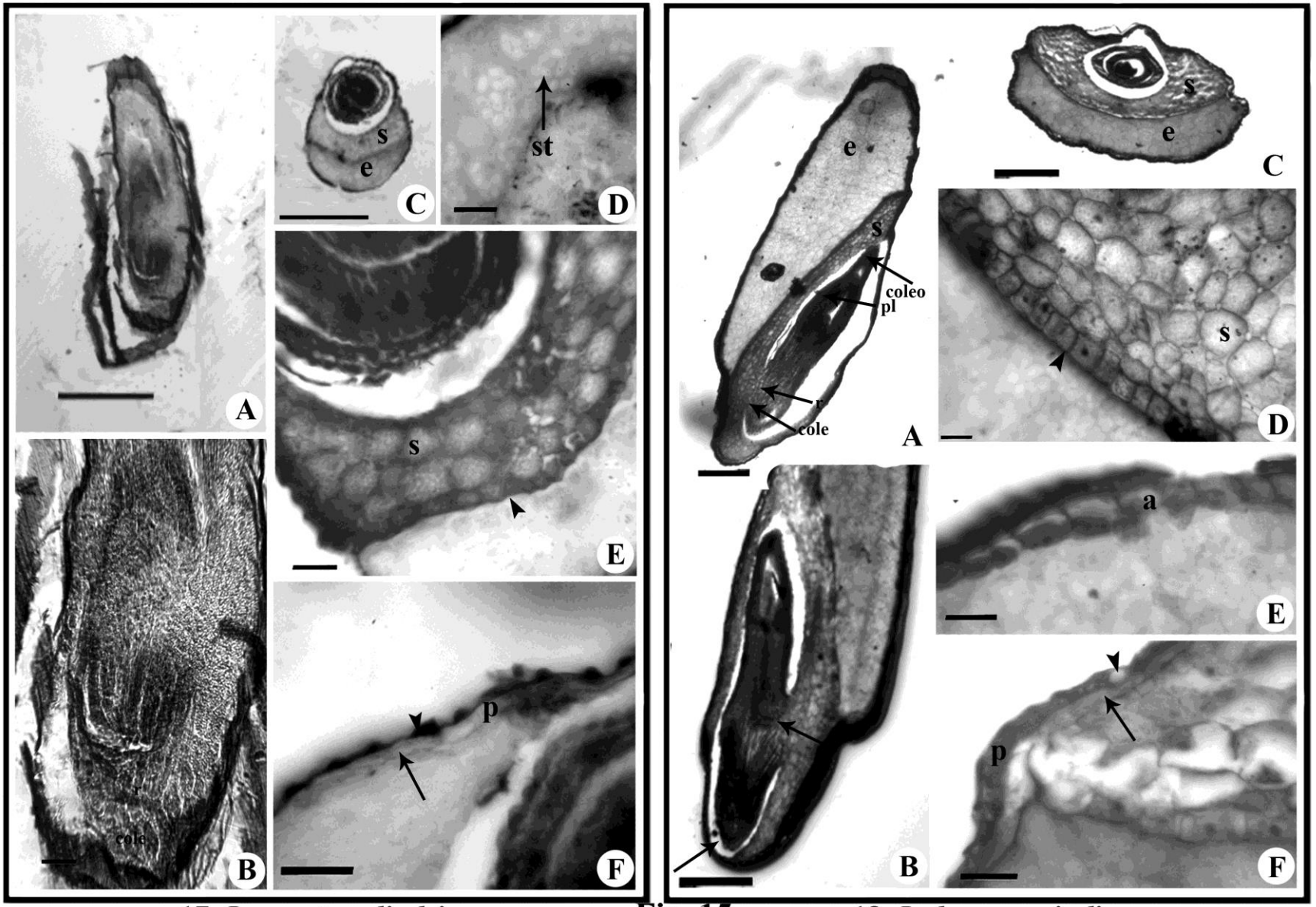
Starch grain: Simple polygon shaped starch grains.

No. of starch grains per endosperm cell: 18±3 **Starch grain size:** 4.17±1.67 (µm)

Aleurone layer: Tangentially elongated rectangular and square shaped aleurone cells (Fig. E).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A-C =125 µm, D- F=12.5 µm



17. *Imperata cylindrica* Fig. 15 18. *Ischaemum indicum*

19. *Ischaemum molle* (Fig. 16(19) A-E)

Shape: Oval shaped in transection, concave from dorsal surface and having size 0.67 (L) X 0.76 (B) mm (Fig. B).

Pericarp: Type A (Fig. C; cross cells (arrowhead), epidermis (arrow)).

Embryo: Type C - Embryo placed an angle of 173.4° (Fig. A). Epiblast is absent.

Scutellum: "V" shaped: Type V3-1 (Fig. B), having an angle of 89.4°. Scutellum cleft/slit is present and it is cover coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. D), and also shows depletion layer (Fig. D, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 170.34°**,** Type – D.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: simple circular and polygon shaped starch grains (Fig. E, arrow).

No. of starch grains per endosperm cell: 17±5 **Starch grain size:** 2.78±0.63 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. E).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-E=12.5 µm

20. *Ischaemum pilosum* (Fig. 16(20) A-F)

Shape: Oblong to circular shaped in transection, convex from dorsal surface and having size 0.91 (L) X 1.03 (B) mm (Fig. C).

Pericarp: Type B (Fig. D; nucellus (arrow)).

Embryo: Type C - Embryo placed an angle of 172.1° (Fig. A). Epiblast is absent.

Scutellum: "Δ" shaped: Type Δ3 (Fig. C), having an angle of 40.4°. Scutellum cleft/slit is present and it is present towards scutellum. Oval to circular shaped, compactly arranged scutellum cells (Fig. F), and also shows depletion layer (Fig. F, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 144.8°**,** Type – B.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

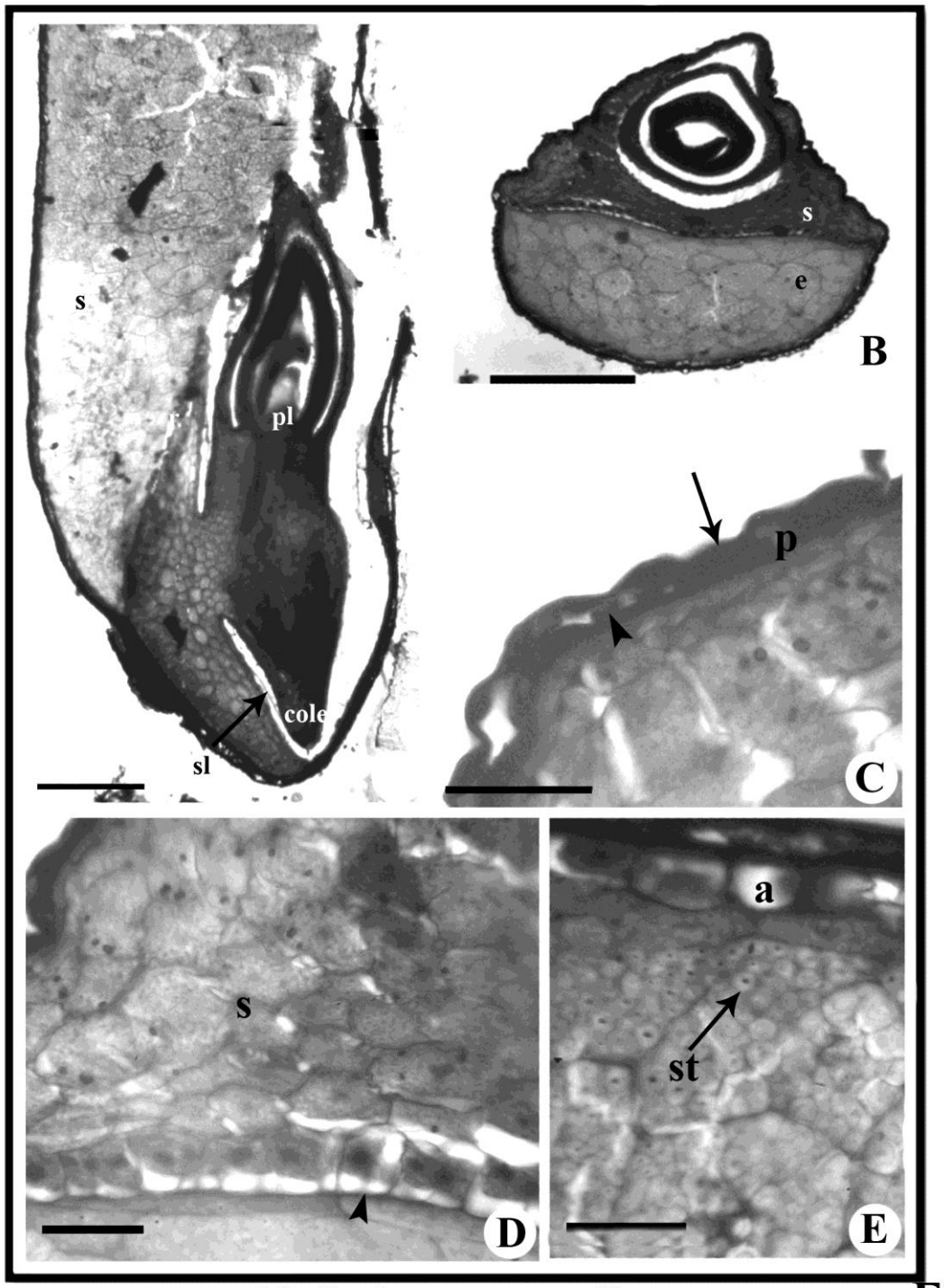
Starch grain: Some cells have simple circular shaped starch grains (arrow) and some cells have simple pentagonal shaped (arrowhead) and compound starch grains are present together (Fig. E).

No. of starch grains per endosperm cell: 24±4 **Starch grain size:** 4.76±2.57 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. D).

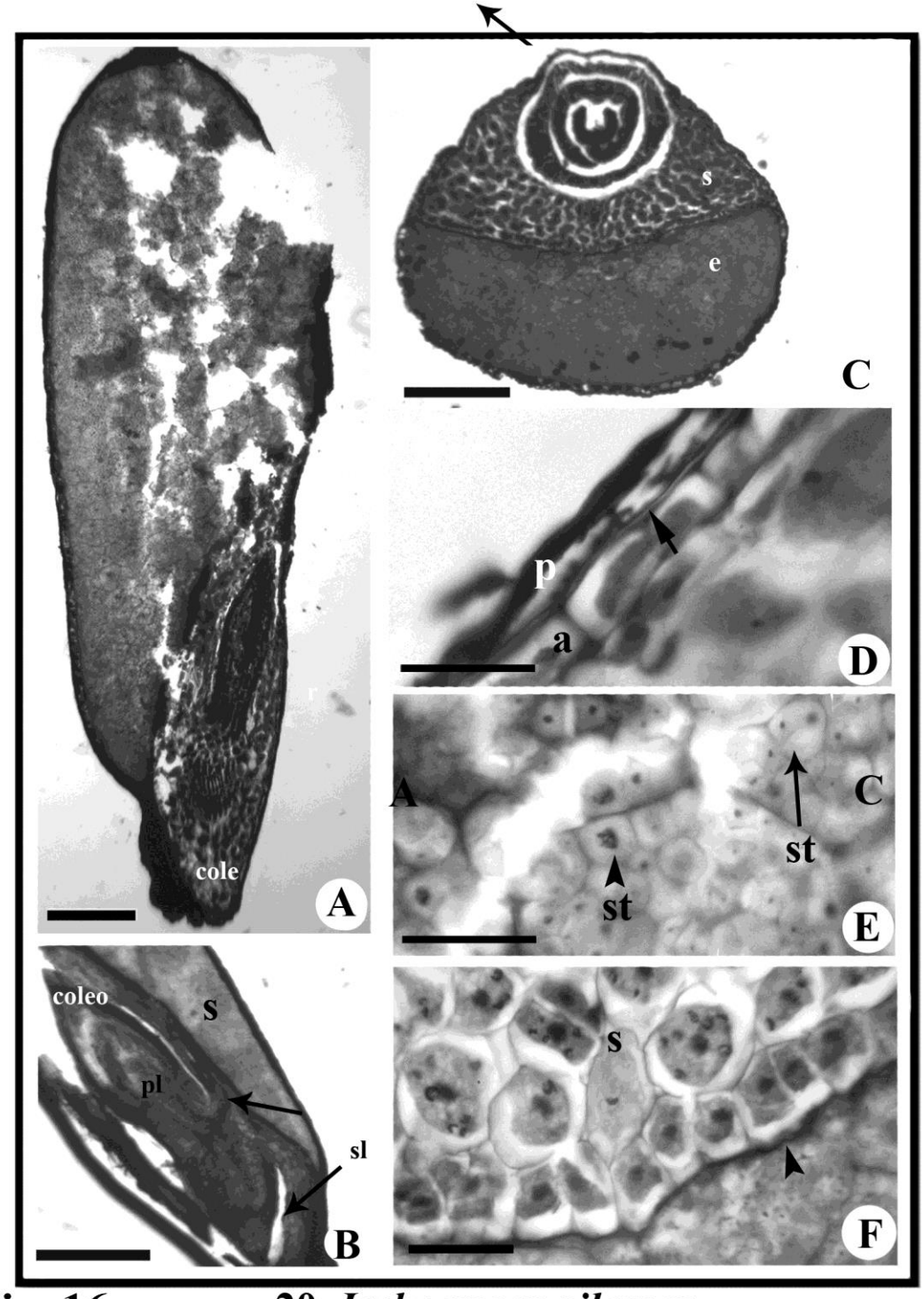
Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A-C =125 µm, D-F =12.5 µm



19. *Ischaemum molle*

Fig. 16



20. *Ischaemum pilosum*

21. *Ischaemum rugosum* (Fig. 17(21) A-F)

Shape: Oblong shaped in transection, convex from dorsal surface and having size 0.91 (L) X 1.34 (B) mm (Fig. C).

Pericarp: Type B (Fig. D; epidermis (arrow), nucellus (arrowhead)).

Embryo: Type C - Embryo placed an angle of 174.5° 6 (Fig. A). Epiblast is absent.

Scutellum: "V" shaped: Type V7 (Fig. C), having an angle of 72.8°. Scutellum cleft/slit is present and it is present towards scutellum (Fig. B). Oval shaped, compactly arranged scutellum cells (Fig. F), and also shows depletion layer (Fig. F, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 173.8°**,** Type – B.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: simple polygon shaped starch grains (Fig. E, arrow).

No. of starch grains per endosperm cell: 28±3 **Starch grain size:** 2.21±0.62 (µm)

Aleurone layer: Both shaped i.e. tangentially elongated and square shaped aleurone cells (Fig. E).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A-C =125 µm, D-F =12.5 µm

Differentiating features:

Tangentially elongated aleurone layer

Scutellum type – V3-1……..……..*I. molle*

Scutellum type- Δ3……..……*I. pilosum*

Square and rectangular both shaped aleurone cells

Scutellum type – V3-2……..……..*I. indicus*

Scutellum type – V7……..……*I. rugosum*

OR

Angle of vascularisation Type- C……..…… *I. indicus*

Angle of vascularisation Type- D……..…… *I. molle*

Angle of vascularisation Type- C

Tangentially elongated aleurone layer……*I. pilosum*

Square and rectangular both shaped aleurone cells…..…… *I. rugosum*

22. *Iseilema laxum* (Fig. 17(22) A-F)

Shape: Oblong shaped in transection and having size 0.38(L) X 0.79(B) mm (Fig. C).

Pericarp: Type B (Fig. D; cross cells (arrowhead)).

Embryo: Type C - Embryo placed an angle of 171.8° (Fig. A). Epiblast is absent.

Scutellum: "V" shaped: Type V7 (Fig. C), having an angle of 71.2°. Scutellum cleft/slit is present and it is broad, cover the coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. E), and also shows depletion layer (Fig. E, arrowhead).

Vascularisation: Type of vascularisation: Panicoid (Fig. B).

Angle of vascularisation: 166.4°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

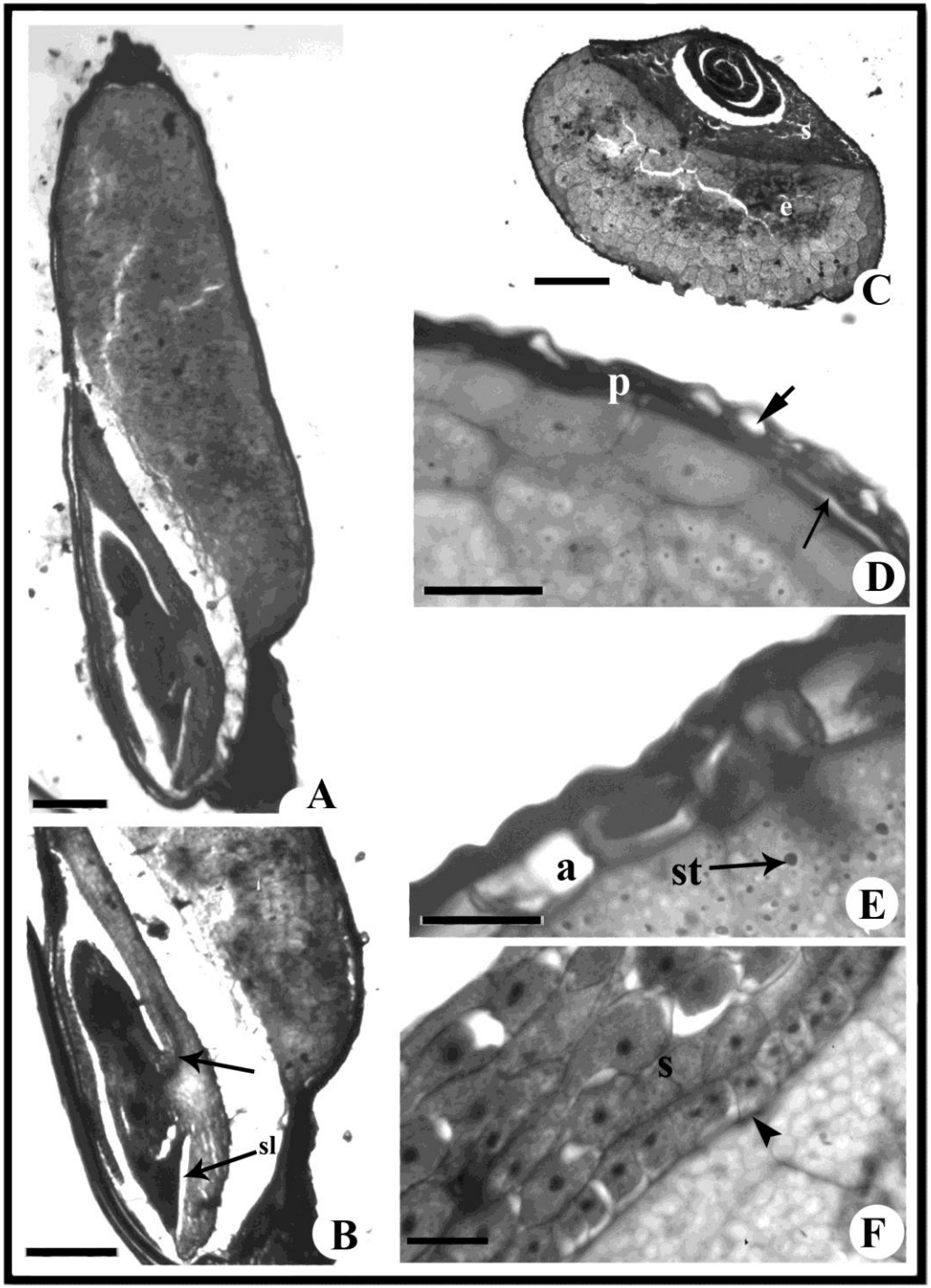
Starch grain: Simple circular shaped starch grains present together (Fig. E, arrow).

No. of starch grains per endosperm cell: 27±6 **Starch grain size:** 2.21±0.23 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. F).

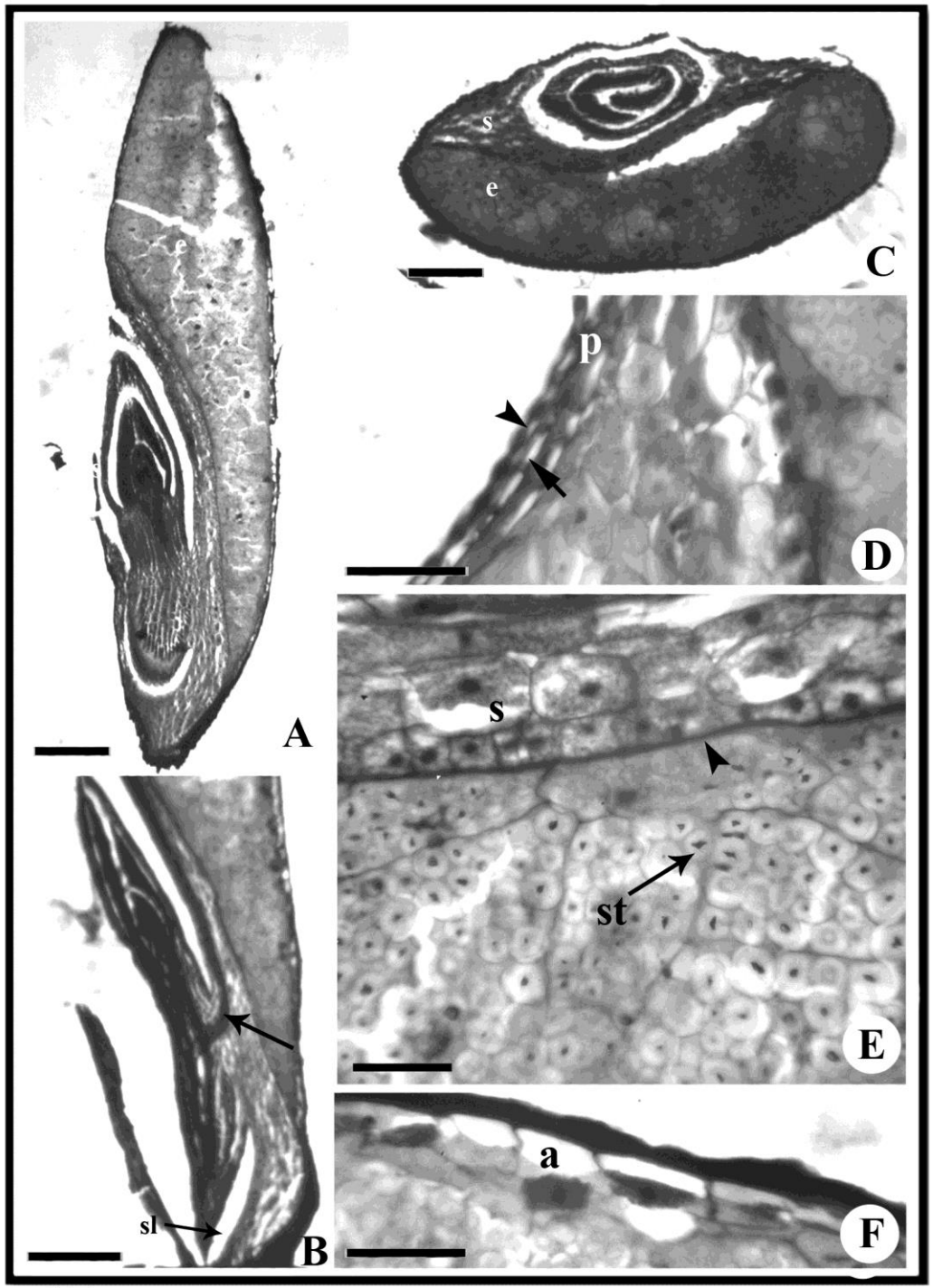
Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A-C =125 µm, D-F =12.5 µm



21. *Ischaemum rugosum*

Fig. 17



22. *Iseilema laxum*

23. *Ophiuros exaltatus* (Fig. 18(23) A-F)

Shape: Circular shaped with flat anterior side in cross section and having size 0.69 X 0.83 mm (Fig. B).

Pericarp: Type C (Fig. F; cross cells (arrowhead)).

Embryo: Type C - Embryo placed an angle of 168.7° (Fig. A). Epiblast is absent.

Scutellum: "V" shaped: Type V1-2, having an angle of 74.3°. Scutellum cleft/slit is present and it is very thin, just like slit. Oval shaped, compactly arranged scutellum cells (Fig. D), and also shows depletion layer (Fig. D, arrowhead).

Vascularisation: Type of vascularisation: Panicoid (Fig. A)

Angle of vascularisation: 167.3°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon shaped starch grains (Fig. C).

No. of starch grains per endosperm cell: 69±8 **Starch grain size:** 3.85±1.27 (µm)

Aleurone layer: Square and tangentially rectangular, both type of aleurone cells are present (Fig. E).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm

24. *Rottboellia exaltata* (Fig. 18(24) A-G)

Shape: Circular shaped with flat anterior side in transection and having size 2.00 (L) X 2.35 (B) mm (Fig. D).

Pericarp: Type C (Fig. E, cross cells (arrowhead)).

Embryo: Type C - Embryo placed an angle of 173.3° (Fig. A, B). Epiblast is absent.

Scutellum: "V" shaped: Type V1-1 (Fig. D), having an angle of 63.2°. Scutellum cleft/slit is present and it is very thin, just like slit. Oval shaped, compactly arranged scutellum cells (Fig. C), and also shows depletion layer.

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 165.3°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

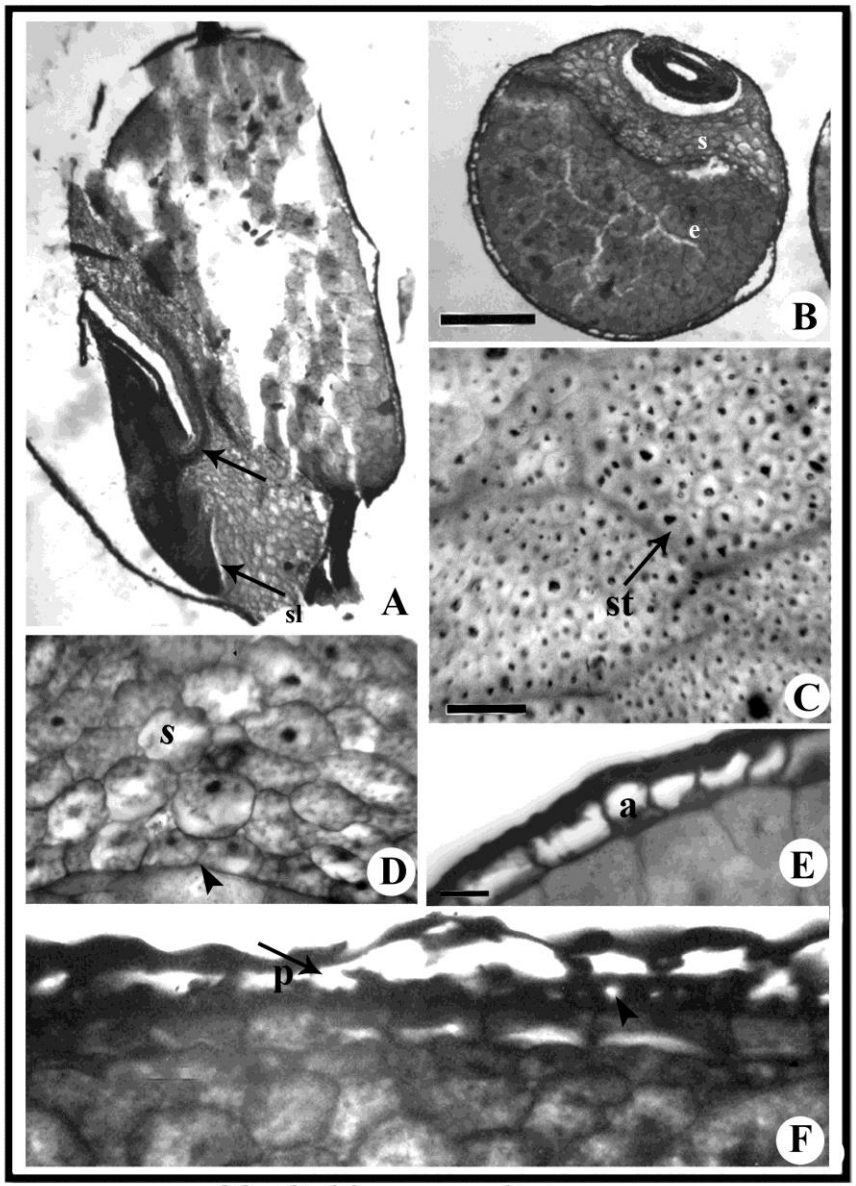
Starch grain: Simple circular and polygon shaped starch (Fig. F).

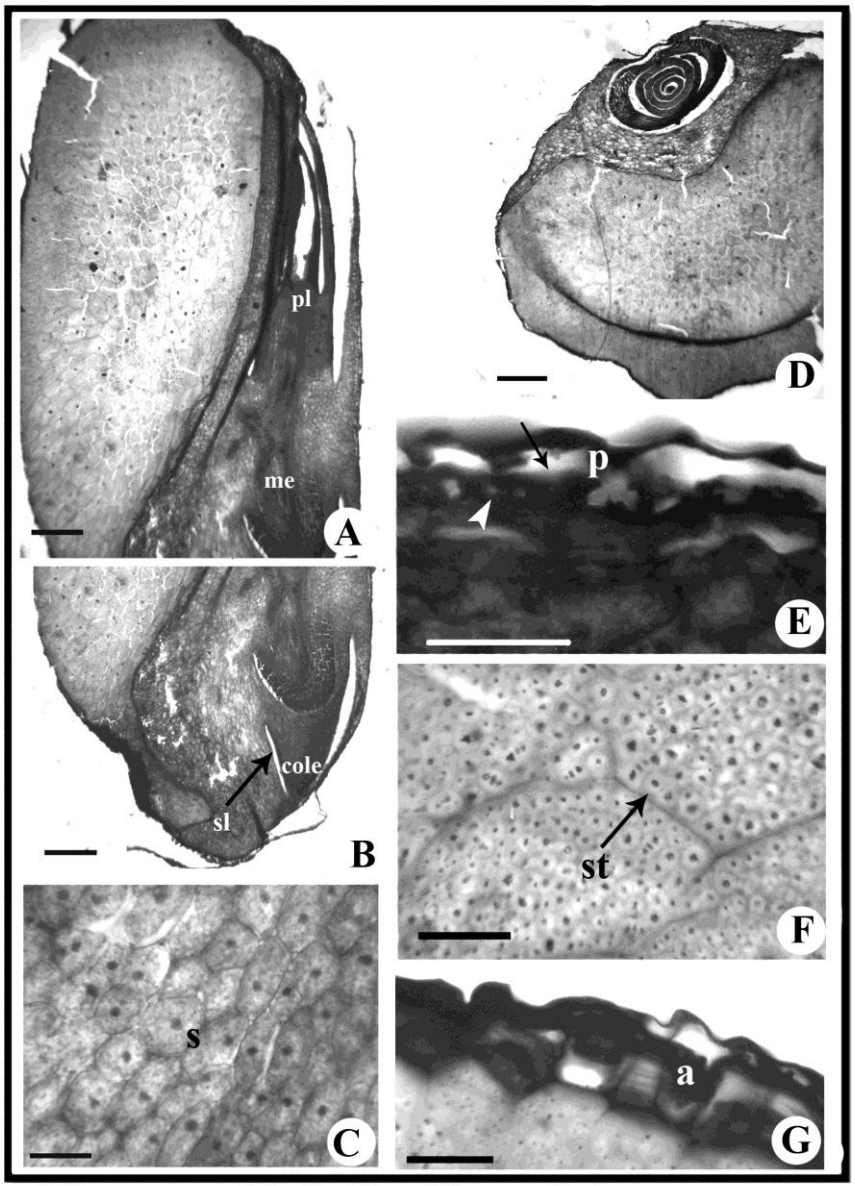
No. of starch grains per endosperm cell: 67±5 **Starch grain size:** 2.5±1.04 (µm)

Aleurone layer: Vertically elongated rectangular shaped aleurone cells (Fig. G).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B, D =125 µm, C, E-G =12.5 µm





23. *Ophiuros exaltatus*

Fig. 18

24. *Rottboellia exaltata*

25. *Saccharum spontanum* (Fig. 19(25) A-F)

Shape: Rectangular shaped with circular corners and flat anterior side in transection and having size 2.00 (L) X 2.35 (B) mm (Fig. B).

Pericarp: Type B (Fig. C; hypodermis (arrow)).

Embryo: Type C - Embryo placed an angle of 171.4° (Fig. A). Epiblast is absent.

Scutellum: Δ shaped: Type - Δ1 (Fig. B), having an angle of 35.8°. Scutellum cleft/slit is present and it covers the coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. E), and also shows depletion layer (Fig. F, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 168.9°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon shaped starch grains (Fig. D).

No. of starch grains per endosperm cell: 36±7 **Starch grain size:** 2.68±0.38 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. C, arrow).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm

Sehima

26. *Sehima ischaemoides*

27. *Sehima nervosum*

28. *Sehima sulcatum*

26. *Sehima ischaemoides* (Fig. 19(26) A-F)

Shape: Lanceolate shape in transaction with convex anterior side and concave posterior side and having size 0.30 (L) X 0.97 (B) mm (Fig. B).

Pericarp: Type B (Fig. F; epidermis (arrow), cross cells (arrowhead)).

Embryo: Type C - Embryo placed an angle of 169.9° (Fig. A). Epiblast is absent.

Scutellum: "V" shaped: Type V7 (Fig. B), having an angle of 77.31°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. D). Depletion layer is present (Fig. D, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 157.1°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

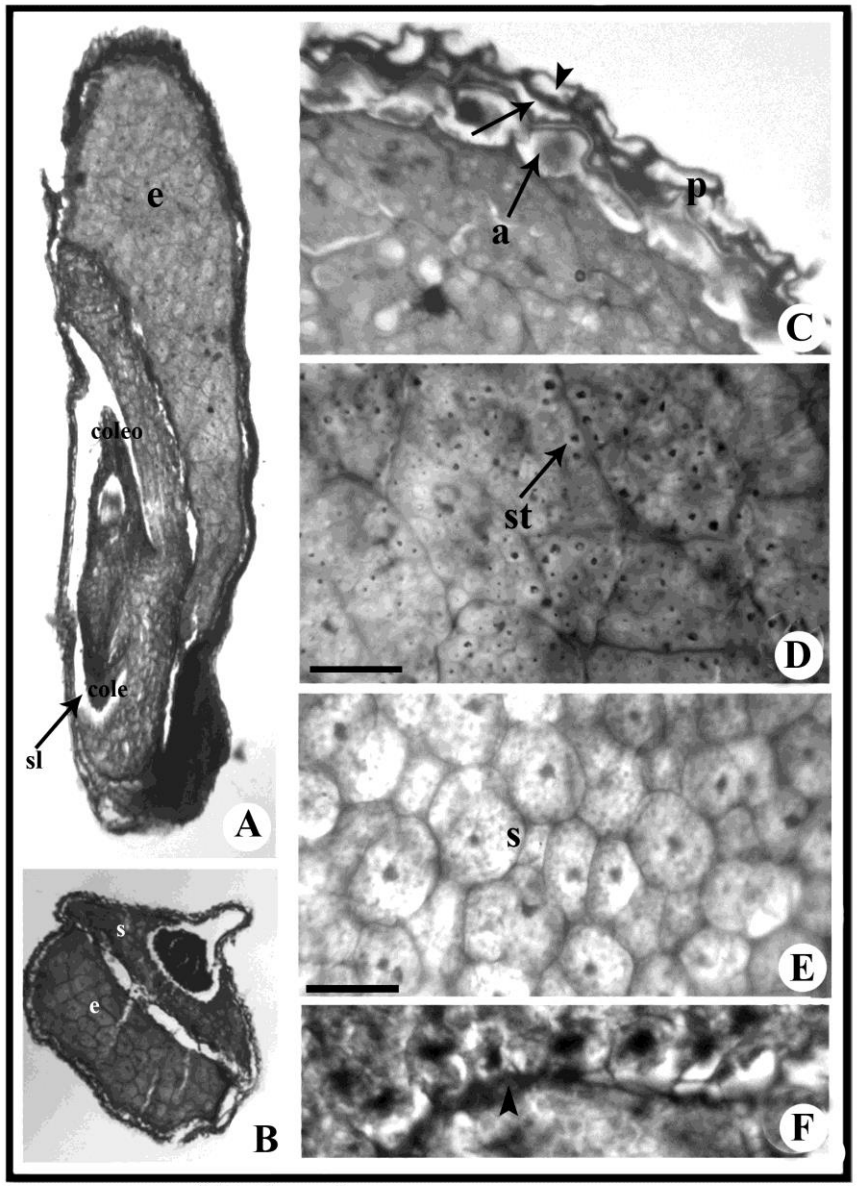
Starch grain: Simple polygon shaped and compounds both the starch grains are present together (Fig. E).

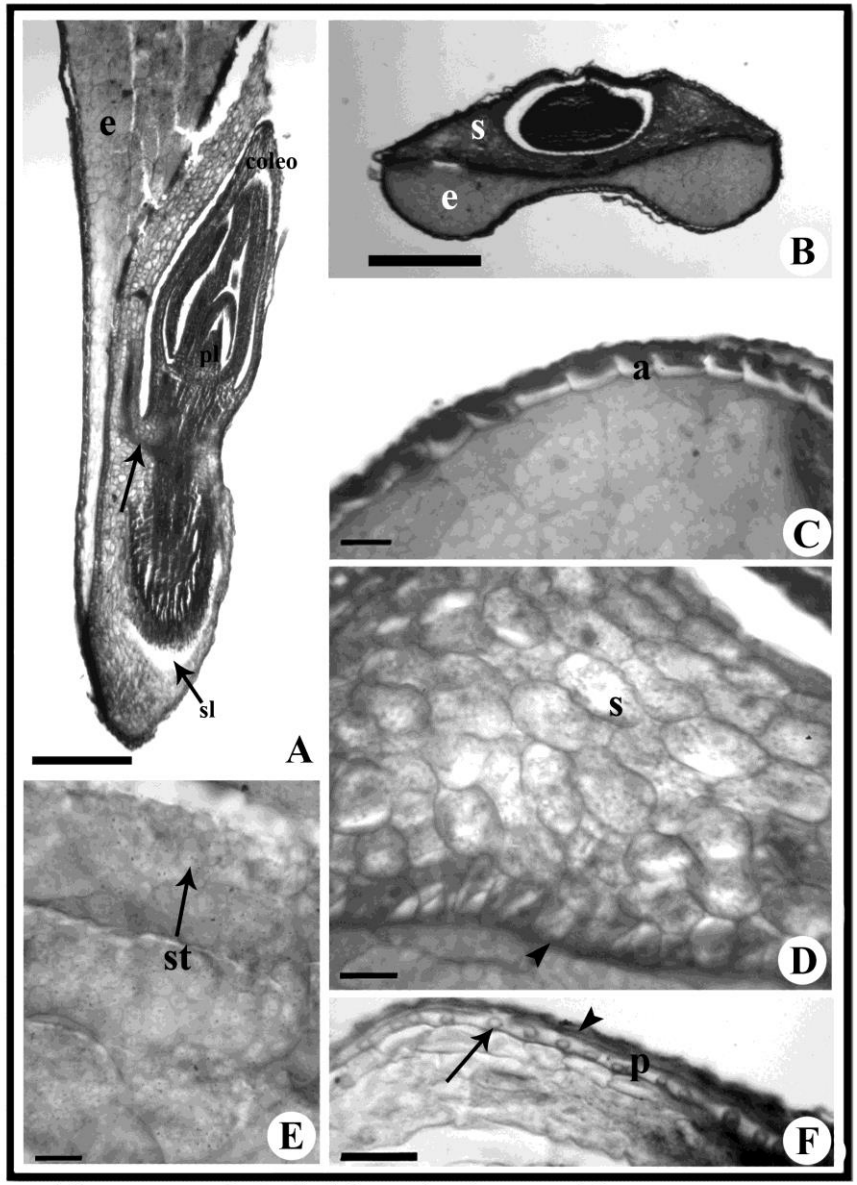
No. of starch grains per endosperm cell: 91±5 **Starch grain size:** 3.13±1.63 (µm)

Aleurone layer: Tengentially elongated rectangular shaped aleurone cells (Fig. C).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm





25. *Saccharum spontaneum* **Fig. 19** 26. *Sehima ischaemoides*

27. *Sehima nervosum* (Fig. 20(27) A-F)

Shape: Triangle shaped with circular corners and flat anterior side in transection and having size 0.47 (L) X 0.97 (B) mm (Fig. B).

Pericarp: Type A (Fig. D; cross cells (arrowhead), nucellus (arrow)).

Embryo: Type C - Embryo placed an angle of 174.2° (Fig. A). Epiblast is absent.

Scutellum: Δ shaped: Type - Δ1 (Fig. B), having an angle of 38.8°. Scutellum cleft/slit is present and it covers the coleorhiza (Fig. E). Oval shaped, compactly arranged scutellum cells, and also shows depletion layer (Fig. E, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 177.8°**,** Type – D.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Some cells have simple circular shaped starch grains and some cells have simple circular shaped and compound starch grains are present together (Fig. F).

No. of starch grains per endosperm cell: 83±7 **Starch grain size:** 3.13±0.74 (µm)

Aleurone layer: Tangentially rectangular aleurone cells (Fig. C).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm

28. *Sehima sulcatum* (Fig. 20(28) A-F)

Shape: Kidney shaped, convex anterior, two lobed structure on posterior side in transection and having size 1.87 (L) X 1.69 (B) mm (Fig. C).

Pericarp: Type A (Fig. F; cross cells (arrowhead), nucellus (arrow)).

Embryo: Type C - Embryo placed an angle of 177.8° (Fig. A). Epiblast is absent.

Scutellum: V shaped: Type – V3-1 (Fig. C), having an angle of 83.3°. Scutellum cleft/slit is present and it covers the coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. D), and also shows depletion layer (Fig. D, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 171.3°**,** Type – D.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular shaped starch grains (Fig. B).

No. of starch grains per endosperm cell: 78±6 **Starch grain size:** 2.5±0.68 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. E).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, C =125 µm, B, D- F=12.5 µm

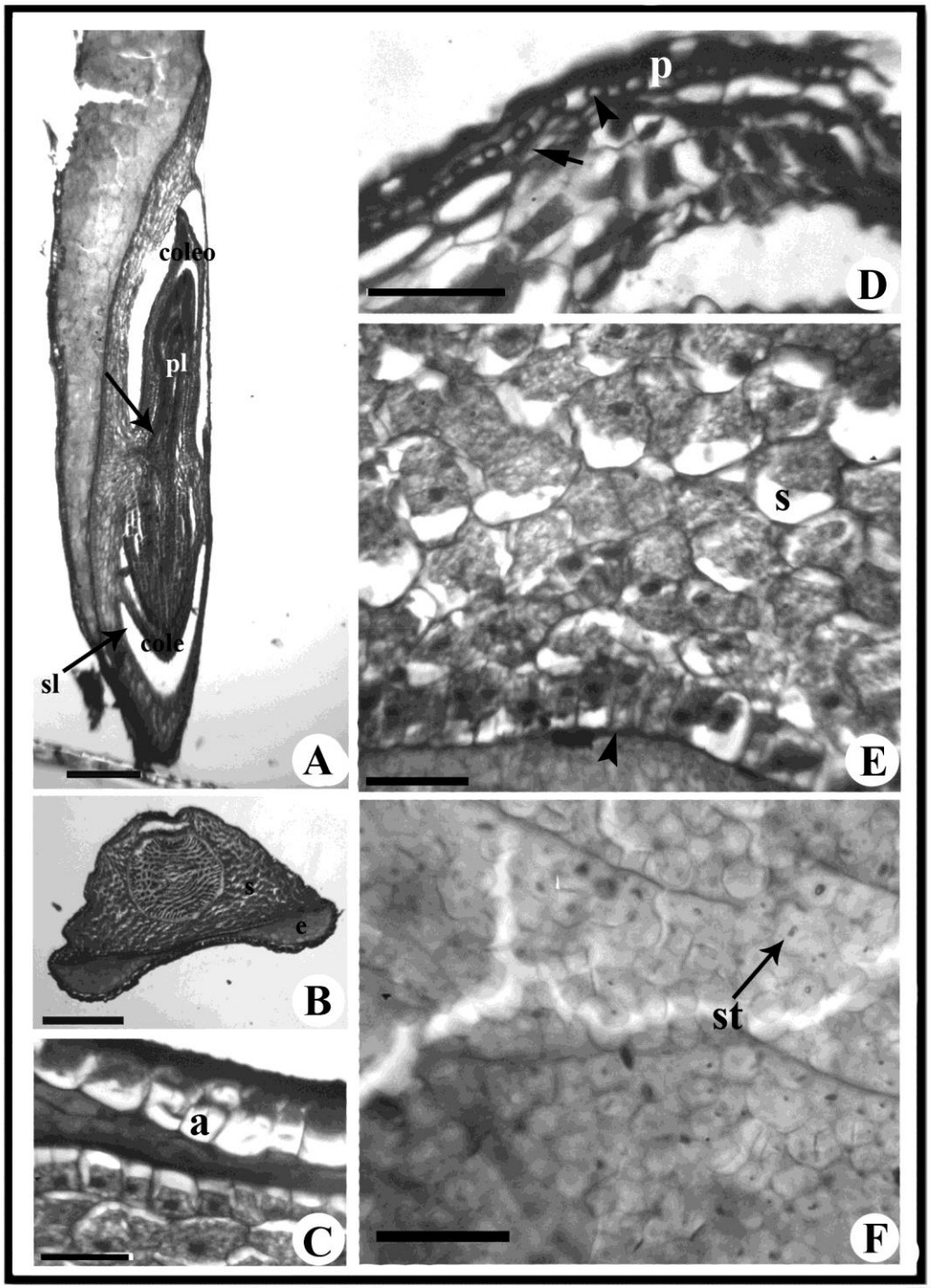
Differentiating features:

Angle of vascularisation Type- C……...……*S. ischaemoides*

Angle of vascularisation Type- D

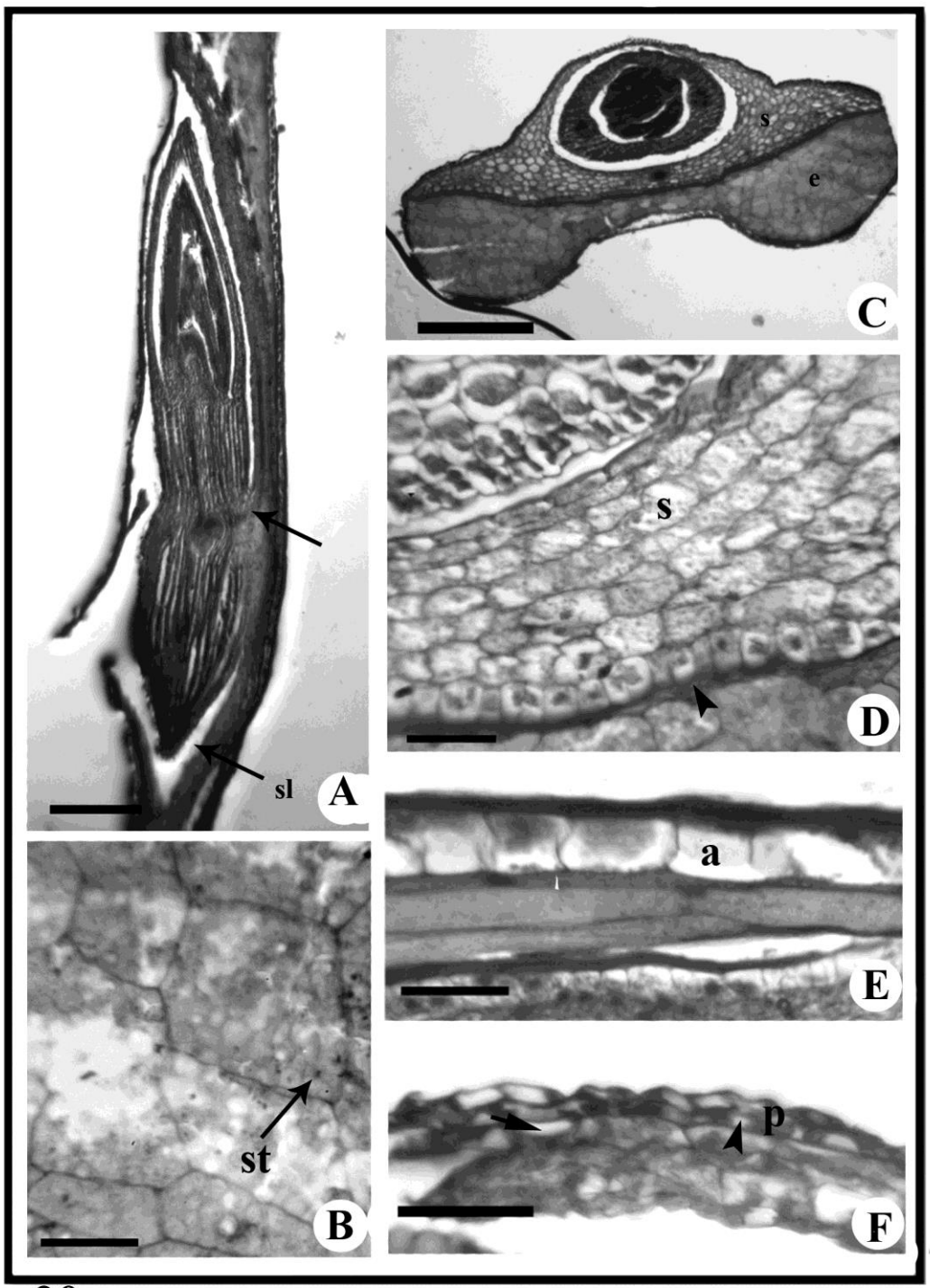
Scutellum type- Δ1……..……..*S. nervosum*

Scutellum type- V3-1……...……..*S. sulcatum*



27. *Sehima nervosum*

Fig. 20



28. *Sehima sulcatum*

29. *Sorghum halepense* (Fig. 21(29) A-F)

Shape: Oval shaped in transection and having size 1.87 (L) X 1.69 (B) mm (Fig. C).

Pericarp: Type A.

Embryo: Type C - Embryo placed an angle of 170.1° (Fig. B). Epiblast is absent.

Scutellum: V shaped: Type - V1-1 (Fig. C), having an angle of 66.7°. Scutellum cleft/slit is present and it covers the coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. D), and also shows depletion layer (Fig. D, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 157.5°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon shaped starch grains present (Fig. E).

No. of starch grains per endosperm cell: 47±5 **Starch grain size:** 5.21±2.17 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. F).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A-C =125 µm, D-F =12.5 µm

30. *Thelepogon elegans* (Fig. 21(30) A-G)

Shape: Square shaped in transaction with circular base and having size 1.19 (L) X 1.53 (B) mm (Fig. C).

Pericarp: Type B (Fig. F; cross cells (arrowhead)).

Embryo: Type C - Embryo placed an angle of 167.7° (Fig. A). Epiblast is absent.

Scutellum: V shaped: Type - V1-1 (Fig. C), having an angle of 60.9°. Scutellum cleft/slit is present and it covers the coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. D), and also shows depletion layer (Fig. D, arrowhead).

Vascularisation: Type of vascularisation: Panicoid (Fig. B)

Angle of vascularisation: 145.2°**,** Type – B.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

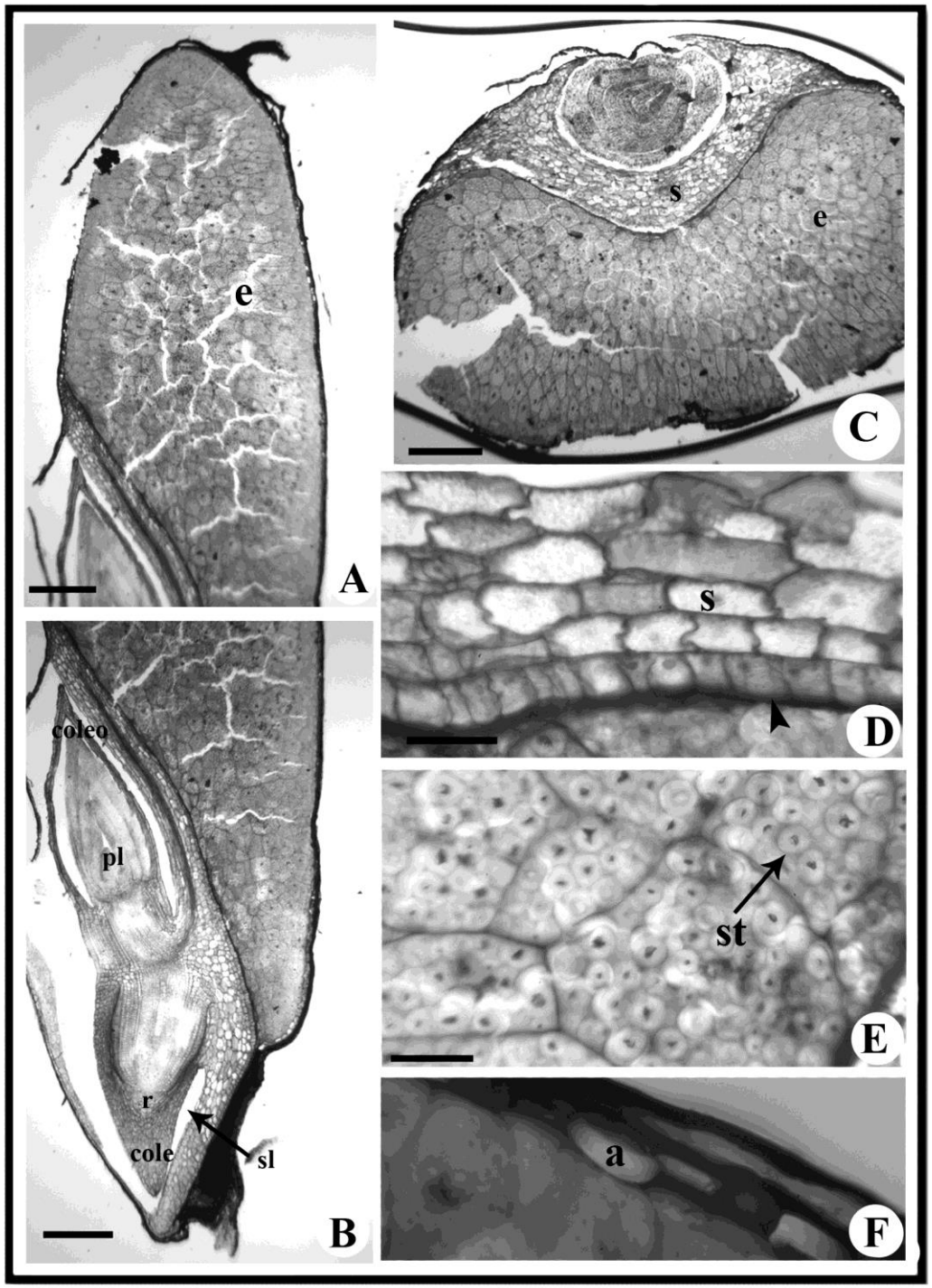
Starch grain: Some cells have simple circular shaped starch grains and some cells have simple circular shaped and compound starch grains are present together (Fig. G).

No. of starch grains per endosperm cell: 45±3 **Starch grain size:** 3.47±1.28 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. E).

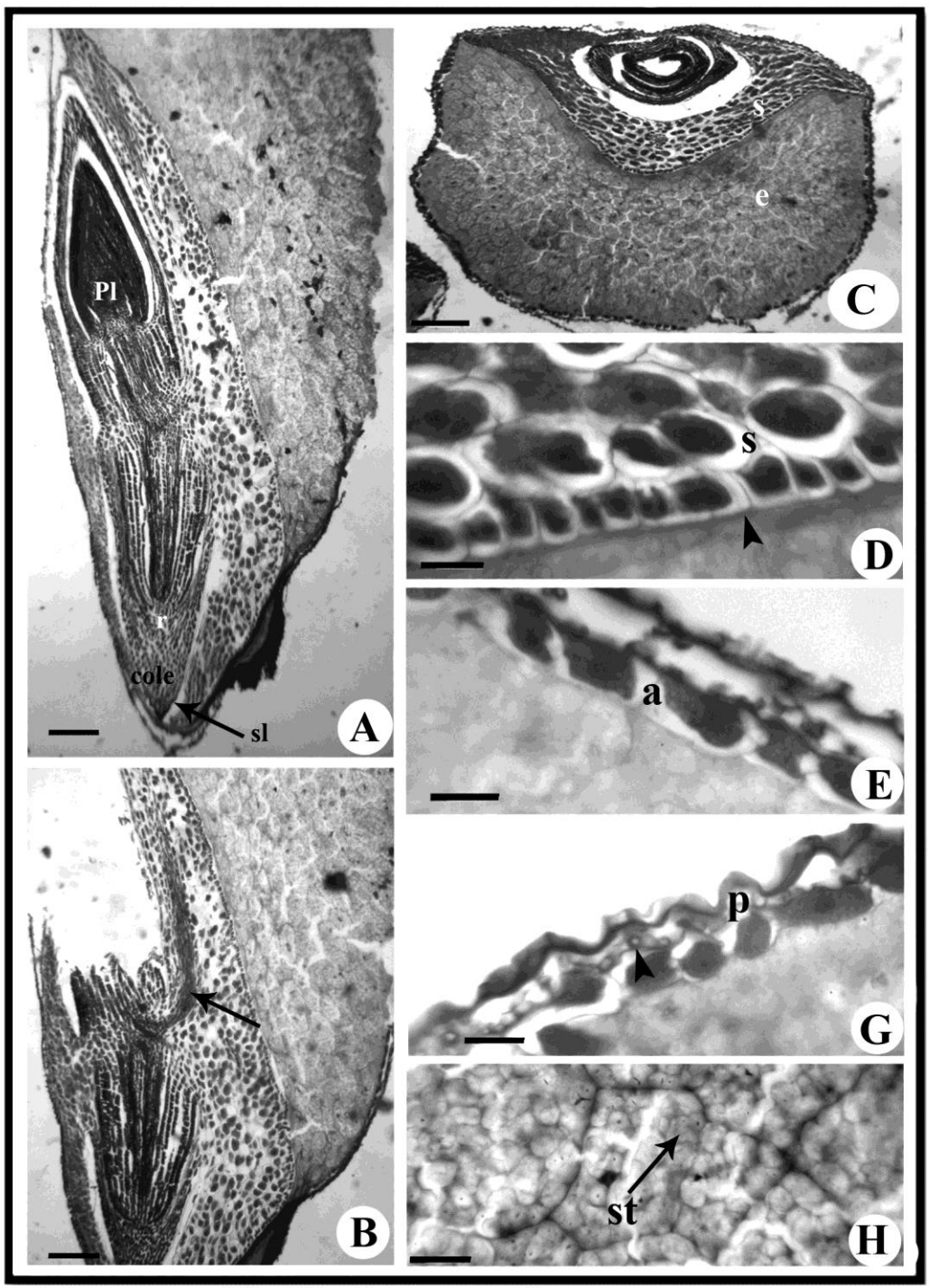
Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A-C =125 µm, D-H =12.5 µm



29. *Sorghum halepense*

Fig. 21



30. *Thelepogon elegans*

Themeda

31. *Themeda cymbaria*

32. *Themeda laxa*

33. *Themeda triandra*

34. *Themeda quadrivalvis*

31. *Themeda cymbaria* (Fig. 22(31) A-G)

Shape: Oval shaped in transaction with dorsal convex surface and having size 0.63 (L) X 0.38 (B) mm (Fig. B).

Pericarp: Type A (Fig. D; cross cells (arrowhead), nucellus (arrow)).

Embryo: Type C - Embryo placed an angle of 171.4° (Fig. A). Epiblast is absent.

Scutellum: U shaped: Type - U1-2 (Fig. B), having an angle of 65.7°. Scutellum cleft/slit is present and it is small slit. Oval shaped, compactly arranged scutellum cells (Fig. F), and also shows depletion layer.

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 163.3°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon shaped starch grains present (Fig. G).

No. of starch grains per endosperm cell: 41±6 **Starch grain size:** 5.21±3.09 (µm)

Aleurone layer: Tangentially elongated rectangular shaped flat aleurone cells (Fig. E, arrow).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-G =12.5 µm

32. *Themeda laxa* (Fig. 22(32) A-F)

Shape: Kidney shaped in transaction with dorsal convex surface and having size 0.36 (L) X 0.64 (B) mm (Fig. A).

Pericarp: Type B (Fig. F).

Embryo: Type C - Embryo placed an angle of 173.2° (Fig. A). Epiblast is absent.

Scutellum: U shaped: Type - U1-2 (Fig. B), having an angle of 57.3°. Scutellum cleft/slit is present and it covers the coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. E), and also shows depletion layer (Fig. E, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 168.7°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

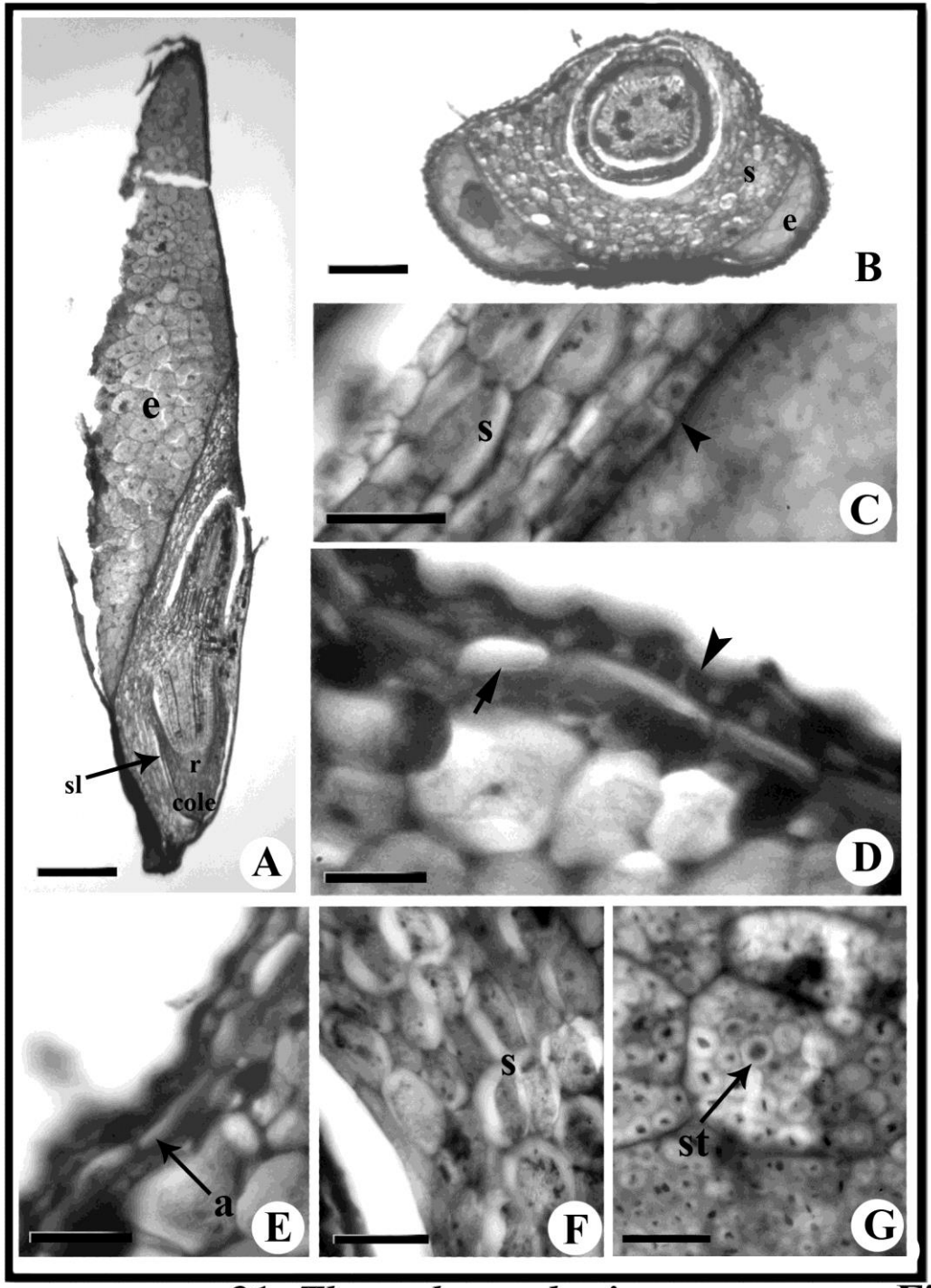
Starch grain: Simple circular and polygon starch grains present (Fig. D).

No. of starch grains per endosperm cell: 38±9 **Starch grain size:** 4.76±1.48 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. C).

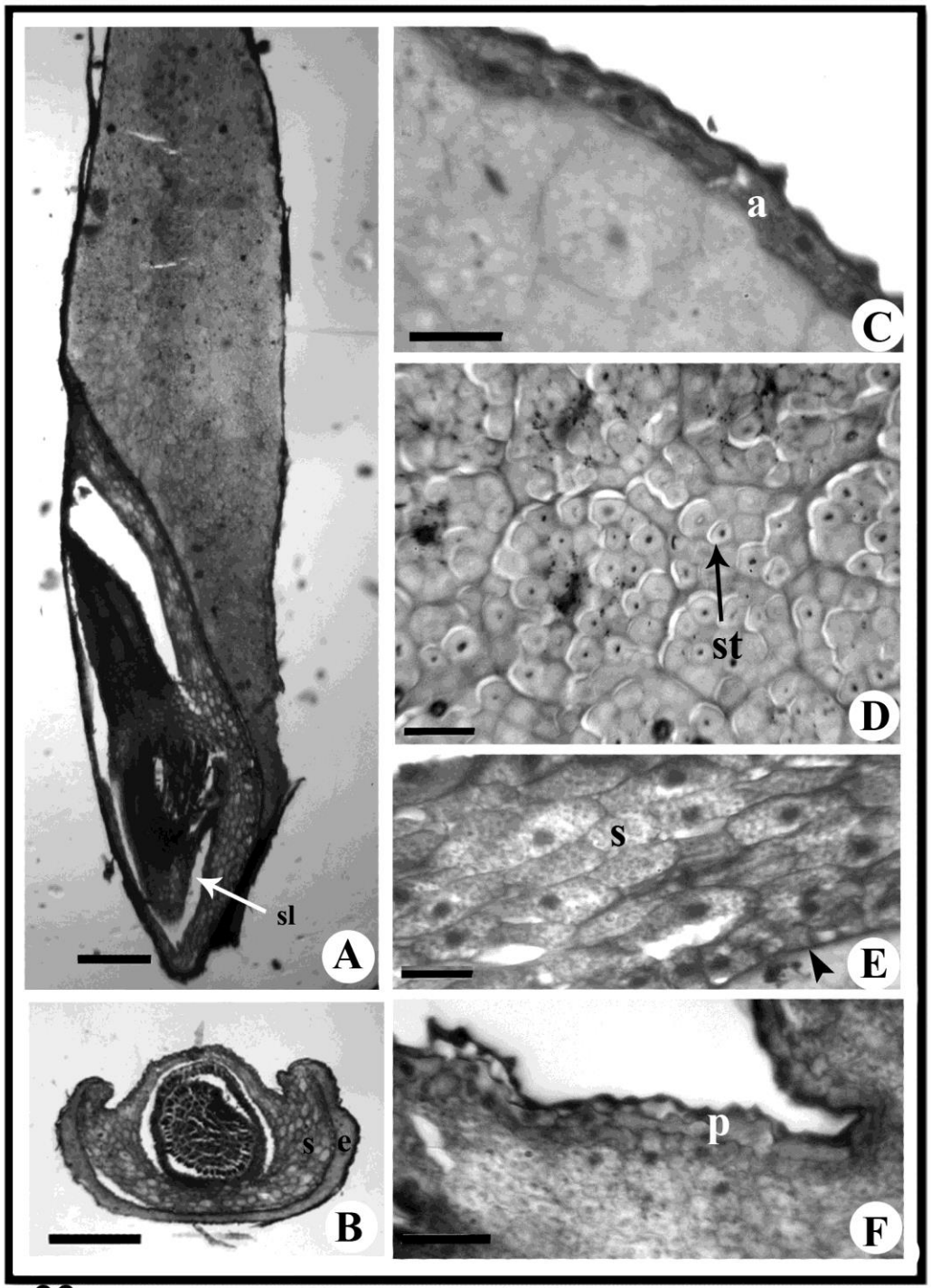
Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm



31. *Themeda cymbaria*

Fig. 22



32. *Themeda laxa*

33. *Themeda triandra* (Fig. 23(33) A-F)

Shape: Cork shaped in transaction with convex anterior and posterior side and having size 0.65 (L) X 0.73 (B) mm (Fig. B).

Pericarp: Type A (Fig. E).

Embryo: Type C - Embryo placed an angle of 172.7° (Fig. A). Epiblast is absent.

Scutellum: "V" shaped: Type V3-3 (Fig. A), having an angle of 62.17°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. D). Depletion layer is present (Fig. D, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 164.4°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon shaped starch grains (Fig. C).

No. of starch grains per endosperm cell: 44±3 **Starch grain size:** 4.69±2.16 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. F).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm

34. *Themeda quadrivalvis* (Fig. 23(34) A-G)

Shape: Crock (Matka) shaped in transaction with dorsal convex surface and having size 0.85 (L) X 0.98(B) mm (Fig. B).

Pericarp: Type A (Fig. C cross cells (arrowhead), D nucellus (arrow)).

Embryo: Type C - Embryo placed an angle of 173.1°. Epiblast is absent.

Scutellum: V shaped: Type – V3-3, having an angle of 61.3°. Scutellum cleft/slit is present and it covers the coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. F), and also shows depletion layer (Fig. G, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 168.4°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon shaped starch grains present (Fig. G, arrow).

No. of starch grains per endosperm cell: 40±5 **Starch grain size:** 3.41±1.39 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. E).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-G =12.5 µm

Differentiating features:

Perricarp type- B……..…….*T. laxa*

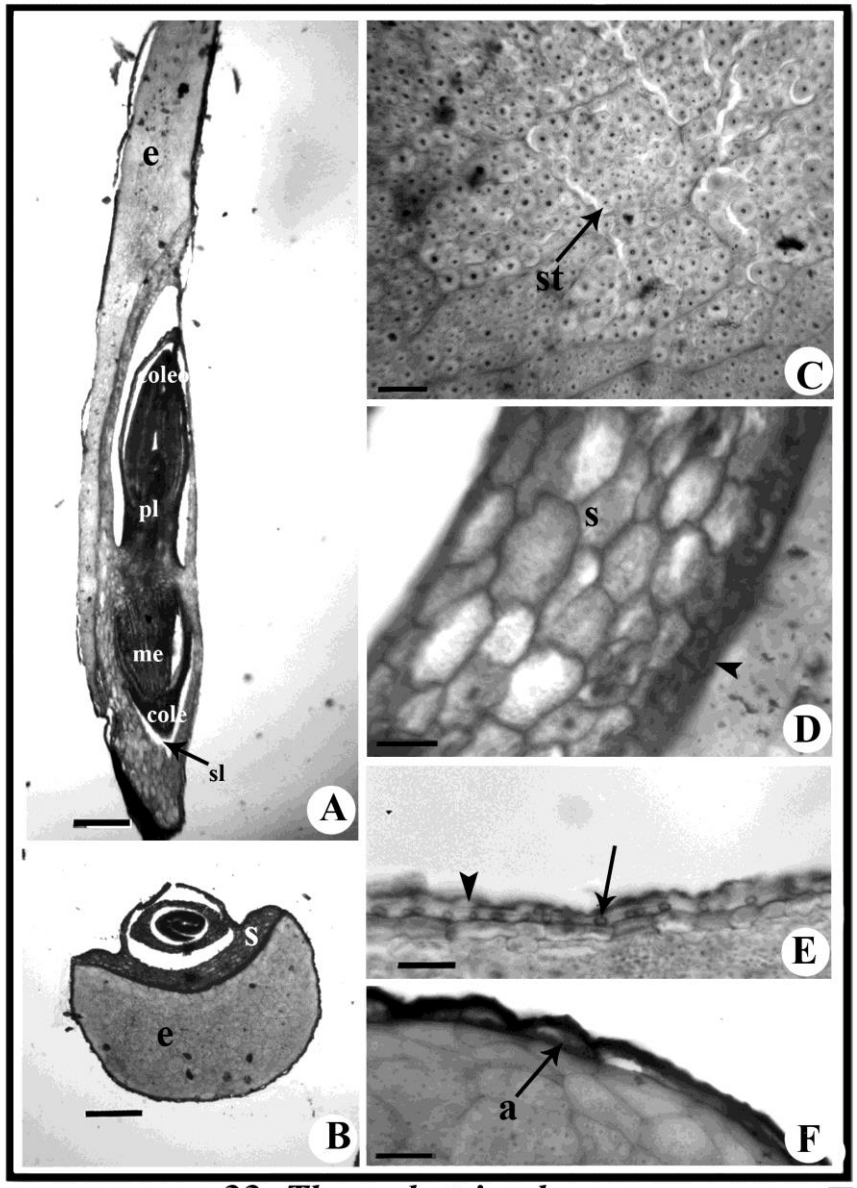
Perricarp type- A

Scutellum type- U1-2……*T. cymbaria*

Scutellum type- V3-4

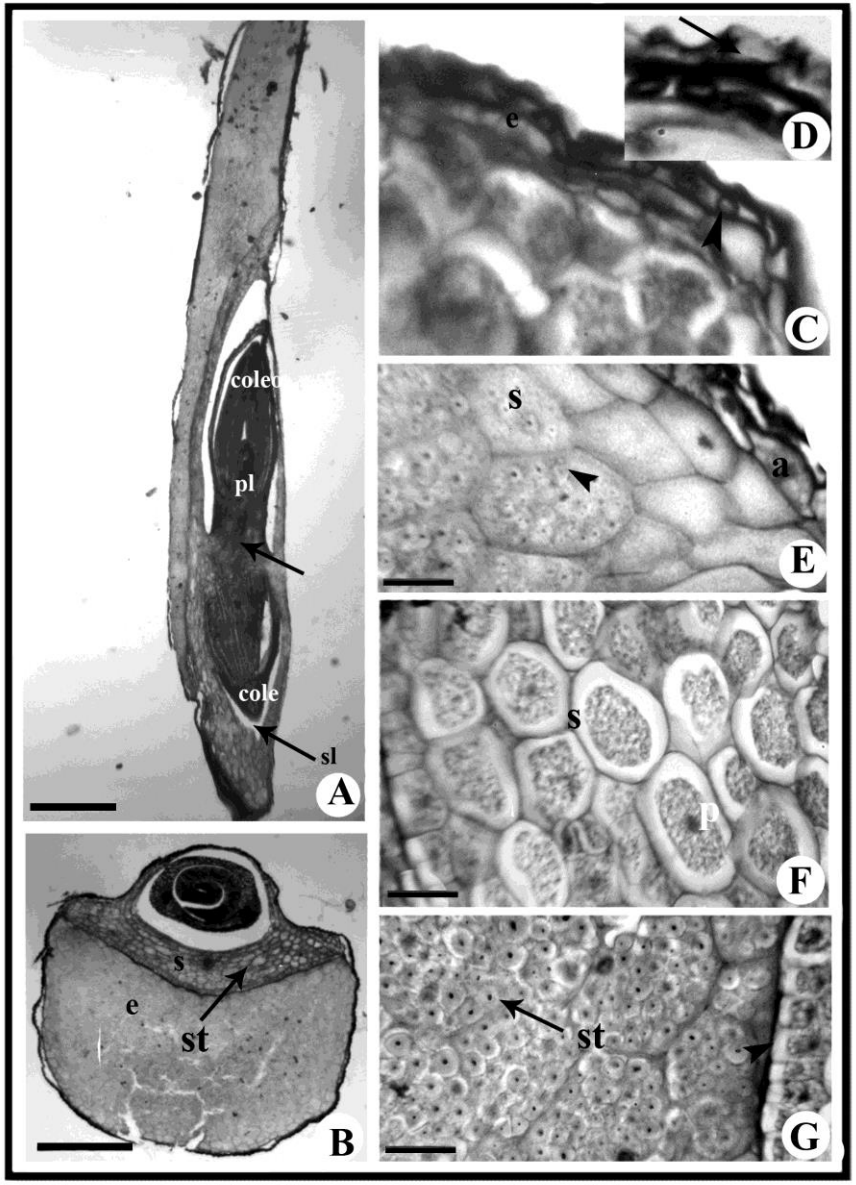
Simple polygonal shaped starch grains, thickness of endosperm: 546.31±7.82 µm ……....……...……*T. triandra*

Simple circular shaped starch grains, thickness of endosperm: 877.3±7.63 µm ……..……*T. qurqdrivalvis*



33. *Themeda triandra*

Fig. 23



34. *Themeda quadrivalvis*

35. *Triplopogon ramosissimus* (Fig. 24(35) A-F)

Shape: Rectangular to oval shaped in transaction with dorsal convex surface and having size 0.48 (L) X 0.95 (B) mm (Fig. B).

Pericarp: Type A (Fig. D; epidermis (arrowhead), hypodermis (arrow), cross cells (arrow)).

Embryo: Type C - Embryo placed an angle of 172.1° (Fig. A). Epiblast is absent.

Scutellum: U shaped: Type – U2-2 (Fig. B), having an angle of 61.7°. Scutellum cleft/slit is present and it covers the coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. C), and also shows depletion layer (Fig. C, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 166.5°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon shaped starch grains present (Fig. C).

No. of starch grains per endosperm cell: 37±8 **Starch grain size:** 2.5±1.08 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. F).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm

36. *Vetivaria zizanioides* (Fig. 24(36) A-F)

Shape: Triangular shaped with circular base in transaction with dorsal convex surface and having size 0.96 (L) X 0.60 (B) mm (Fig. B).

Pericarp: Type C (Fig. E; epidermis (arrowhead), nucellus (arrow)).

Embryo: Type C - Embryo placed an angle of 171.1° (Fig. A). Epiblast is absent.

Scutellum: Δ shaped: Type – Δ5 (Fig. B), having an angle of 56.9°. Scutellum cleft/slit is present and it covers the coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. C), and also shows depletion layer (Fig. C, arrowhead).

Vascularisation: Type of vascularisation: Panicoid (Fig. A, arrow)

Angle of vascularisation: 167.9°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

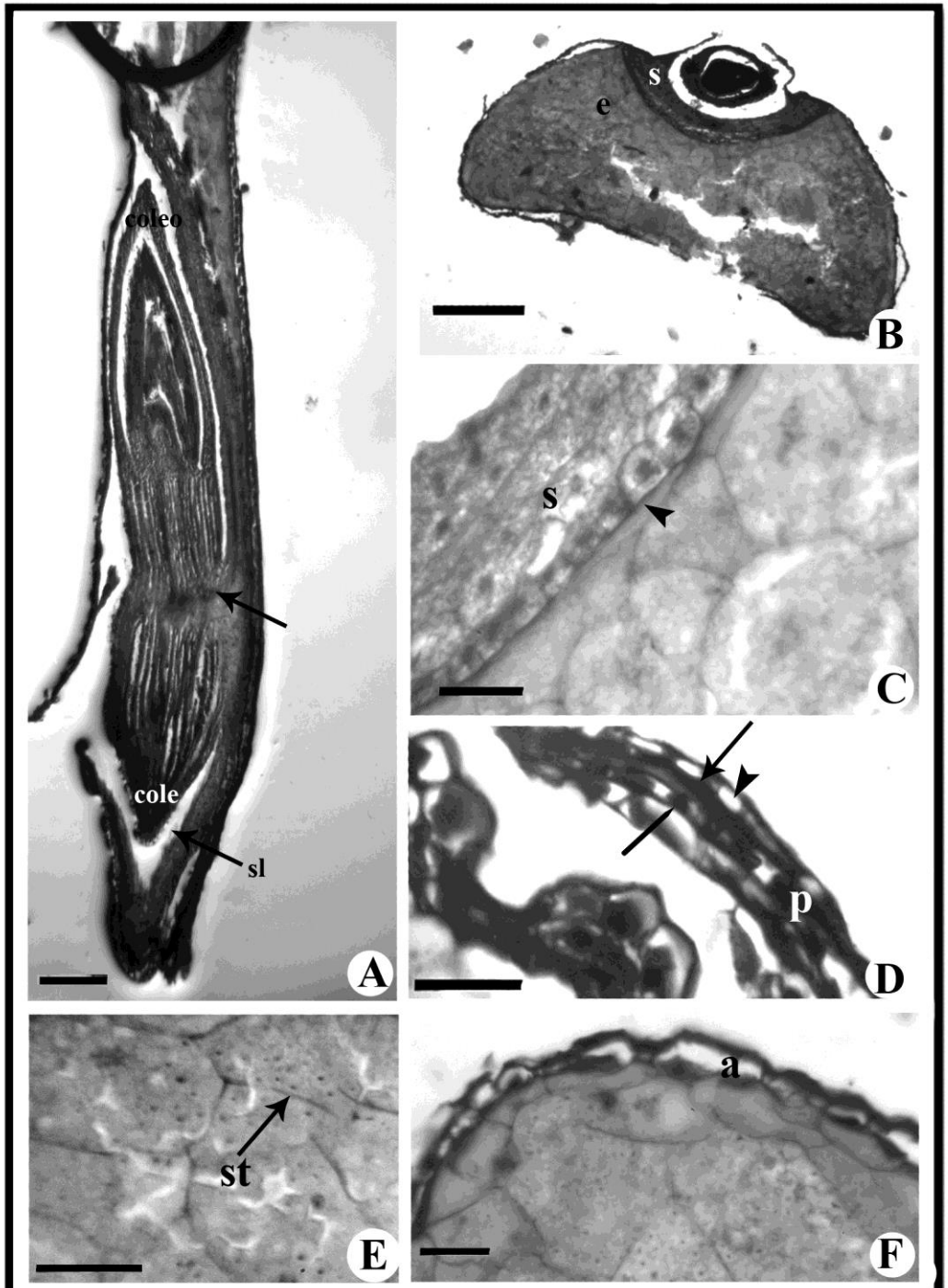
Starch grain: Simple circular and polygon shaped starch grains present (Fig. D).

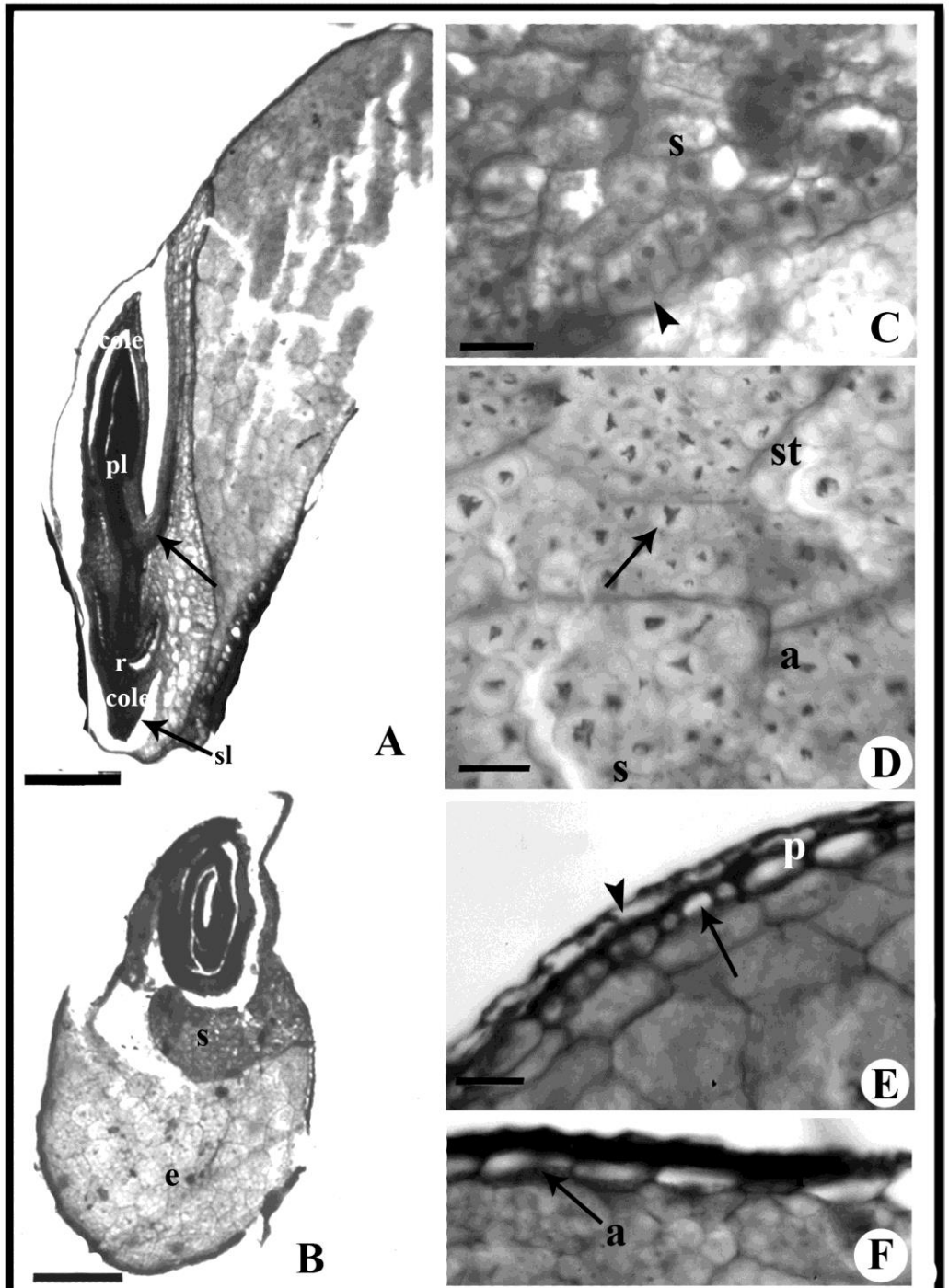
No. of starch grains per endosperm cell: 32±7 **Starch grain size:** 10±3.86 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. F).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm





35. *Triplopogon ramosissimus* **Fig. 24** **36. *Vetivaria zinzanoides***

37. *Alloteropis cimicina* (Fig. 25(37) A-F)

Shape: Triangular shaped with circular base in transaction with dorsal convex surface and having size 0.34 (L) X 3.45 (B) mm (Fig. B).

Pericarp: Type C (Fig. F).

Embryo: Type C - Embryo placed an angle of 166.7° (Fig. A). Epiblast is absent.

Scutellum: V shaped: Type – V6 (Fig. B), having an angle of 61.2°. Scutellum cleft/slit is present in form of small slit. Oval shaped, compactly arranged scutellum cells (Fig. D), and also shows depletion layer (Fig. D, arrowhead).

Vascularisation: Type of vascularisation: Panicoid (Fig. A, arrow)

Angle of vascularisation: 141.7°**,** Type – B.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon shaped starch grains present (Fig. C).

No. of starch grains per endosperm cell: 54±5 **Starch grain size:** 5±1.68 (µm)

Aleurone layer: Tangentially elongated rectangular and square shaped aleurone cells (Fig. E).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm

Brachiaria

38. *Brachiaria distachya*

39. *Brachiaria eruciformis*

40. *Brachiaria ramosa*

41. *Brachiaria reptans*

38. *Brachiaria distachya* (Fig. 25(38) A-F)

Shape: Oval to rectangular shaped with circular base in transaction with dorsal convex surface and having size 0.52 (L) X 1.50 (B) mm (Fig. B).

Pericarp: Type C (Fig. E; cross cells (arrowhead), nucellus (arrow)).

Embryo: Type C - Embryo placed an angle of 166.8° (Fig. A). Epiblast is absent.

Scutellum: V shaped: Type – V3-5 (Fig. B), having an angle of 82.33°. Scutellum cleft/slit is present in form of small slit. Oval shaped, compactly arranged scutellum cells (Fig. F), and also shows depletion layer (Fig. F, arrowhead).

Vascularisation: Type of vascularisation: Panicoid (Fig. A, arrow)

Angle of vascularisation: 154.0°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

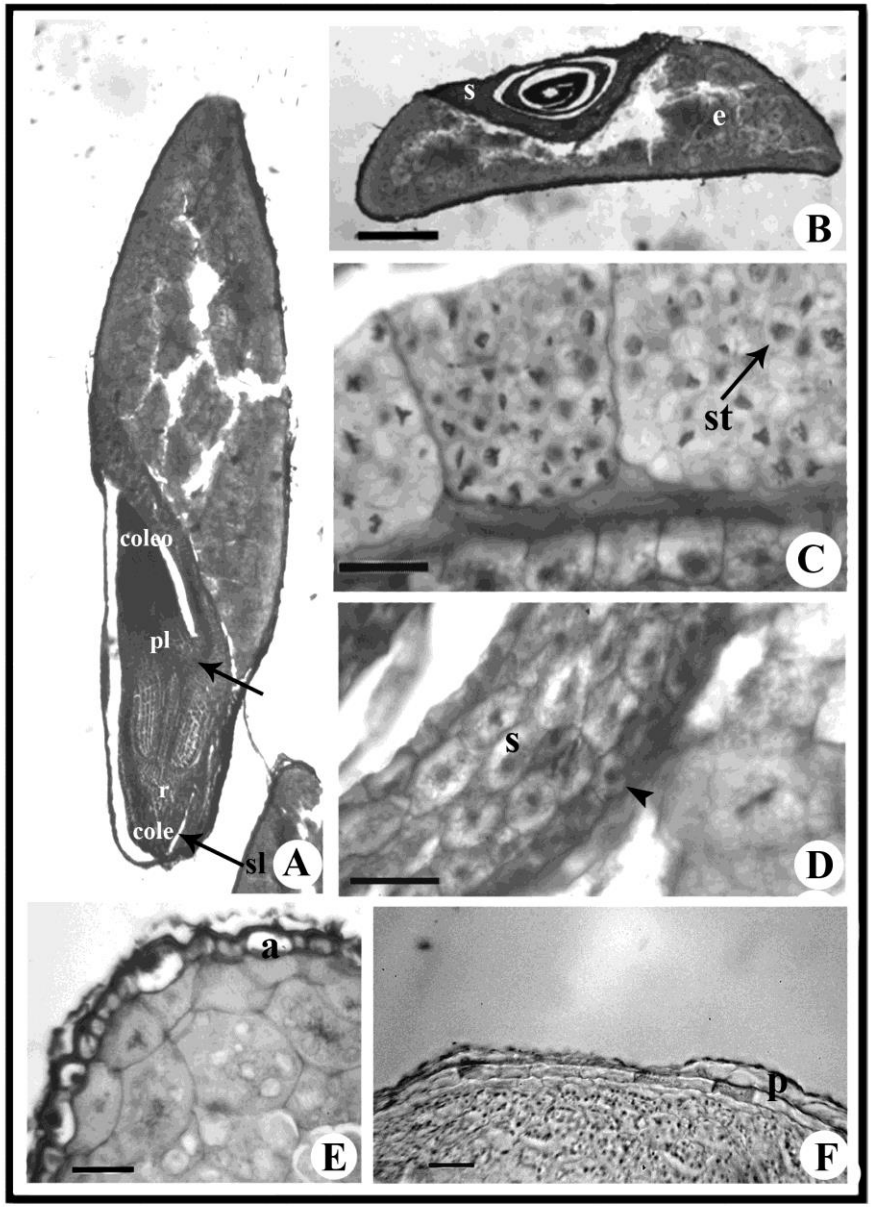
Starch grain: Simple circular and polygon starch grains present (Fig. D).

No. of starch grains per endosperm cell: 29±11 **Starch grain size:** 3.13±1.93 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. C).

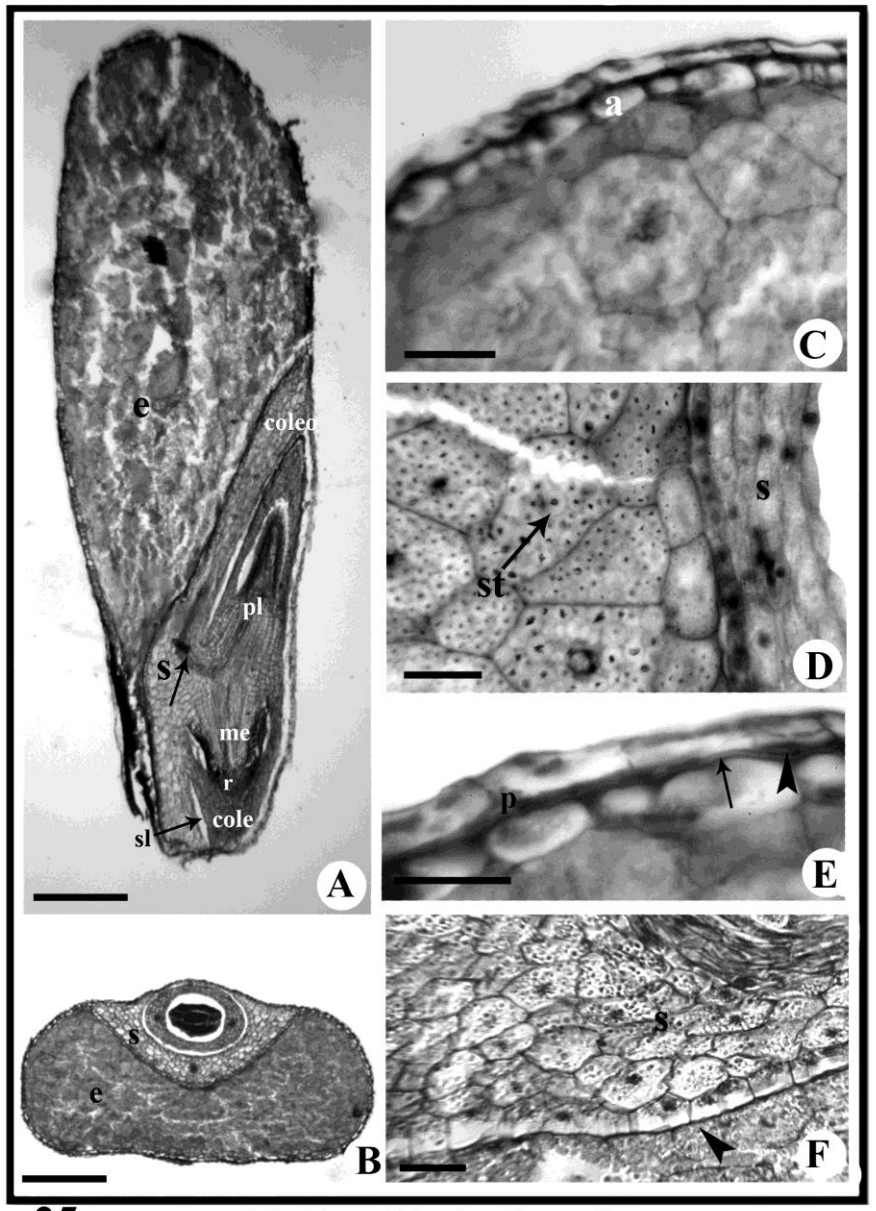
Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm



37. *Alloperopsis cimicina*

Fig. 25



38. *Brachiaria distachya*

39. *Brachiaria eruciformis* (Fig. 26(39) A-F)

Shape: Oval shaped with flat base and convex anterior side in transaction and having size 0.36 (L) X 0.67 (B) mm (Fig. B).

Pericarp: Type C (Fig. E; cross cells (arrowhead)).

Embryo: Type C - Embryo placed an angle of 170.3° (Fig. A). Epiblast is absent.

Scutellum: V shaped: Type – V3-6 (Fig. B), having an angle of 46.06°. Scutellum cleft/slit is present and it covers the coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. D).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 168.8°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon shaped starch grains present (Fig. C).

No. of starch grains per endosperm cell: 26±9 **Starch grain size:** 2.88±0.36 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. F).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm

40. *Brachiaria ramosa* (Fig. 26(40) A-F)

Shape: Oval shaped with flat base and convex anterior side in transaction and having size 0.62 (L) X 1.35 (B) mm (Fig. B).

Pericarp: Type C (Fig. D; nucellus (arrow), cross cells (arrowhead)).

Embryo: Type C - Embryo placed an angle of 160.3° (Fig. A). Epiblast is absent.

Scutellum: V shaped: Type – V3-5 (Fig. B), having an angle of 78.37°. Scutellum cleft/slit is present. Oval shaped, compactly arranged scutellum cells (Fig. C) and depletion layer is also present (Fig. C, arrowhead).

Vascularisation: Type of vascularisation: Panicoid (Fig. A, arrowhead)

Angle of vascularisation: 152.38 °**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

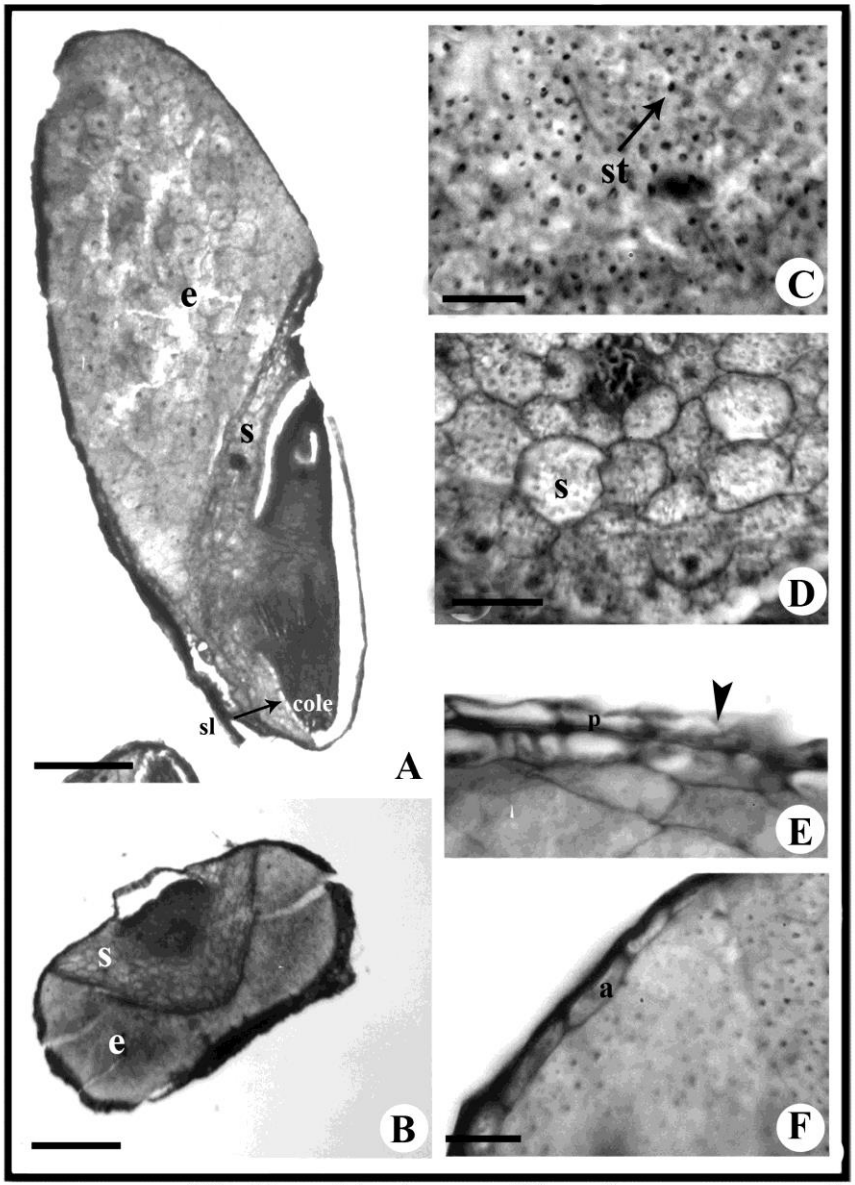
Starch grain: Simple circular and polygon starch grains present (Fig. F).

No. of starch grains per endosperm cell: 23±8 **Starch grain size:** 4.17±1.74 (µm)

Aleurone layer: Tangentially elongated rectangular shaped small aleurone cells (Fig. D, arrow).

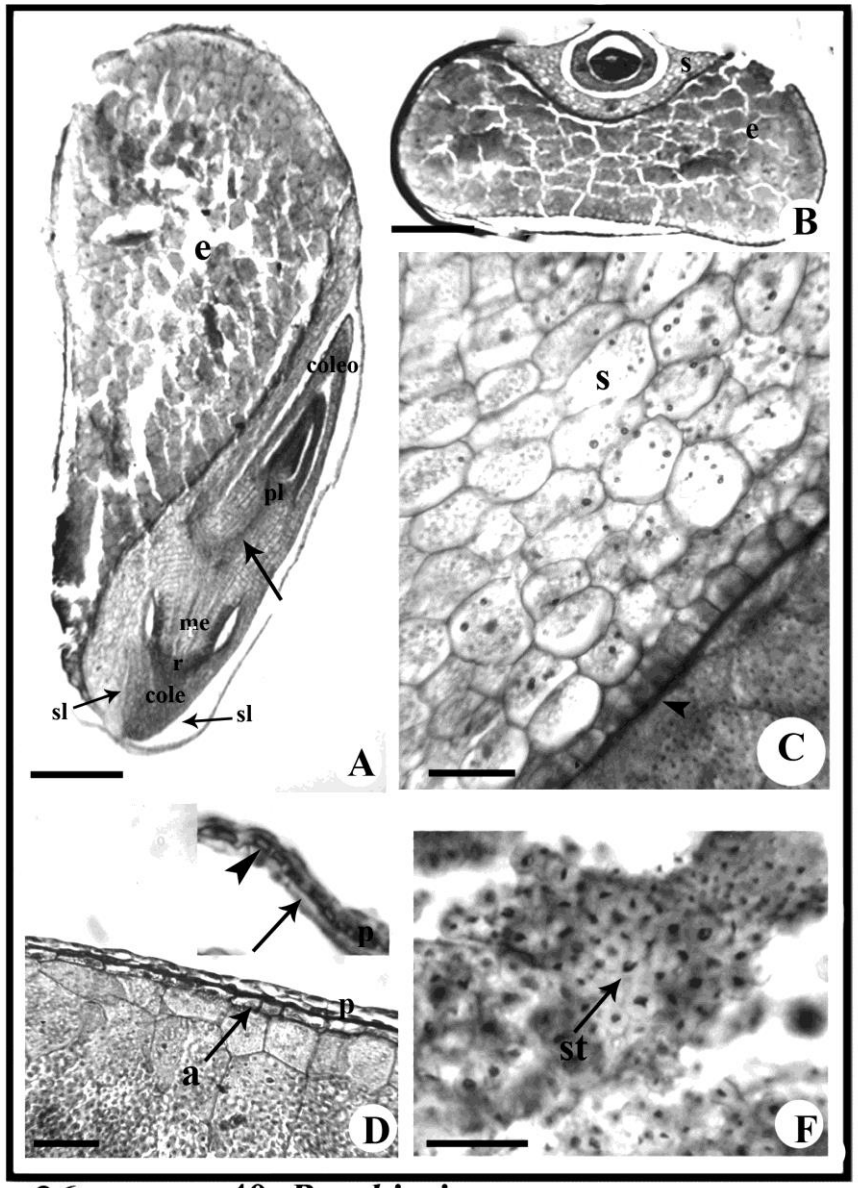
Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm



39. *Brachiaria eruciformis*

Fig. 26



40. *Brachiaria ramosa*

41. *Brachiaria reptans* (Fig. 27(41) A-F)

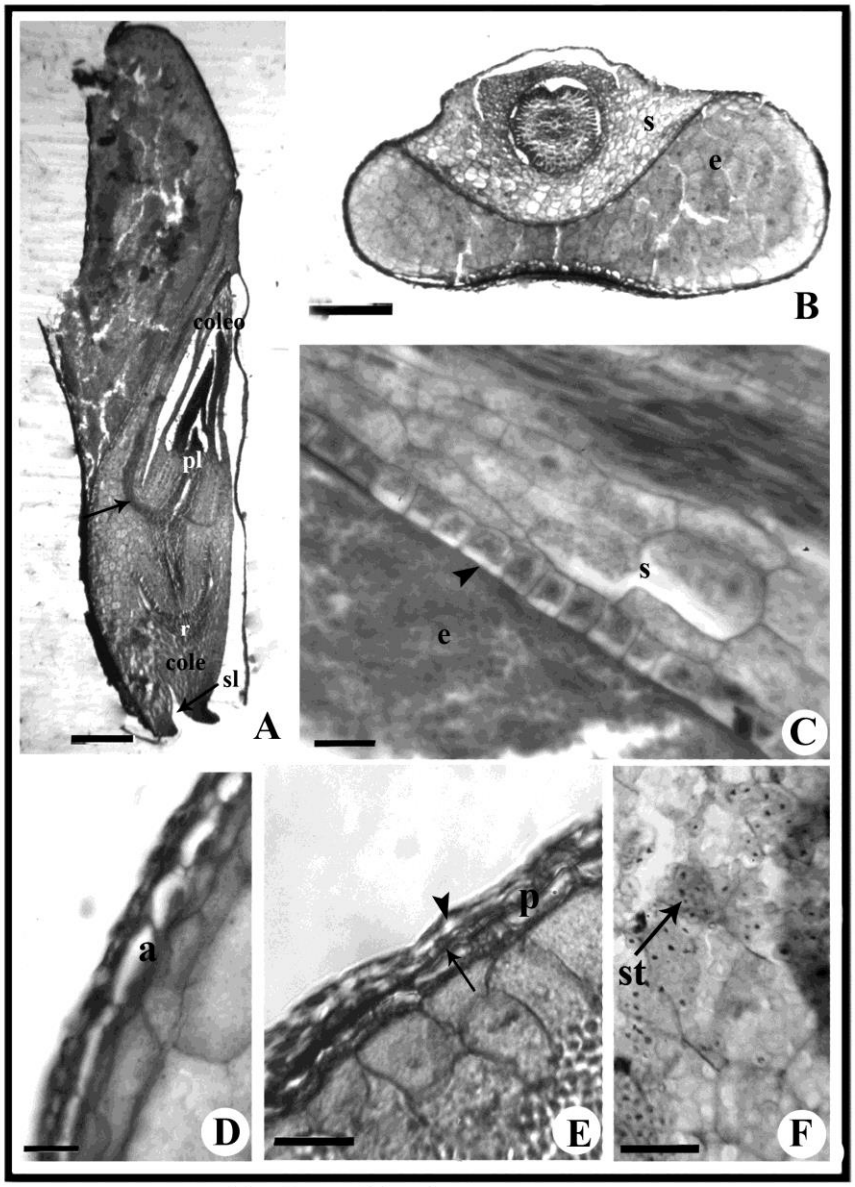
Shape: Oval to dumble shaped with convex anterior side in transaction and having size 0.43 (L) X 1.42 (B) mm (Fig. B).
Pericarp: Type C (Fig. E; epidermis (arrowhead), cross cells (arrow)).
Embryo: Type C - Embryo placed an angle of 173.2 ° (Fig. A). Epiblast is absent.
Scutellum: V shaped: Type – V3-3 (Fig. B), having an angle of 61.24°. Scutellum cleft/slit is present and it is present in the center of the proximal end. Oval shaped, compactly arranged scutellum cells (Fig. C) and depletion layer present (Fig. C).
Vascularisation: Type of vascularisation: Panicoid (Fig. A, arrow)
Angle of vascularisation: 156.2°**,** Type – C.
Pattern of embryonic leaf: P- type
Endosperm: Polygon shaped endospermic cells.
Starch grain: Simple circular and polygon shaped starch grains present (Fig. E).
No. of starch grains per endosperm cell: 21±7 **Starch grain size:** 2.88±0.34 (µm)
Aleurone layer: Tangentially elongated rectangular small aleurone cells (Fig. D).
Caryopsis type and formula: True panicoids type and having formula P-PP.
Bar Size: A, B =125 µm, C-F =12.5 µm
Differentiating features:
Scutellum type- V3-6……*B. eruciformis*
Scutellum type- V3-3……..……*B. reptans*
Scutellum type- V3-5
Endosperm thickness: 335.8±11.21 µm ……..*B. distachya*
Endosperm is very thick, almost three times more (897.71±23.63 µm)…….
……..*B.ramosa*

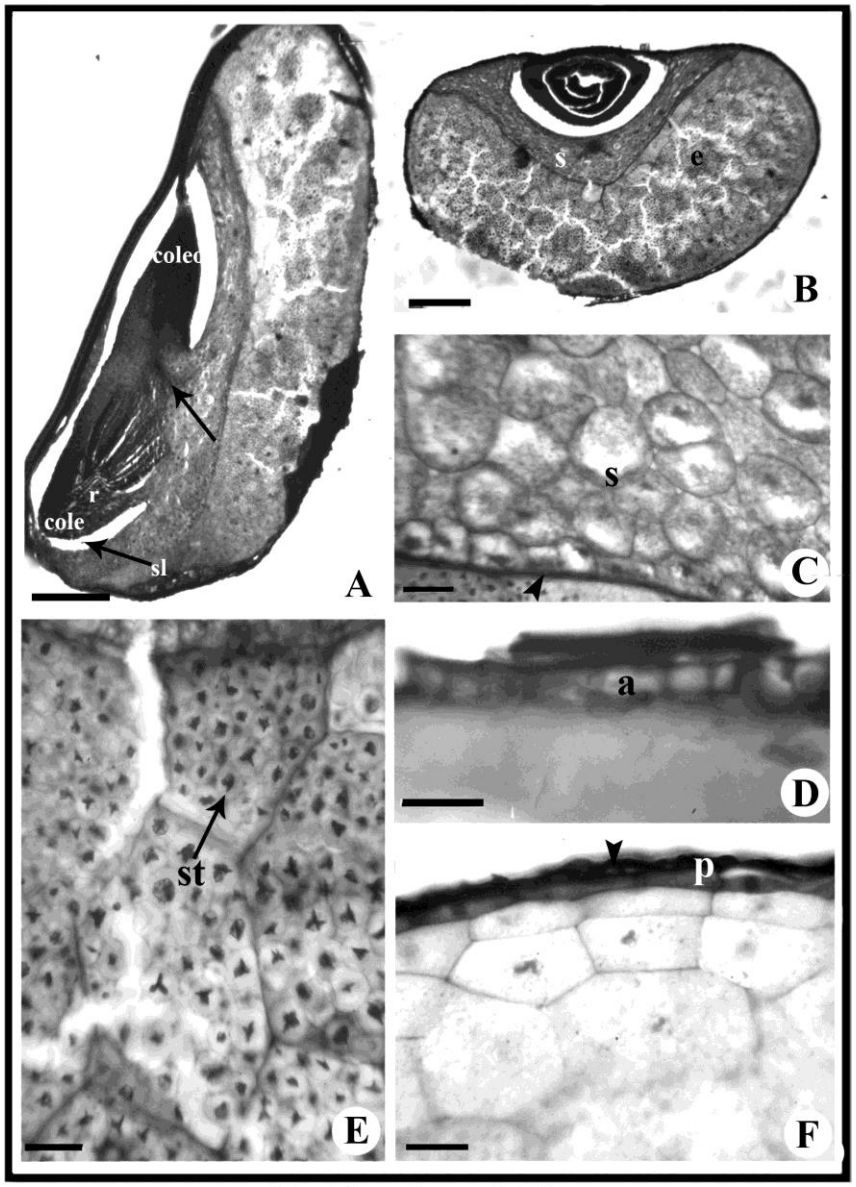
Cenchrus

42. *Cenchrus biflorus*
43. *Cenchrus ciliaris*
44. *Cenchrus setigerus*

42. *Cenchrus biflorus* (Fig. 27(42) A-F)

Shape: Semicircle shaped with flat anterior side and circular posterior side in transaction and having size 0.82 (L) X 1.34 (B) mm (Fig. B).
Pericarp: Type C (Fig. F; epidermis (arrowhead)).
Embryo: Type C - Embryo placed an angle of 172.7 ° (Fig. A). Epiblast is absent.
Scutellum: V shaped: Type – V2 (Fig. B), having an angle of 53.9°. Scutellum cleft/slit is present. Oval shaped, compactly arranged scutellum cells (Fig. C) and depletion layer is also present (Fig. C, arrowhead).
Vascularisation: Type of vascularisation: Panicoid (Fig. A)
Angle of vascularisation: 164.1°**,** Type – C.
Pattern of embryonic leaf: P- type
Endosperm: Polygon shaped endospermic cells.
Starch grain: Simple polygon shaped starch grains present (Fig. E).
No. of starch grains per endosperm cell: 45±8 **Starch grain size:** 5.68±2.27 (µm)
Aleurone layer: Tangentially elongated rectangular and small squarish shaped aleurone cells (Fig. D).
Caryopsis type and formula: True panicoids type and having formula P-PP.
Bar Size: A, B =125 µm, C-F =12.5 µm





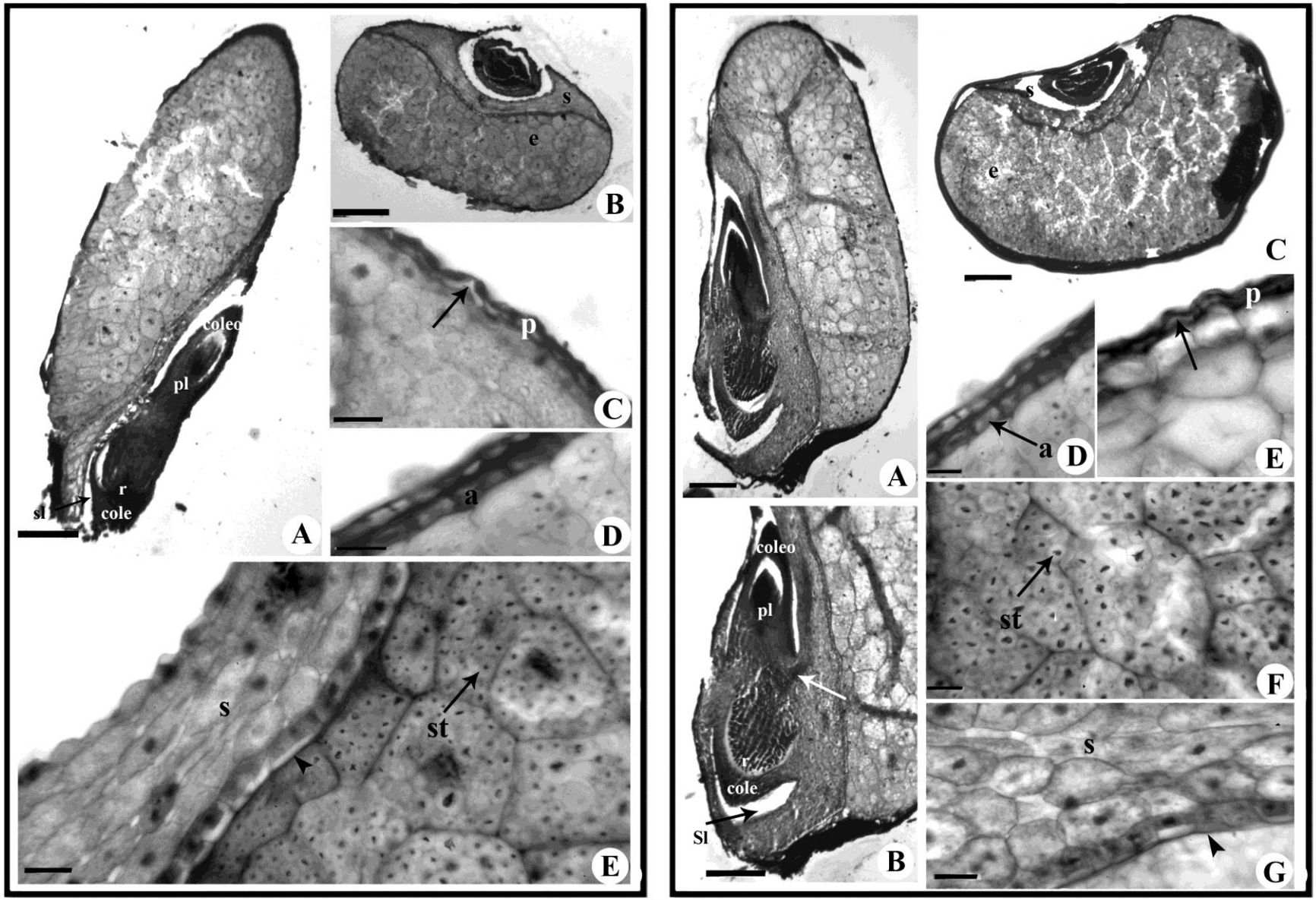
41. *Brachiaria reptans* **Fig. 27** 42. *Cenchrus biflorus*

43. *Cenchrus ciliaris* (Fig. 28(43) A-E)

Shape: Oblong to oval shaped with convex anterior side and circular posterior side in transaction and having size 0.52 (L) X 0.64 (B) mm (Fig. B).
Pericarp: Type C (Fig. C).
Embryo: Type C - Embryo placed an angle of 172.9 ° (Fig. A). Epiblast is absent.
Scutellum: V shaped: Type – V8-2, having an angle of 71.3°. Scutellum cleft/slit is present. Oval shaped, slightly flat, compactly arranged scutellum cells (Fig. E) and depletion layer is also present (Fig. E, arrowhead).
Vascularisation: Type of vascularisation: Panicoid
Angle of vascularisation: 167.8°**,** Type – C.
Pattern of embryonic leaf: P- type
Endosperm: Polygon shaped endospermic cells.
Starch grain: Simple circular and polygon shaped starch grains present (Fig. E, arrow).
No. of starch grains per endosperm cell: 39±6 **Starch grain size:** 5±1.83 (µm)
Aleurone layer: Tangentially elongated rectangular small aleurone cells (Fig. D).
Caryopsis type and formula: True panicoids type and having formula P-PP.
Bar Size: A, B =125 µm, C-E =12.5 µm

44. *Cenchrus setigerus* (Fig. 28(44) A-G)

Shape: Kidney shaped with flat anterior side and circular posterior side in transaction and having size 0.83 (L) X 1.39 (B) mm (Fig. B).
Pericarp: Type C (Fig. E; epidermis (arrow)).
Embryo: Type C - Embryo placed an angle of 166.2 ° (Fig. A). Epiblast is absent.
Scutellum: V shaped: Type – V6 (Fig. B), having an angle of 58.96°. Scutellum cleft/slit is present and it is covering the coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. G), depletion layer is also present (Fig. G, arrowhead).
Vascularisation: Type of vascularisation: Panicoid (Fig. B)
Angle of vascularisation: 146.3°**,** Type – B.
Pattern of embryonic leaf: P- type
Endosperm: Polygon shaped endospermic cells.
Starch grain: Simple circular and polygon shaped starch grains present (Fig. F).
No. of starch grains per endosperm cell: 41±4 **Starch grain size:** 6.25±2.57 (µm)
Aleurone layer: Tangentially elongated rectangular small aleurone cells (Fig. D).
Caryopsis type and formula: True panicoids type and having formula P-PP.
Bar Size: A, C =125 µm, B= 85.5 µm, D-G =12.5 µm
Differentiating features:
Square and rectangular both shaped aleurone cells…….*C. biflorus*
Tangentially elongated aleurone cells
Angle of vascularisation Type- C…….*C. ciliaris*
Angle of vascularisation Type- B……. *C. setigerus*



43. *Cenchrus ciliaris* **Fig. 28** 44. *Cenchrus setigerus*

Digitaria

45. *Digitaria ciliaris*

46. *Digitaria granularis*

47. *Digitaria longiflora*

48. *Digitaria stircta*

45. *Digitaria ciliaris* (Fig. 29(45) A-F)

Shape: Oblong to oval shaped with flat anterior side and circular posterior side in transaction and having size 0.62 (L) X 0.43 (B) mm (Fig. A).

Pericarp: Type D (Fig. F; epidermis (arrow), nucellus (arrowhead)).

Embryo: Type B - Embryo placed an angle of 157.76 ° (Fig. A). Epiblast is absent.

Scutellum: V shaped: Type – V7 (Fig. B), having an angle of 67.5°. Scutellum cleft/slit is present. Oval shaped, compactly arranged scutellum cells (Fig. C) and depletion layer is also present (Fig. C, arrowhead).

Vascularisation: Type of vascularisation: Panicoid (Fig. A, arrow)

Angle of vascularisation: 145.45°**,** Type – B.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon shaped starch grains present (Fig. D).

No. of starch grains per endosperm cell: 30±9 **Starch grain size:** 3.85±1.63 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. E).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm

46. *Digitaria granularis* (Fig. 29(46) A-F)

Shape: Oblong shaped with convex anterior side and flat posterior side in transaction and having size 0.49 (L) X 0.64(B) mm (Fig. B).

Pericarp: Type C (Fig. E; epidermis cells (arrowhead), nucellus (arrow)).

Embryo: Type C - Embryo placed an angle of 148.2 ° (Fig. A). Epiblast is absent.

Scutellum: V shaped: Type – V4-2, having an angle of 51.44° (Fig. B). Scutellum cleft/slit is present and it is present in the center of the proximal end. Oval shaped, compactly arranged scutellum cells (Fig. F) and depletion layer is also present (Fig. F, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 142.5°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

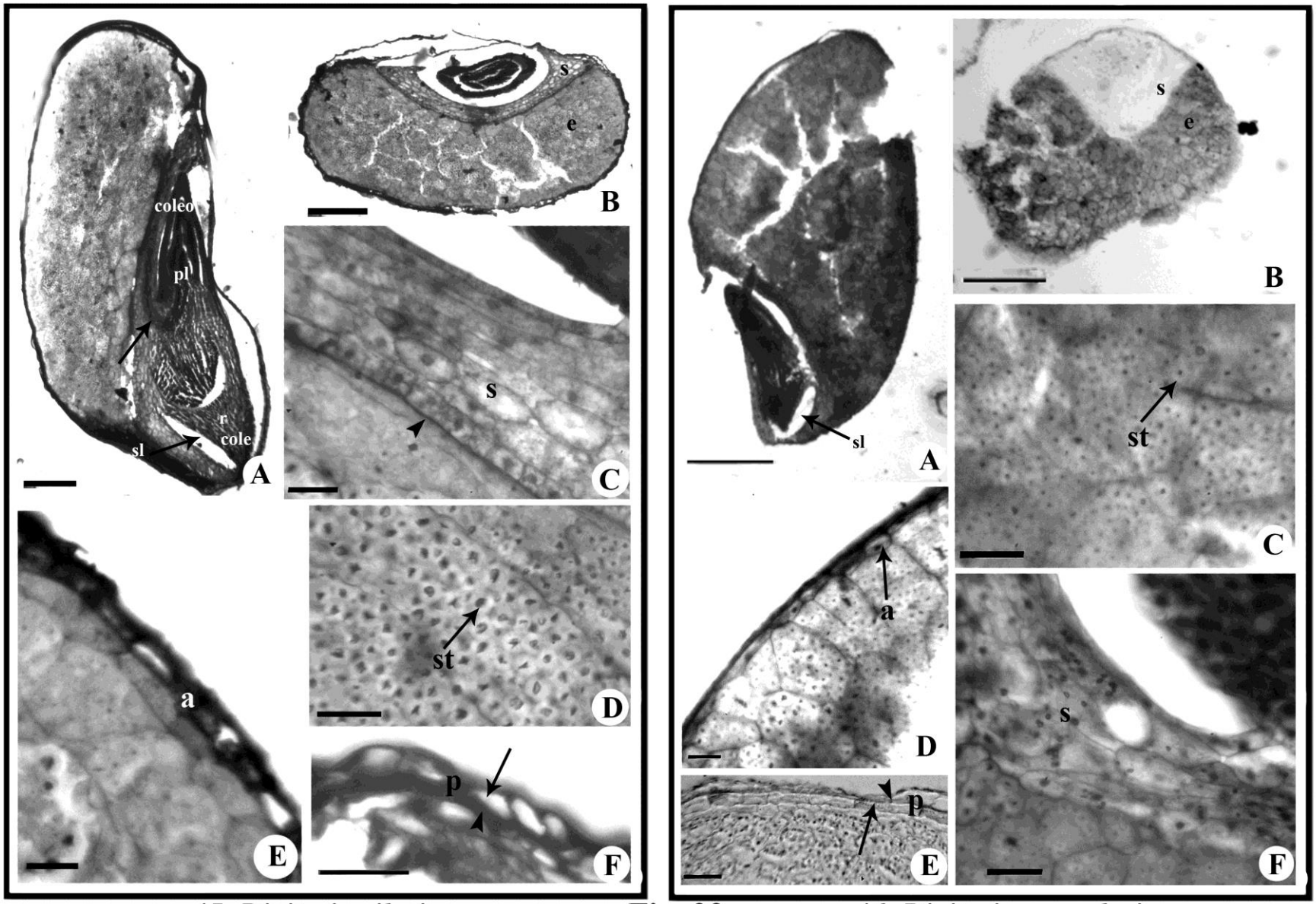
Starch grain: Simple circular and polygon starch grains present (Fig. C).

No. of starch grains per endosperm cell: 38±7 **Starch grain size:** 2.68±0.74 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. D, arrow).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm



45. *Digitaria cilaris* Fig. 29 46. *Digitaria granularis*

47. *Digitaria longiflora* (Fig. 30(47) A-E)

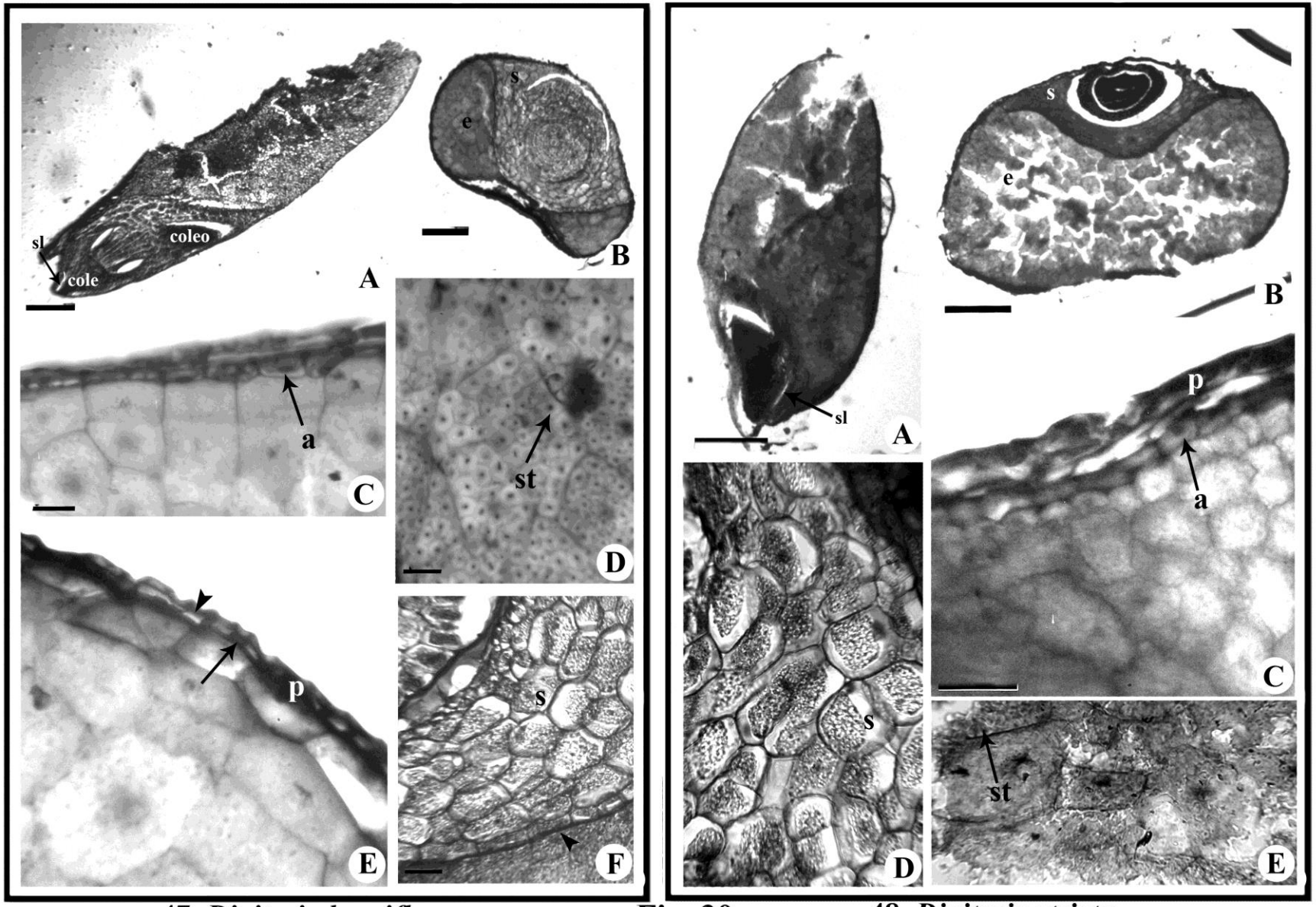
Shape: Oblong to oval shaped with convex anterior side and concave posterior side in transaction and having size 0.70 (L) X 1.13 (B) mm (Fig. B).
Pericarp: Type C (Fig. E; epidermis (arrowhead), cross cells (arrow)).
Embryo: Type C - Embryo placed an angle of 163.4 ° (Fig. A). Epiblast is absent.
Scutellum: V shaped: Type – U1-2 (Fig. B), having an angle of 59.72°. Scutellum cleft/slit is present and it is present in form of small slit. Oval shaped, compactly arranged scutellum cells (Fig. F) and depletion layer is also present (Fig. F, arrowhead).
Vascularisation: Type of vascularisation: Panicoid
Angle of vascularisation: 146.1°**,** Type – B.
Pattern of embryonic leaf: P- type
Endosperm: Polygon shaped endospermic cells.
Starch grain: Simple polygon shaped starch grains present (Fig. D).
No. of starch grains per endosperm cell: 44±5 **Starch grain size:** 8.34±3.04 (µm)
Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. C, arrow).
Caryopsis type and formula: True panicoids type and having formula P-PP.
Bar Size: A, B =125 µm, C-F =12.5 µm

48. *Digitaria stricta* (Fig. 30(48) A-E)

Shape: Oblong shaped with convex anterior side and flat posterior side in transaction and having size 0.47 (L) X 0.78 (B) mm (Fig. B).
Pericarp: Type D (Fig. C; epidermis cells (arrowhead)).
Embryo: Type C - Embryo placed an angle of 162.1 ° (Fig. A). Epiblast is absent.
Scutellum: V shaped: Type – V8-3, having an angle of 62.4° (Fig. B). Scutellum cleft/slit is present. Oval shaped, compactly arranged scutellum cells (Fig. D).
Vascularisation: Type of vascularisation: Panicoid
Angle of vascularisation: 143.4°**,** Type – B.
Pattern of embryonic leaf: P- type
Endosperm: Polygon shaped endospermic cells.
Starch grain: Simple circular and polygon shaped starch grains present (Fig. E).
No. of starch grains per endosperm cell: 43±8 **Starch grain size:** 6.95±2.56 (µm)
Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. C, arrow).
Caryopsis type and formula: True panicoids type and having formula P-PP.
Bar Size: A, B =125 µm, C-E =12.5 µm

Differentiating features:

Angle of vascularisation Type- C……..…….*D. granularis*
Angle of vascularisation Type- B
Embryo type- B……..……..*D. ciliaris*
Embryo type- C
Scutellum type- U1-2……..*D. longiflora*
Scutellum type- V8-3……...…….*D. stricta*



47. *Digitaria longiflora* **Fig. 30** 48. *Digitaria stricta*

Echinichloa

49. *Echinichloa colona*

50. *Echinochloa crusgalli*

51. *Echionochloa stagnina*

49. *Echinochloa colona* (Fig. 31(49) A-F)

Shape: Oblong shaped with convex anterior side and concave posterior side in transaction and having size 0.88 (L) X 1.42 (B) mm (Fig. B).

Pericarp: Type B (Fig. E; epidermis (arrowhead), cross cells (arrow)).

Embryo: Type C - Embryo placed an angle of 163.8 ° (Fig. A). Epiblast is absent.

Scutellum: V shaped: Type – V7 (Fig. B), having an angle of 65.74°. Scutellum cleft/slit is present and it covers the whole coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. C) and depletion layer is also present (Fig. C, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 131.3°**,** Type – B.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon starch grains present (Fig. F).

No. of starch grains per endosperm cell: 48±12 **Starch grain size:** 3.75±1.64 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. D).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm

50. *Echinochloa crusgalli* (Fig. 31(50) A-F)

Shape: Oblong shaped with convex anterior side and concave posterior side in transaction and having size 0.93 (L) X 1.67 (B) mm (Fig. B).

Pericarp: Type B (Fig. E; epidermis cells (arrow), cross cells (arrowhead)).

Embryo: Type C - Embryo placed an angle of 163.4 ° (Fig. A). Epiblast is absent.

Scutellum: V shaped: Type – V8-2 (Fig. B), having an angle of 69.9°. Scutellum cleft/slit is present and it is present in form of small slit. Oval shaped, compactly arranged scutellum cells (Fig. D) and depletion layer is also present (Fig. E, arrowhead).

Vascularisation: Type of vascularisation: Panicoid (Fig. A, arrow)

Angle of vascularisation: 143.5°**,** Type – B.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

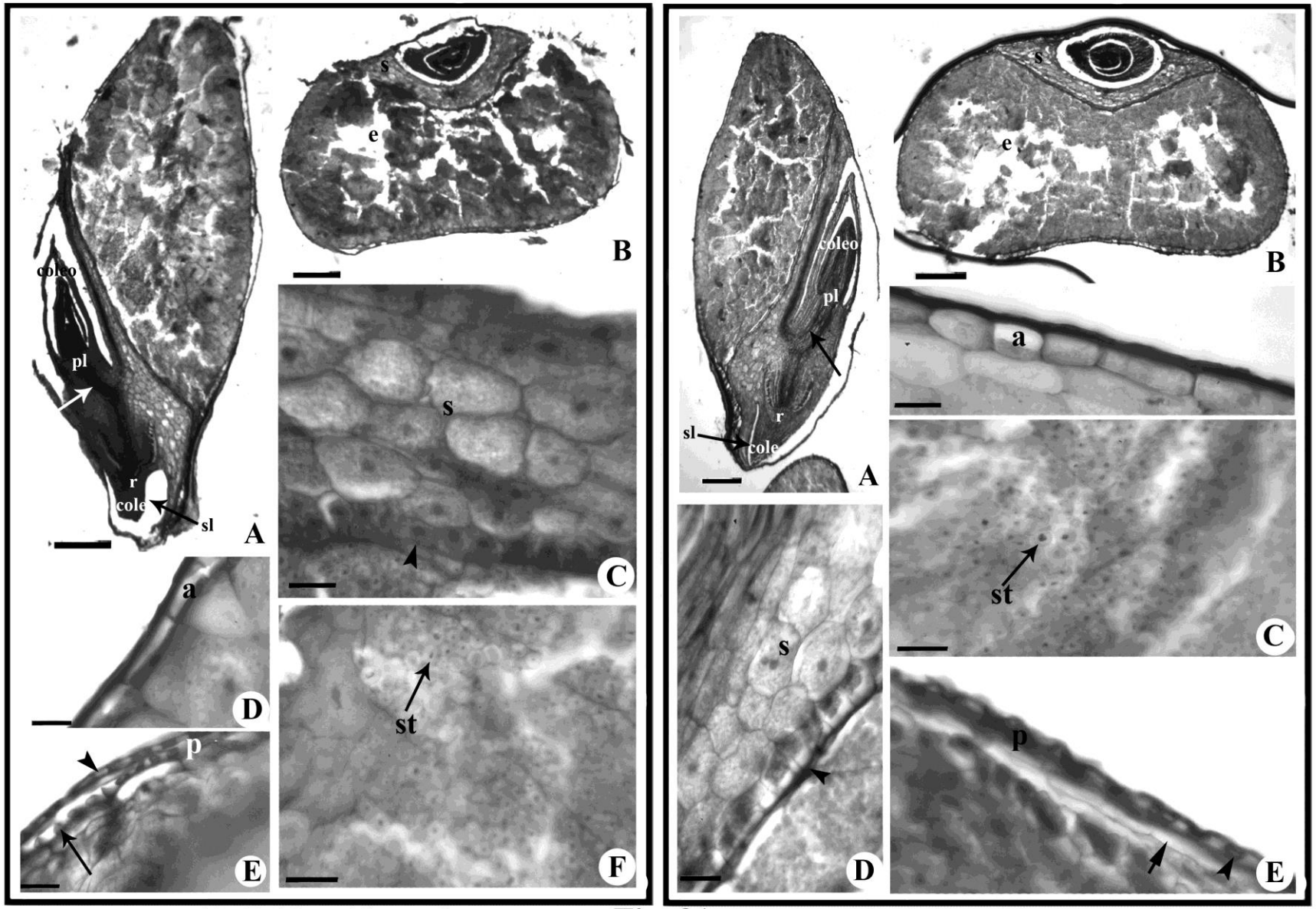
Starch grain: Simple circular and polygon starch grains present (Fig. D).

No. of starch grains per endosperm cell: 47±6 **Starch grain size:** 5±1.88 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. C).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-E =12.5 µm



49. *Echinochloa colona* **Fig. 31** 50. *Echinochloa crusgalli*

51. *Echinochloa stagnina* (Fig. 32(51) A-E)

Shape: Oblong to oval shaped with flat anterior side and circular posterior side in transaction and having size 1.25 (L) X 2.33 (B) mm (Fig. B).

Pericarp: Type B (Fig. D; epidermis (arrow), cross cells (arrowhead)).

Embryo: Type C - Embryo placed an angle of 163.2 ° (Fig. A). Epiblast is absent.

Scutellum: V shaped: Type – V8-1 (Fig. B), having an angle of 45.89°. Scutellum cleft/slit is present and it is present at the side of coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. E), depletion layer is also present (Fig. E, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 143.6°**,** Type – B.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon starch grains present (Fig. D).

No. of starch grains per endosperm cell: 41±9 **Starch grain size:** 5.56±3.02 (µm)

Aleurone layer: Tangentially elongated rectangular and square shaped mixed aleurone cells (Fig. C).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm

Differentiating featrures:

Square and rectangular both shaped aleurone cells…….*E. stagnina*

Tangentially elongated aleurone cells

Scutellum type- V7……..…….*E. colona*

Scutellum type- V8-2……...……..*E. crusgalli*

52. *Eremopogon foveolatus* (Fig. 32(52) A-F)

Shape: Oblong to oval shaped with flat anterior side and circular posterior side in transaction and having size 0.5 (L) X 1.54 (B) mm (Fig. B).

Pericarp: Type C (Fig. D; epidermis cells (arrow), cross cells (arrowhead)).

Embryo: Type C - Embryo placed an angle of 167.9 ° (Fig. A). Epiblast is absent.

Scutellum: V shaped: Type – V5 (Fig. B), having an angle of 52.9°. Scutellum cleft/slit is present and it is present at the side of coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. E).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 155.0°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

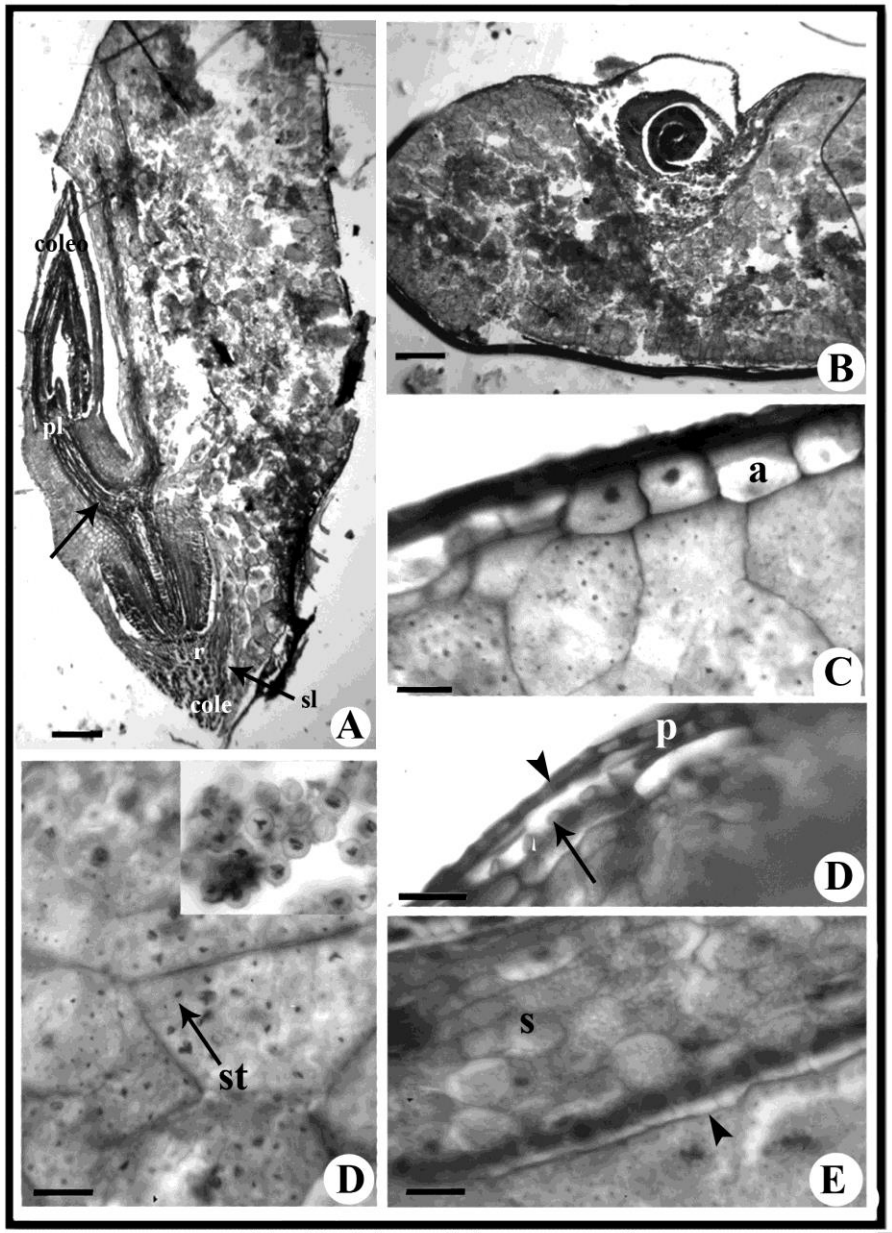
Starch grain: Simple circular and polygon starch grains present (Fig. F).

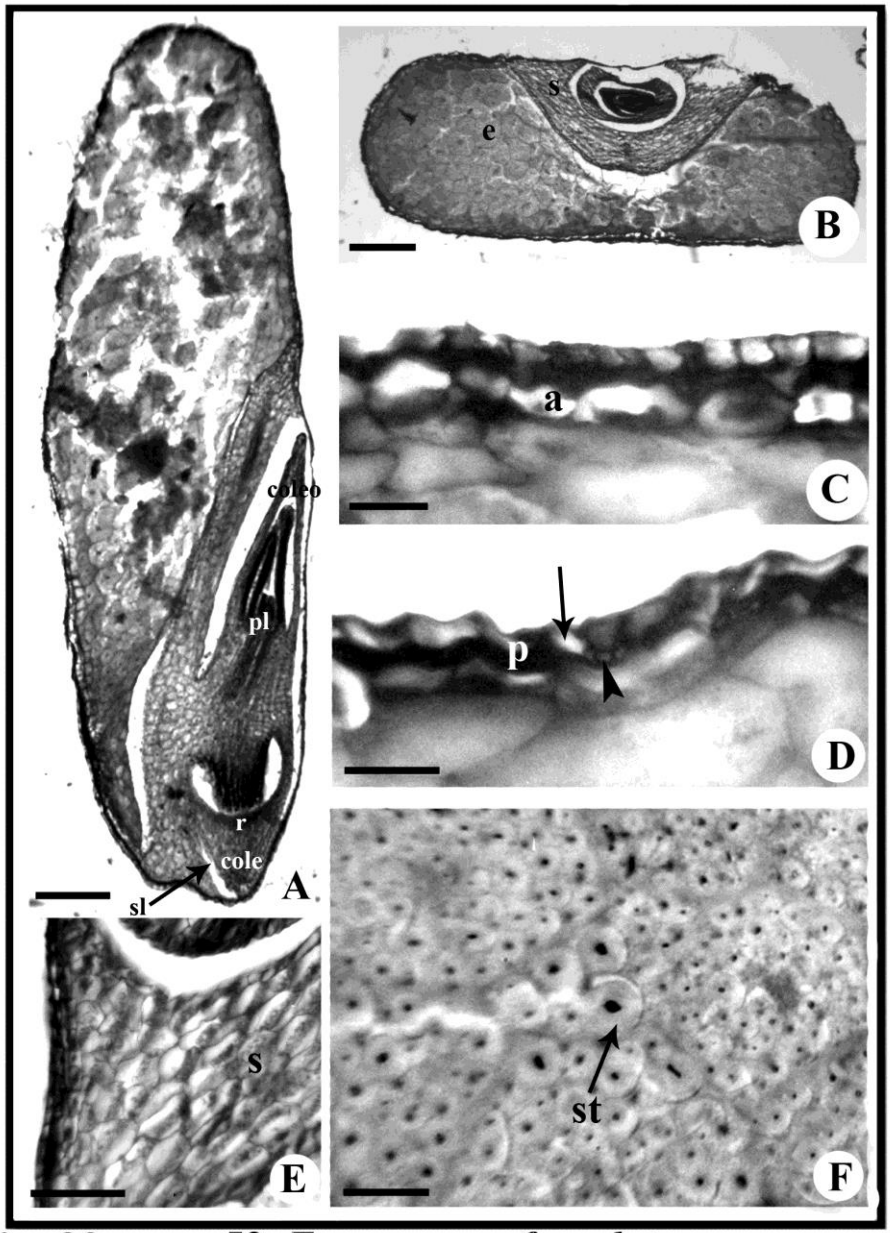
No. of starch grains per endosperm cell: 35±7 **Starch grain size:** 7.14±2.95 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. C).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm





51. *Echinochloa stagnina* **Fig. 32** 52. *Eremopogon foveolatus*

53. *Eriochloa procera* (Fig. 33(53) A-F)

Shape: Oblong shaped in transaction with concave anterior side and flat posterior side and having size 0.64 (L) X 1.83 (B) mm (Fig. B).

Pericarp: Type A (Fig. F; epidermis (arrowhead), cross cells (arrow)).

Embryo: Type C - Embryo placed an angle of 160.2° (Fig. A). Epiblast is absent.

Scutellum: "V" shaped: Type V5 (Fig. B), having an angle of 52.9°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. D). Depletion layer is present.

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 154.1°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon shaped starch grains (Fig. E).

No. of starch grains per endosperm cell: 77±6 **Starch grain size:** 2.78±1.17 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. C).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm

Oplismenus

54. *Oplismenus burmannii*

55. *Oplismenus composites*

54. *Oplismenus burmannii* (Fig. 33(54) A-F)

Shape: Oblong to oval shaped with flat anterior side and circular posterior side in transaction and having size 0.39 (L) X 0.55 (B) mm (Fig. B).

Pericarp: Type C (Fig. C; epidermis cells (arrow), cross cells (arrowhead)).

Embryo: Type B - Embryo placed an angle of 154.4 ° (Fig. A). Epiblast is absent.

Scutellum: V shaped: Type – U2-2 (Fig. B), having an angle of 55.3°. Scutellum cleft/slit is present and it is present at the side of coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. E) and depletion layer is also present (Fig. E, arrowhead).

Vascularisation: Type of vascularisation: Panicoid (Fig. A, arrow)

Angle of vascularisation: 150.2°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

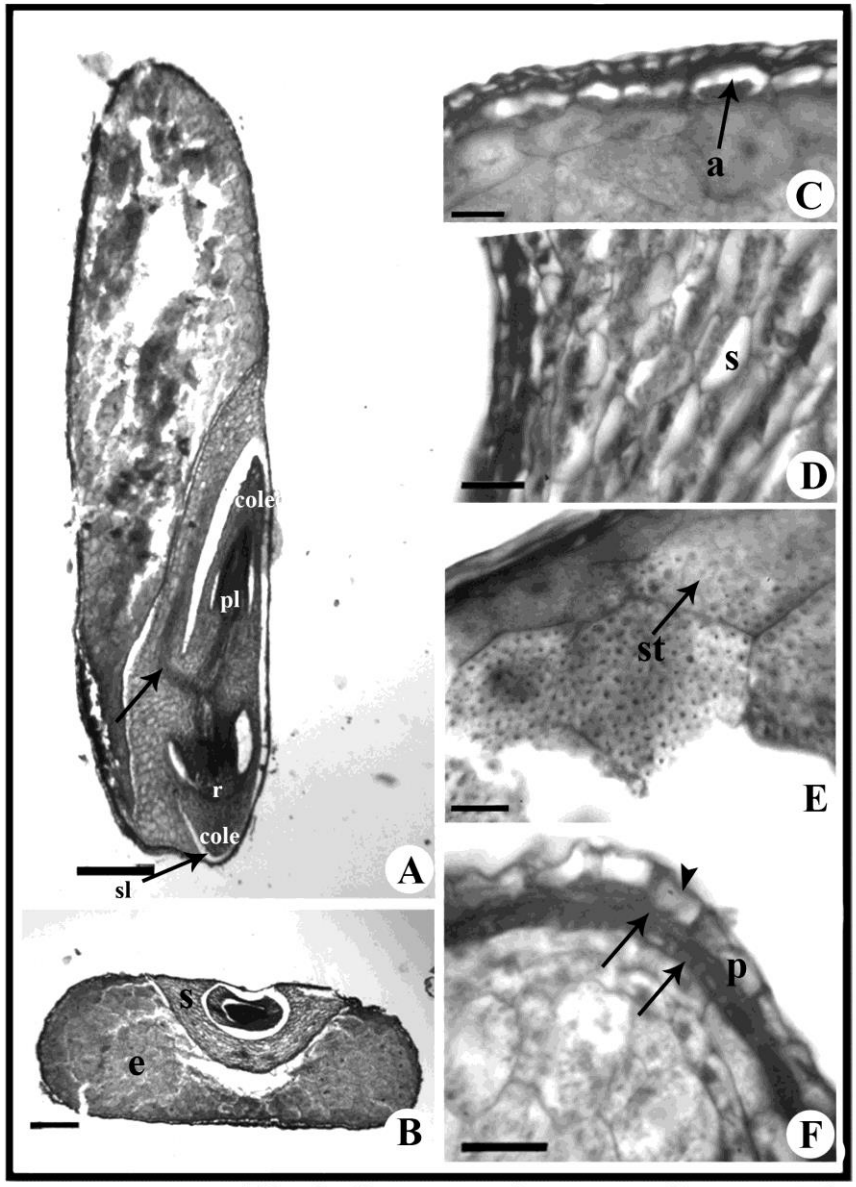
Starch grain: Simple polygon shaped starch grains present (Fig. D).

No. of starch grains per endosperm cell: 37±10 **Starch grain size:** 4.35±2.05 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. F).

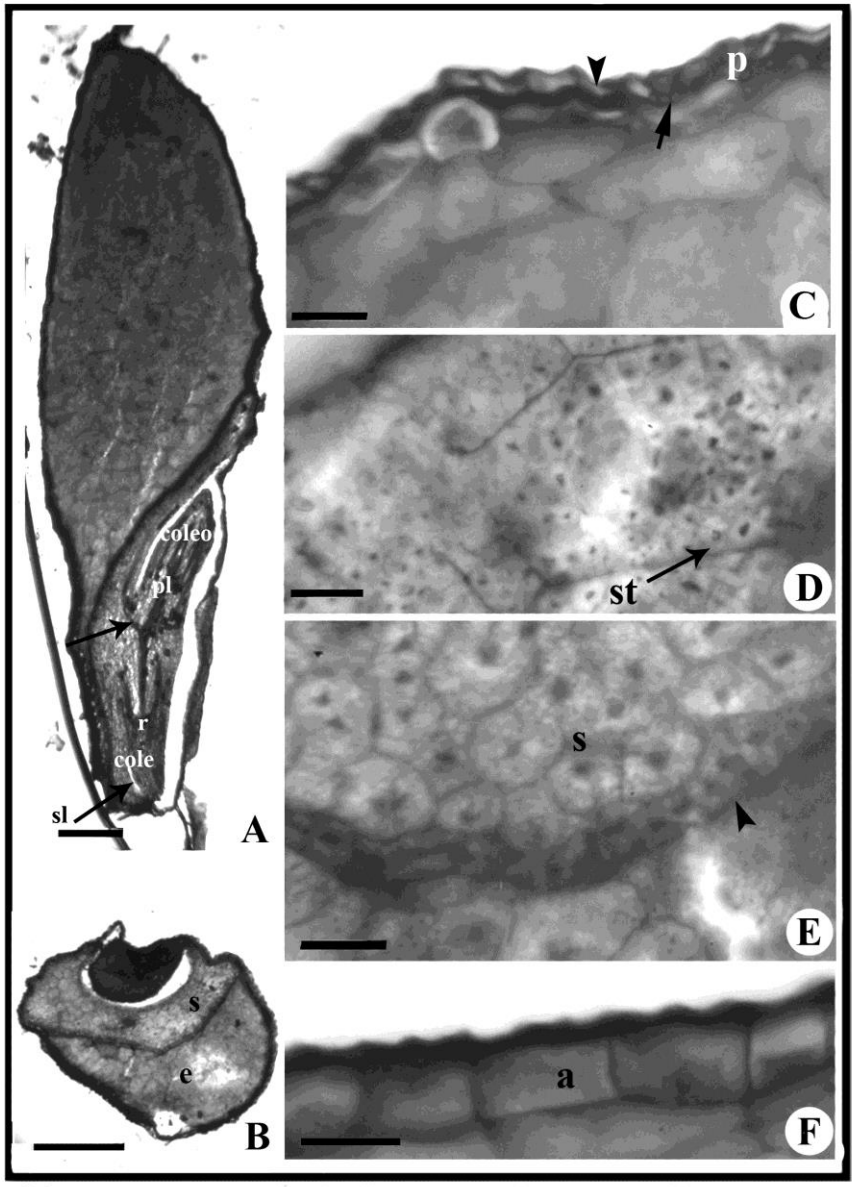
Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm



53. *Oplismenus burmannii*

Fig. 33



54. *Oplismenus burmannii*

55. *Oplismenus composites* (Fig. 34(55) A-F)

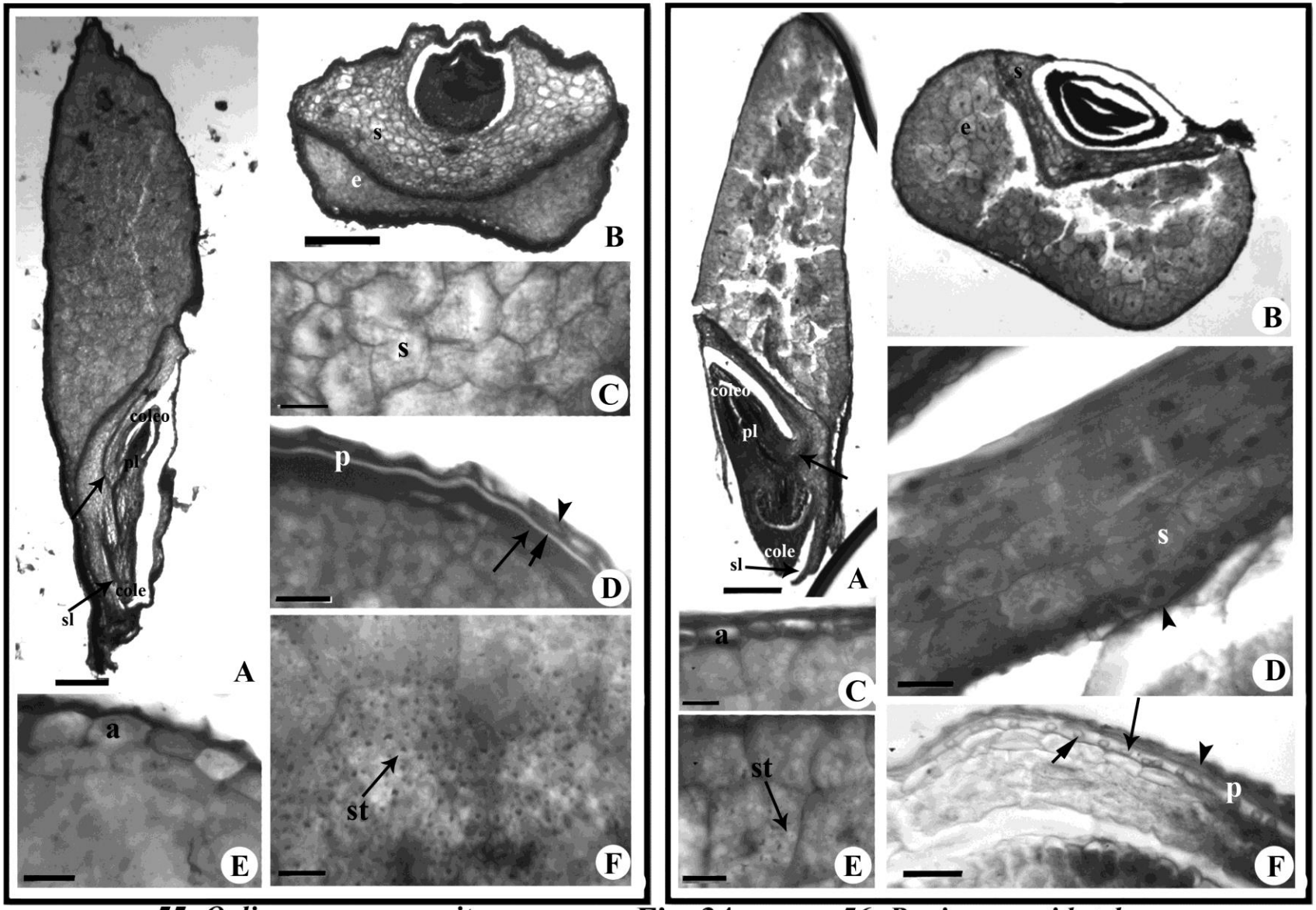
Shape: Rectangular shaped with curved angles and wavy anterior side and convex posterior side in transaction and having size 0.52 (L) X 0.94 (B) mm (Fig. B).
Pericarp: Type B (Fig. D; epidermis (arrowhead), nucellus (arrow)).
Embryo: Type C - Embryo placed an angle of 164.9 ° (Fig. A). Epiblast is absent.
Scutellum: V shaped: Type – V9 (Fig. B), having an angle of 64.9°. Scutellum cleft/slit is present and it is present at the side of the coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. C).
Vascularisation: Type of vascularisation: Panicoid (Fig. A, arrow)
Angle of vascularisation: 154.7°**,** Type – C.
Pattern of embryonic leaf: P- type
Endosperm: Polygon shaped endospermic cells.
Starch grain: Simple circular and polygon shaped starch grains present (Fig. F).
No. of starch grains per endosperm cell: 59±7 **Starch grain size:** 5±1.38 (µm)
Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. E).
Caryopsis type and formula: True panicoids type and having formula P-PP.
Bar Size: A, B =125 µm, C-F =12.5 µm
Differentiating features:
Pericarp type- C, scutellum type- U2-2……..……..*O. burmanii*
Pericarp type- B, scutellum type- V9……..……..*O. composites*

Panicum

56. *Panicum antidotale*
57. *Panicum maximum*
58. *Panicum miliaceum*
59. *Panicum trypheron*

56. *Panicum antidotale* (Fig. 34(56) A-F)

Shape: Oblong to rectangular shaped with convex anterior side and flat posterior side in transaction and having size 0.58(L) X 0.89 (B) mm (Fig. B).
Pericarp: Type B (Fig. F; epidermis cells (arrowhead), cross cells (arrow)).
Embryo: Type C - Embryo placed an angle of 164.4° (Fig. A). Epiblast is absent.
Scutellum: V shaped: Type – V4-2 (Fig. B), having an angle of 42.79°. Scutellum cleft/slit is present and it is present at the side of coleorhiza in form of big slit. Oval shaped, compactly arranged scutellum cells (Fig. D) and depletion layer is also present (Fig. D, arrowhead).
Vascularisation: Type of vascularisation: Panicoid (Fig. A, arrow)
Angle of vascularisation: 132.2°**,** Type – B.
Pattern of embryonic leaf: P- type
Endosperm: Polygon shaped endospermic cells.
Starch grain: Simple circular and polygon starch grains present (Fig. E).
No. of starch grains per endosperm cell: 42±5 **Starch grain size:** 2.78±0.83 (µm)
Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. C).
Caryopsis type and formula: True panicoids type and having formula P-PP.
Bar Size: A, B =125 µm, C-F =12.5 µm



55. *Oplismenus compositus* **Fig. 34** 56. *Panicum antidotale*

57. *Panicum maximum* (Fig. 35(57) A-F)

Shape: Oblong shaped with convex anterior side and circular posterior side in transaction and having size 0.57 (L) X 1.07 (B) mm (Fig. B).

Pericarp: Type B (Fig. F; epidermis (arrow), cross cells (arrowhead)).

Embryo: Type C - Embryo placed an angle of 174.7 ° (Fig. A). Epiblast is absent.

Scutellum: U shaped: Type – U2-3 (Fig. B), having an angle of 64.32°. Scutellum cleft/slit is present and it is covering the whole coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. C) and depletion layer is also present (Fig. C, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 157.5°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon starch grains present (Fig. E).

No. of starch grains per endosperm cell: 33±7 **Starch grain size:** 4.17±1.66 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. D).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm

58. *Panicum miliaceum* (Fig. 35(58) A-G)

Shape: Oblong shaped with flat anterior side and concave posterior side in transaction and having size 1.07 (L) X 1.82 (B) mm (Fig. B).

Pericarp: Type B (Fig. E; epidermis cells (arrow), cross cells (arrowhead)).

Embryo: Type C - Embryo placed an angle of 165.7 ° (Fig. A). Epiblast is absent.

Scutellum: V shaped: Type – V6 (Fig. B), having an angle of 55.03°. Scutellum cleft/slit is present and it is present at the side of the coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. F) and depletion layer is also present (Fig. F, arrowhead).

Vascularisation: Type of vascularisation: Panicoid (Fig. D)

Angle of vascularisation: 155.3°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

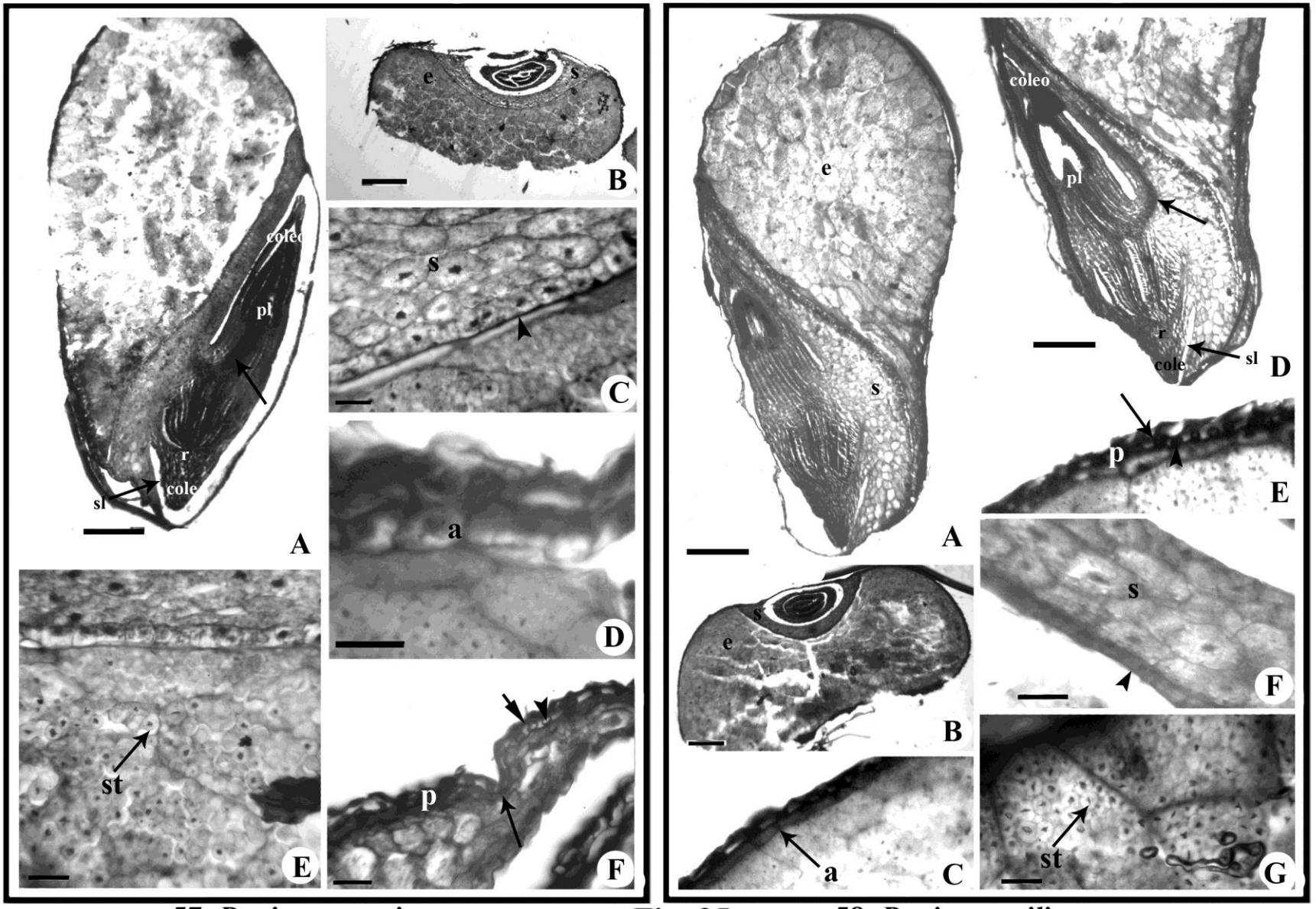
Starch grain: Simple circular and polygon starch grains present (Fig. G).

No. of starch grains per endosperm cell: 58±5 **Starch grain size:** 4.17±0.83 (µm)

Aleurone layer: Tangentially elongated rectangular shaped flat aleurone cells (Fig.C).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, D =85.5 µm, C, E-G =12.5 µm



57. *Panicum maximum* **Fig. 35** 58. *Panicum miliaceum*

59. *Panicum trypheron* (Fig. 36(59) A-F)

Shape: Oblong shaped with flat anterior side and concave posterior side in transaction and having size 0.68 (L) X 1.49 (B) mm (Fig. B).

Pericarp: Type B (Fig. F; epidermis (arrowhead), nucellus (arrow)).

Embryo: Type B - Embryo placed an angle of 157.7 ° (Fig. A). Epiblast is absent.

Scutellum: V shaped: Type – V2 (Fig. B), having an angle of 52.1°. Scutellum cleft/slit is present and it is covering the whole coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. E) and depletion layer is also present (Fig. E, arrowhead).

Vascularisation: Type of vascularisation: Panicoid (Fig. A, arrow)

Angle of vascularisation: 131.1°**,** Type – B.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon starch grains present (Fig. C).

No. of starch grains per endosperm cell: 47±10 **Starch grain size:** 2.78±1.43 (µm)

Aleurone layer: Tangentially elongated rectangular and square aleurone cells (Fig.D).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm

Differentiating features:

Embryo type- B……...…….*P. trypheron*

Embryo type- C

Angle of vascularisation type- C……...……..*P. miliaceum*

Angle of vascularisation type- B

Scutellum type- V4-2……..……..*P. antidotalae*

Scutellum type- U2-3…….……..*P. maximum*

Paspalidium

60. *Paspalidium flavidum*

61. *Paspalidium geminatum*

60. *Paspalidium flavidum* (Fig. 36(60) A-F)

Shape: Oval shaped with convex anterior side and circular posterior side in transaction and having size 0.67 (L) X 1.62 (B) mm (Fig. B).

Pericarp: Type A (Fig. F; cross cells (arrowaa0, nucellus (arrowhead), subepidermis (line)).

Embryo: Type B - Embryo placed an angle of 147.2 ° (Fig. A). Epiblast is absent.

Scutellum: U shaped: Type – U2-3 (Fig. B), having an angle of 59.36°. Scutellum cleft/slit is present and it is present at side of coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. D) and depletion layer is also present (Fig. D, arrowhead).

Vascularisation: Type of vascularisation: Panicoid (Fig. A)

Angle of vascularisation: 156.4°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

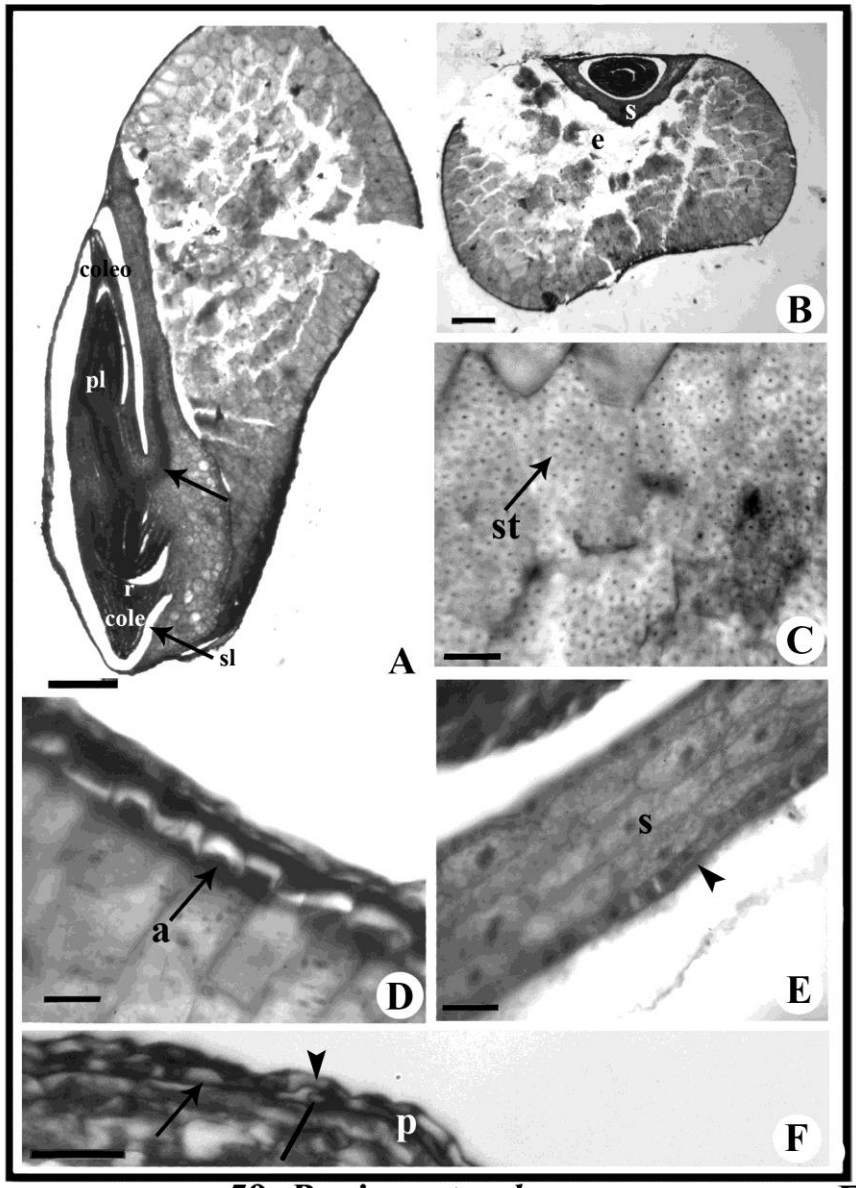
Starch grain: Simple circular and polygon starch grains present (Fig. E).

No. of starch grains per endosperm cell: 71±12 **Starch grain size:** 5.36±2.37 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. C).

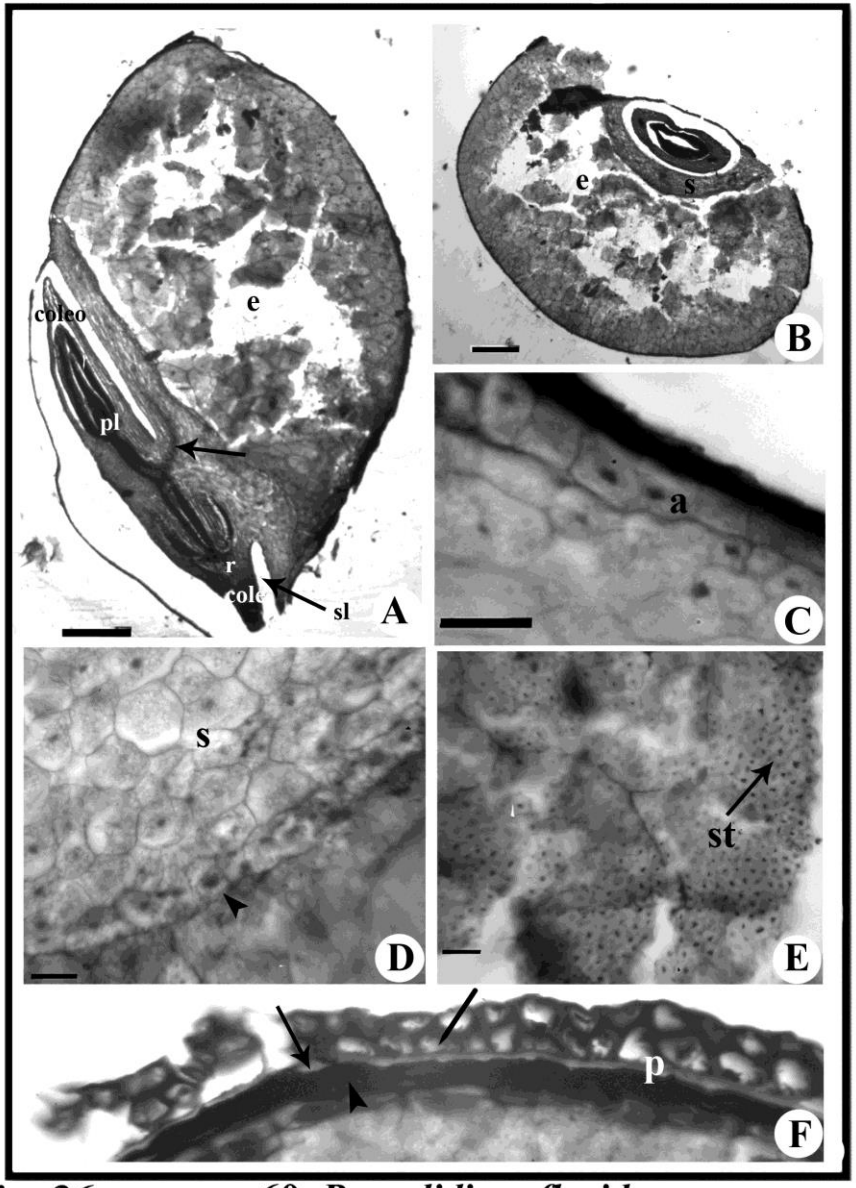
Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm



59. *Panicum trypheron*

Fig. 36



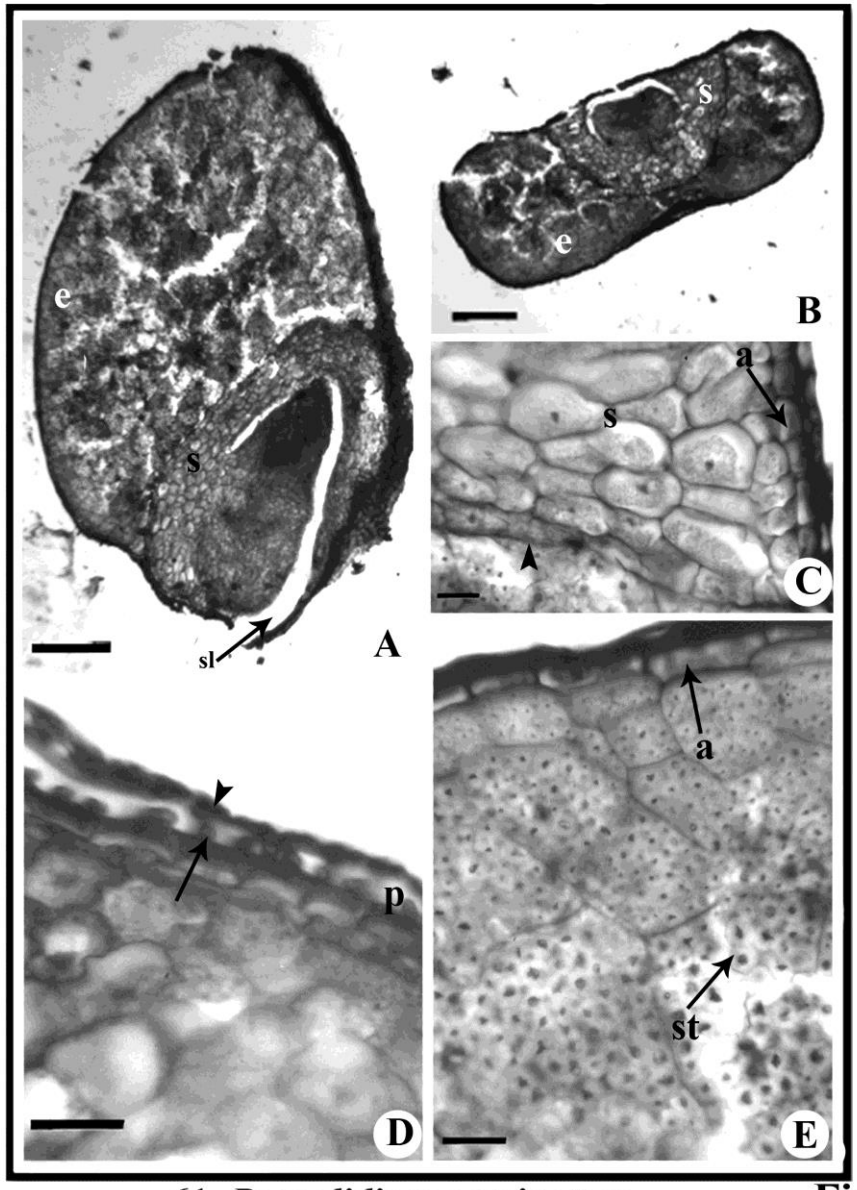
60. *Paspalidium flavidum*

61. *Paspalidium geminatum* (Fig. 37(61) A-E)

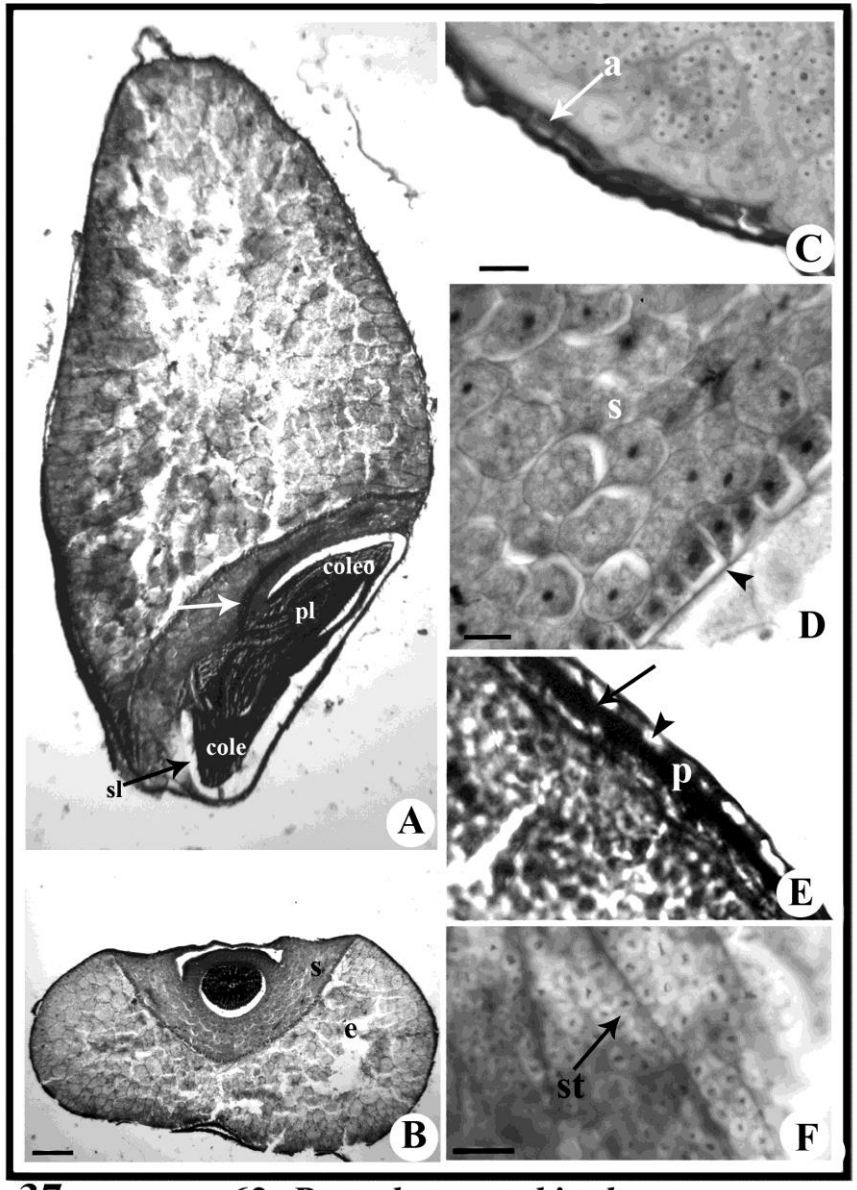
Shape: Kidney shaped in transaction and having size 0.44 (L) X 1.11 (B) mm (Fig.B).
Pericarp: Type A (Fig. D, epidermis cells (arrrowhead), cross cells (arrow)).
Embryo: Type C - Embryo placed an angle of 162.5° (Fig. A). Epiblast is absent.
Scutellum: "V" shaped: Type V1-2 (Fig. B), having an angle of 69.34°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. C). Depletion layer is present (Fig. C, arrowhead).
Vascularisation: Type of vascularisation: Panicoid
Angle of vascularisation: 167.2°**,** Type – C.
Pattern of embryonic leaf: P- type
Endosperm: Polygon shaped endospermic cells.
Starch grain: Simple polygon shaped starch grains (Fig. E).
No. of starch grains per endosperm cell: 60±9 **Starch grain size:** 3.75±1.36 (µm)
Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. E, arrow).
Caryopsis type and formula: True panicoids type and having formula P-PP.
Bar Size: A, B =125 µm, C-E =12.5 µm
Differentiating features:
Embryo type- B, Scutellum type- U2-3……*P. flavidum*
Embryo type- C, Scutellum type- V1-2……*P. geminatum*

62. *Paspalum scrobiculatum* (Fig. 37(62) A-F)

Shape: Oblong to oval shaped with flat anterior side and circular posterior side in transaction and having size 1.08 (L) X 2.25 (B) mm (Fig. B).
Pericarp: Type D (Fig. E; epidermis cells (arrowhead), nucellus (arrow)).
Embryo: Type B - Embryo placed an angle of 152.2 ° (Fig. A). Epiblast is absent.
Scutellum: V shaped: Type – V2 (Fig. B), having an angle of 48.18°. Scutellum cleft/slit is present and it is present in the center of the proximal end. Oval shaped, compactly arranged scutellum cells (Fig. D) and depletion layer is also present (Fig. D, arrowhead).
Vascularisation: Type of vascularisation: Panicoid
Angle of vascularisation: 135.5°**,** Type – B.
Pattern of embryonic leaf: P- type
Endosperm: Polygon shaped endospermic cells.
Starch grain: Simple circular shaped starch grains present (Fig. F).
No. of starch grains per endosperm cell: 49±7 **Starch grain size:** 5±0.97 (µm)
Aleurone layer: Tangentially elongated rectangular shaped small aleurone cells (Fig. C).
Caryopsis type and formula: True panicoids type and having formula P-PP.
Bar Size: A, B =125 µm, C-F =12.5 µm



61. *Paspalidium geminatum*



62. *Paspalum scrobiculatum*

Fig. 37

63. *Pennisetum setosum* (Fig. 38(63) A-F)

Shape: Oval shaped with convex anterior side and flat posterior side in transaction and having size 0.52 (L) X 0.59 (B) mm (Fig. B).

Pericarp: Type C (Fig. F, epidermis (arrowhead), cross cells (arrow)).

Embryo: Type C - Embryo placed an angle of 164.8 ° (Fig. A). Epiblast is absent.

Scutellum: V shaped: Type – V7 (Fig. B), having an angle of 79.83°. Scutellum cleft/slit is present. Oval to circular shaped, compactly arranged scutellum cells (Fig. D) and depletion layer is also present (Fig. D, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 160.2°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon starch grains present (Fig. D).

No. of starch grains per endosperm cell: 16±4 **Starch grain size:** 10±4.26 (µm)

Aleurone layer: Tangentially elongated rectangular and square shaped aleurone cells (Fig. E).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm

Setaria

64. *Setaria glauca*

65. *Setaria tomentosa*

66. *Setaria verticillata*

64. *Setaria gluca* (Fig. 38(64) A-E)

Shape: Oblong shaped with convex anterior side and concave posterior side in transaction and having size 0.53 (L) X 1.08 (B) mm (Fig. B).

Pericarp: Type C.

Embryo: Type B - Embryo placed an angle of 155.7 ° (Fig. A). Epiblast is absent.

Scutellum: V shaped: Type – V8-3 (Fig. B), having an angle of 63.7°. Scutellum cleft/slit is present and it is present at the side of the coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. D) and depletion layer is also present (Fig. D, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 144.1°**,** Type – B.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

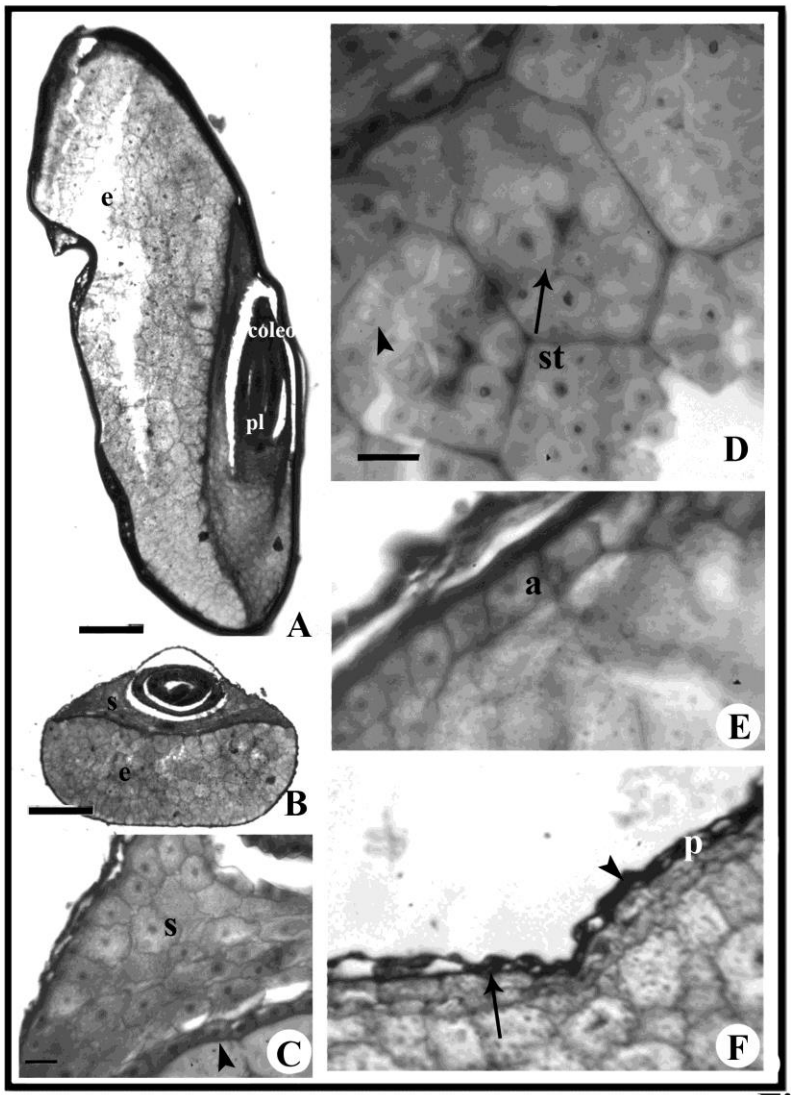
Starch grain: Simple circular and polygon starch grains present (Fig. C).

No. of starch grains per endosperm cell: 73±3 **Starch grain size:** 4.17±1.00 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. E).

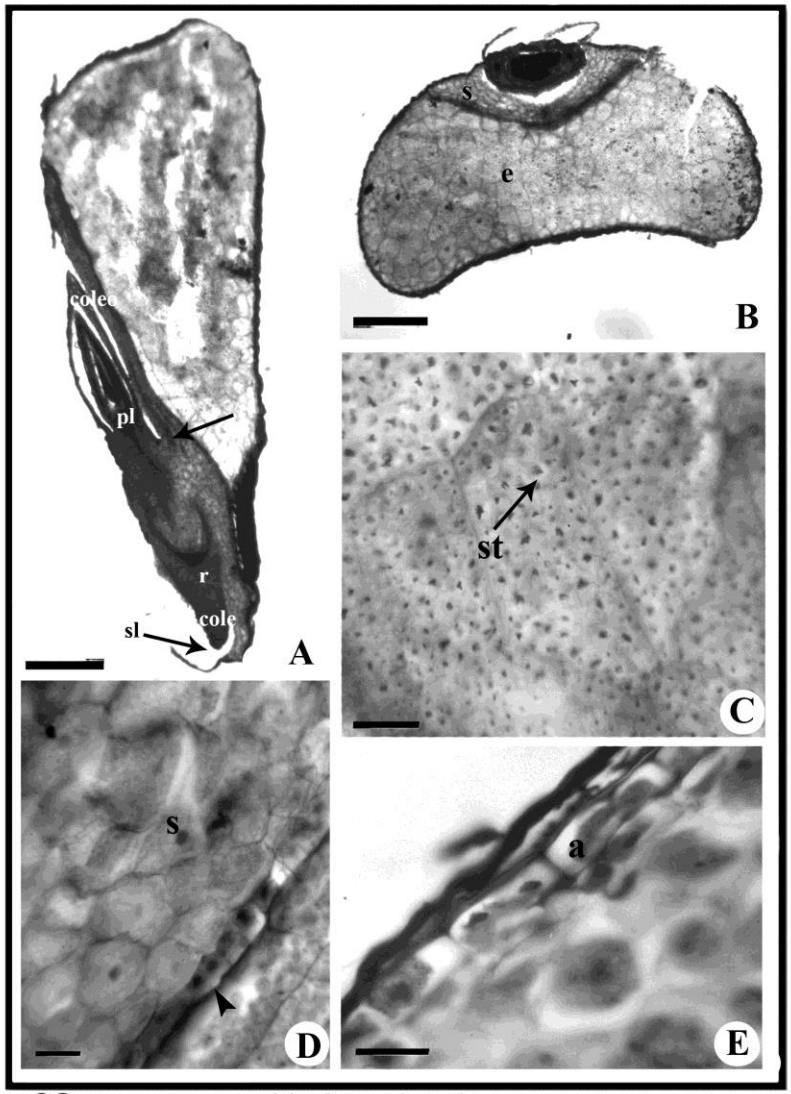
Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm



63. *Pennisetum setosum*

Fig. 38



64. *Setaria glauca*

65. *Setaria tomentosa* (Fig. 39(65) A-F)

Shape: Kidney shaped with convex anterior side and concave posterior side in transaction and having size 0.91 (L) X 0.66 (B) mm (Fig. B).

Pericarp: Type D (Fig. F; nucellus (arrowhead), epidermis (arrowhead)).

Embryo: Type C - Embryo placed an angle of 167.1° (Fig. A). Epiblast is absent.

Scutellum: V shaped: Type – V3-4 (Fig. B), having an angle of 54.37°. Scutellum cleft/slit is present and it is present at the side of the coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. C) and depletion layer is also present (Fig. C, arrowhead).

Vascularisation: Type of vascularisation: Panicoid (Fig. A, arrow)

Angle of vascularisation: 142.1°**,** Type – B.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon starch grains present (Fig. D).

No. of starch grains per endosperm cell: 58±6 **Starch grain size:** 3.57±0.89 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. E).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm

66. *Setaria verticillata* (Fig. 39(66) A-F)

Shape: Rectangular shaped with convex anterior side and concave posterior side in transaction and having size 1.06 (L) X 1.24 (B) mm (Fig. B).

Pericarp: Type B (Fig. F; epidermis cells (arrowhead), cross cells (arrow), nucellus (line)).

Embryo: Type B - Embryo placed an angle of 141.8 ° (Fig. A). Epiblast is absent.

Scutellum: U shaped: Type – U2-3 (Fig. B), having an angle of 66.38°. Scutellum cleft/slit is present and it is covering the whole colerorhiza. Oval shaped, compactly arranged scutellum cells (Fig. D) and depletion layer is also present (Fig. D, arrowhead).

Vascularisation: Type of vascularisation: Panicoid (Fig. A, arrow)

Angle of vascularisation: 135.8°**,** Type – B.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon starch grains present (Fig. E).

No. of starch grains per endosperm cell: 74±5 **Starch grain size:** 2.27±1.09 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. C).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm

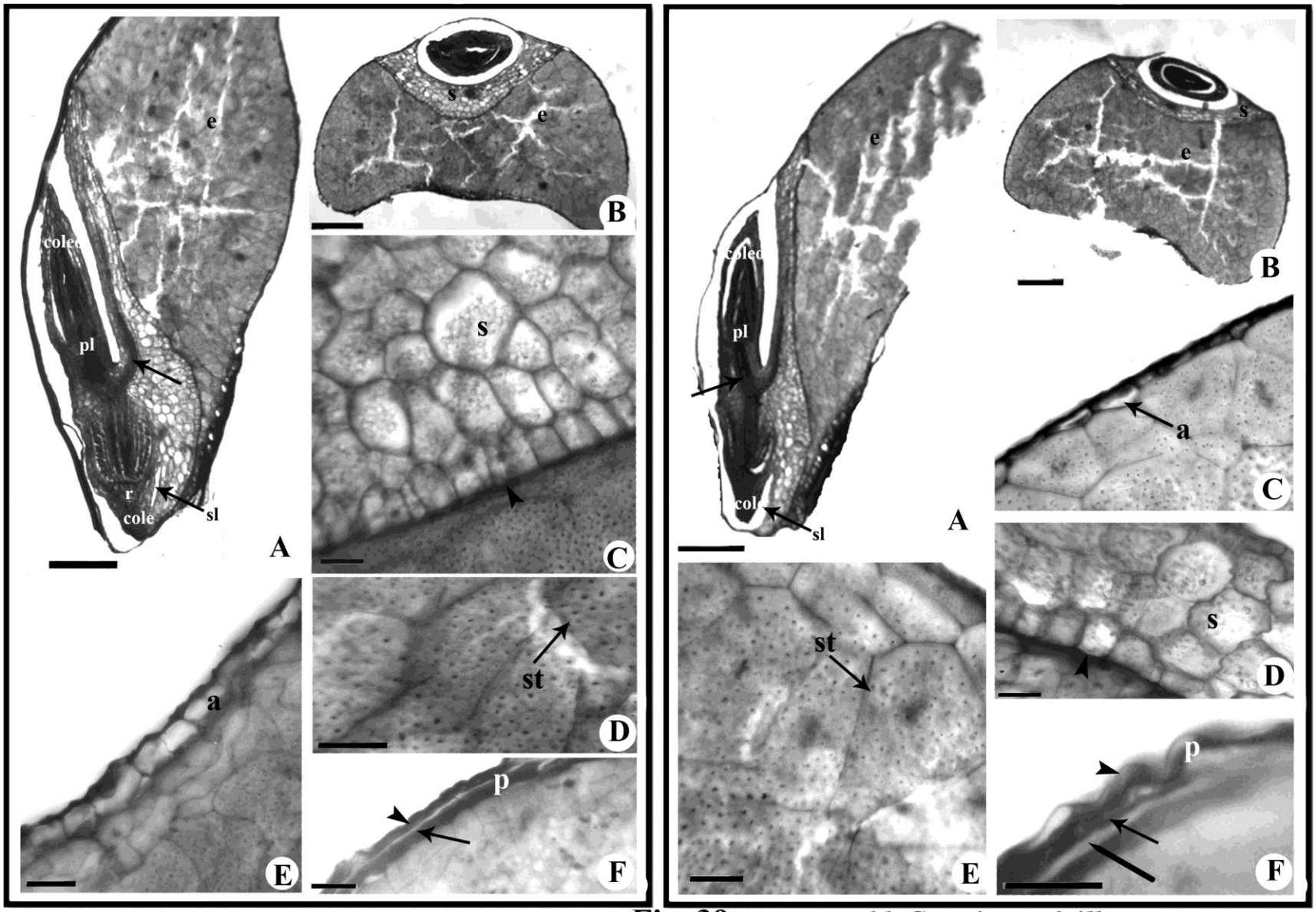
Differentiating features:

Embryo type- C……*S. tomentosa*

Embryo type- B

Scutellum type- V8-3……..……..……..*S. glauca*

Scutellum type- U2-3……...……..*S. verticillata*



65. *Setaria tomentosa* **Fig. 39** 66. *Setaria verticillata*

67. *Isachne globosa* (Fig. 40(61) A-F)

Shape: Oval or circular shaped with convex anterior side and pointed posterior side in transaction and having size 0.68 (L) X 0.91 (B) mm (Fig. B).

Pericarp: Type C (Fig. F; epidermis (arrowhead), hypodermis (arrow), nucellus (line)).

Embryo: Type A - Embryo placed an angle of 108.8° (Fig. A). Epiblast is absent.

Scutellum: V shaped: Type – V7 (Fig. B), having an angle of 71.63°. Scutellum cleft/slit is present and it is covering the whole coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. D).

Vascularisation: Type of vascularisation: Panicoid (Fig. A, arrow)

Angle of vascularisation: 99.0°**,** Type – A.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon shaped starch grains present.

No. of starch grains per endosperm cell: 46±11 **Starch grain size:** 1.97±0.62 (µm)

Aleurone layer: Tangentially elongated rectangular and square shaped mixed aleurone cells (Fig. E).

Caryopsis type and formula: True panicoids type and having formula P-PP.

Bar Size: A, B =125 µm, C-F =12.5 µm

Aristida

68. *Aristida adscensionis*

69. *Aristida funiculata*

68. *Aristida adscensioinis* (Fig. 40(69) A-E)

Shape: Circular shaped in transaction with convex anterior and posterior side and having size 0.43 (L) X 0.35 (B) mm (Fig. B).

Pericarp: Type B (Fig. D).

Embryo: Type B - Embryo placed an angle of 153.73° (Fig. A). Epiblast is absent.

Scutellum: "Δ" shaped: Type Δ4 (Fig. B). Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. E). Depletion layer is present (Fig. E, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 149.98°**,** Type – B.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

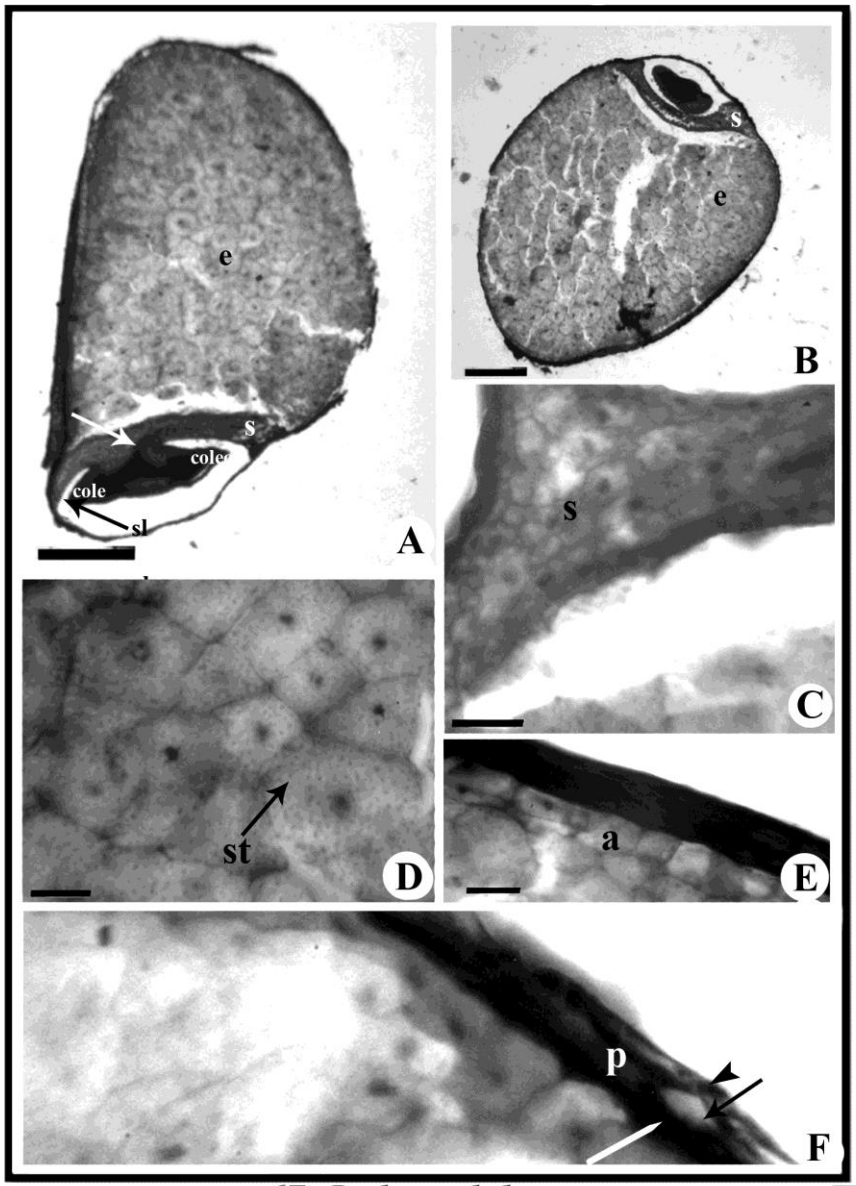
Starch grain: Simple circular and polygon shaped starch grains (Fig. C).

No. of starch grains per endosperm cell: 43±6 **Starch grain size:** 2.63±0.56 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. C, arrow).

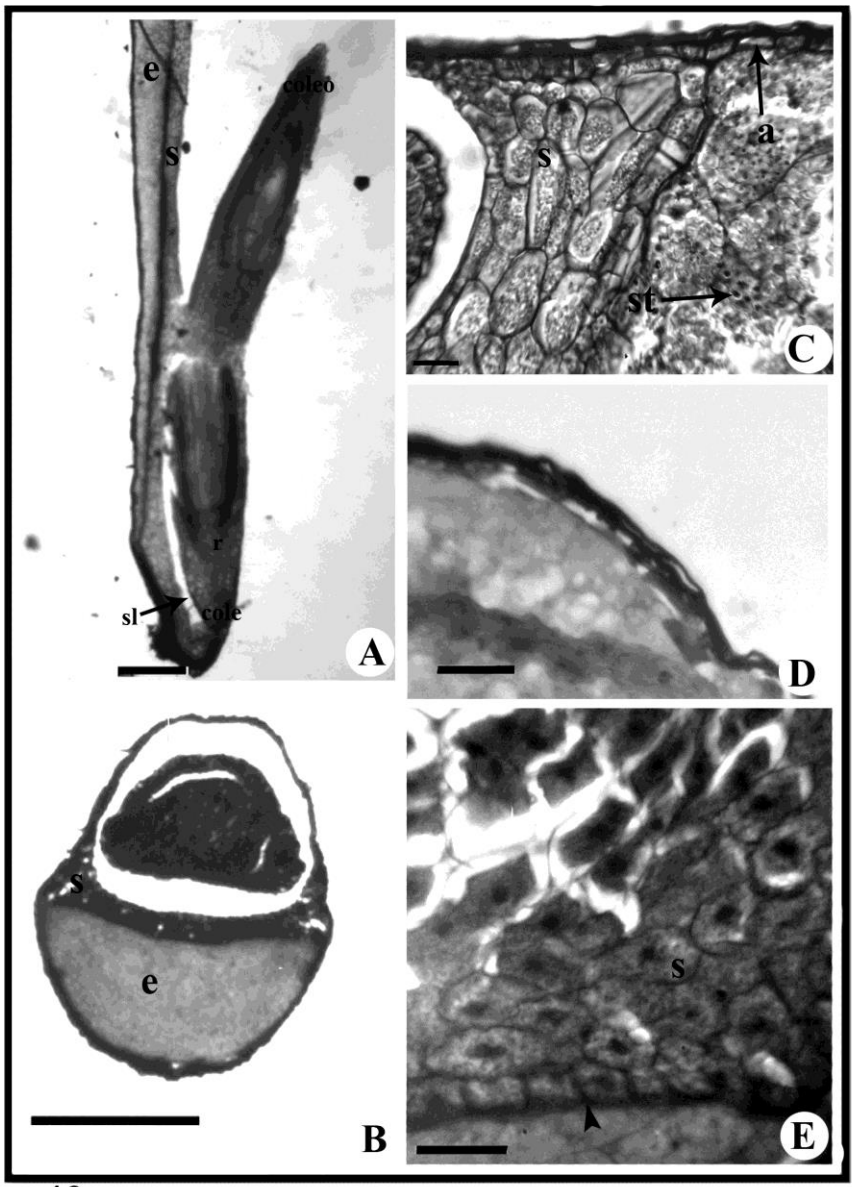
Caryopsis type and formula: Arundionoia-Danthonioid type, having formula P-PF.

Bar Size: A, B =125 µm, C-E =12.5 µm



67. *Ischne globosa*

Fig. 40



68. *Aristida adscensionis*

69. *Aristida funiculata* (Fig. 41(1) A-E)

Shape: Oblong shaped in transaction with convex anterior and posterior side and having size 0.44 (L) X 0.42 (B) mm (Fig. B).

Pericarp: Type B (Fig. C; epidermis (arrowhead), hypodermis (arrow)).

Embryo: Type B - Embryo placed an angle of 152.3° (Fig. A). Epiblast is absent.

Scutellum: "Δ" shaped: Type Δ4 (Fig. B). Scutellum cleft/slit is present. Oval shaped scutellum cells. Depletion layer is present.

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 148.38°**,** Type – B.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon shaped starch grains (Fig. D).

No. of starch grains per endosperm cell: 38±5 **Starch grain size:** 3.41±1.29 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. E).

Caryopsis type and formula: Arundionoia-Danthonioid type and having formula P-PF.

Bar Size: A, B =125 µm, C-E =12.5 µm

Differentiating features:

Circular shaped in transection…….*A. adscensionis*

Oblong shaped in transection……..…….*A. funiculata*

70. *Perotis indica* (Fig. 41(70) A-F)

Shape: Circular to oblong shaped in transaction with convex anterior and flat posterior side and having size 0.26 (L) X 0.28 (B) mm (Fig. C).

Pericarp: Type C (Fig. E; epidermis (arrowhead), hypodermis (arrow)).

Embryo: Type C - Embryo placed an angle of 167.0° (Fig. A). Type IV epiblast.

Scutellum: "Δ" shaped: Type Δ3 (Fig. C), having an angle of 41.9°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. F). Depletion layer is present (Fig. F, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 163.7°**,** Type – C.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

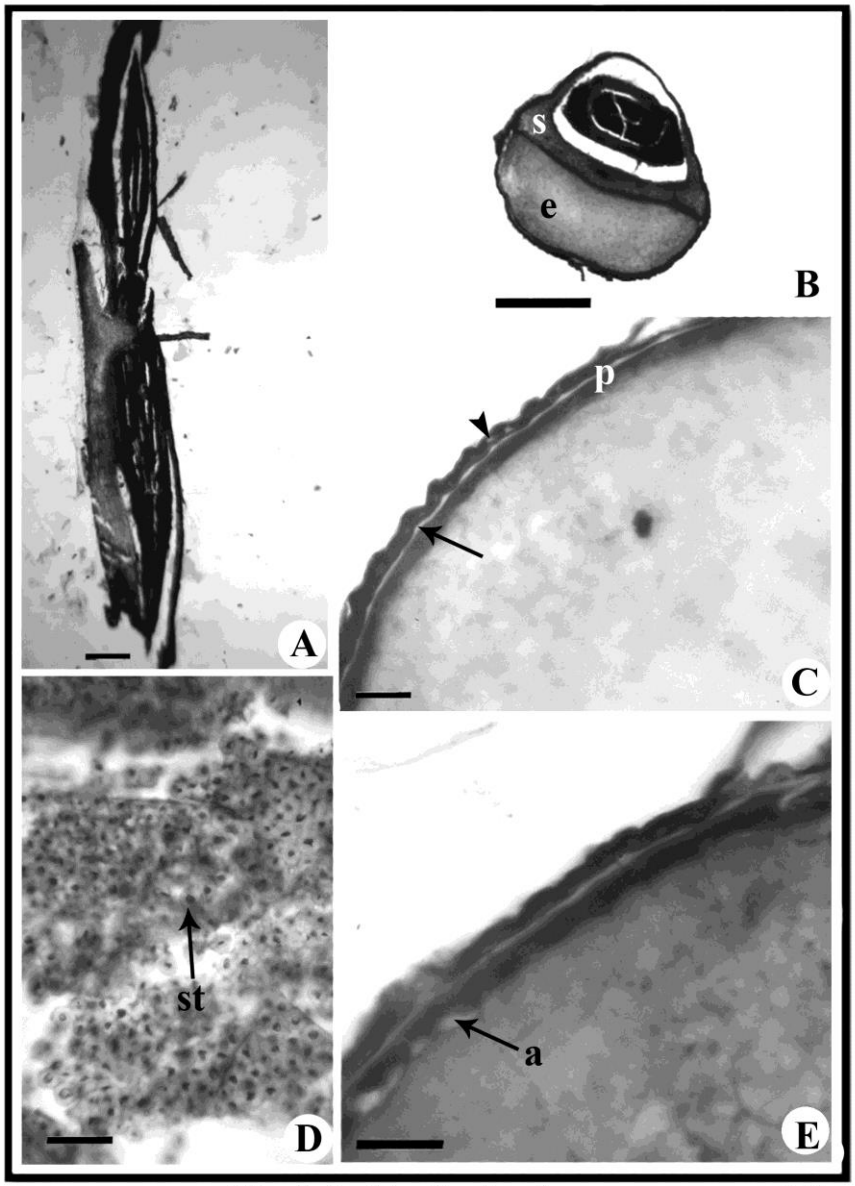
Starch grain: Simple polygon shaped starch grains.

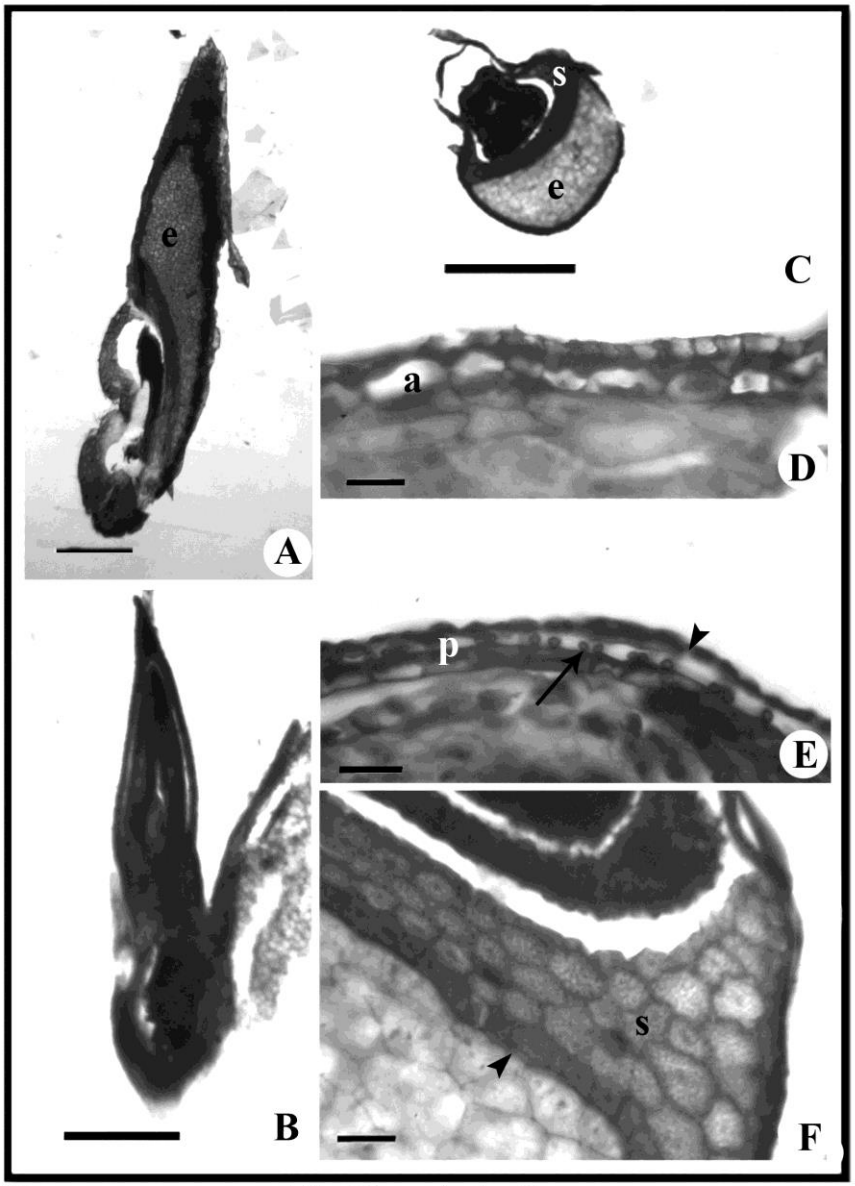
No. of starch grains per endosperm cell: 31±7 **Starch grain size:** 2.5±1.32 (µm)

Aleurone layer: Tangentially elongated rectangular shaped alerurone cells (Fig. D).

Caryopsis type and formula: Chloridoid-Eragrostoid type and having formula P+PF.

Bar Size: A-C =125 µm, D-F =12.5 µm





69. *Aristida funiculata* **Fig. 41** 70. *Perotis indica*

Chloris

71. *Chloris barbata*

72. *Choris montana*

73. *Chloris virgata*

71. *Chloris barbata* (Fig. 42(71) A-F)

Shape: Triangular shaped with convex anterior side and flat posterior side in transaction and having size 0.38 (L) X 0.46 (B) mm (Fig. B).

Pericarp: Type C (Fig. F; epidermis (arrowhead), nucellus (arrow), cross cells (arrowa)).

Embryo: Type C - Embryo placed an angle of 176.0° (Fig. A). Type - II- Epiblast is Present.

Scutellum: Δ shaped: Type–Δ6 (Fig. B), having an angle of 59.53°. Scutellum cleft is present and it is at the side of the colrorhiza. Oval shaped, compactly arranged scutellum cells (Fig. D), depletion layer is also present (Fig. D, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 166.1°**,** Type – C.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple polygon shaped starch grains present (Fig. E).

No. of starch grains per endosperm cell: 33±6 **Starch grain size:** 7.03±3.14 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. C).

Caryopsis type and formula: Chloridoid-Eragrostoid type, having formula P+PF.

Bar Size: A, B =125 µm, C-F =12.5 µm

72. *Chloris Montana* (Fig. 42(72) A-F)

Shape: Oval shaped with convex anterior side and concave posterior side in transaction and having size 0.49 (L) X 0.69 (B) mm (Fig. B).

Pericarp: Type C (Fig. F; epidermis (arrowhead), nucellus (arrow), cross cells (line)).

Embryo: Type C - Embryo placed an angle of 170.7° (Fig. A). Type - II- Epiblast is Present.

Scutellum: Δ shaped: Type – Δ3 (Fig. B), having an angle of 35.64°. Scutellum cleft is present; it is present at the side of the coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. C), depletion layer is also present (Fig. C, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 152.5°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

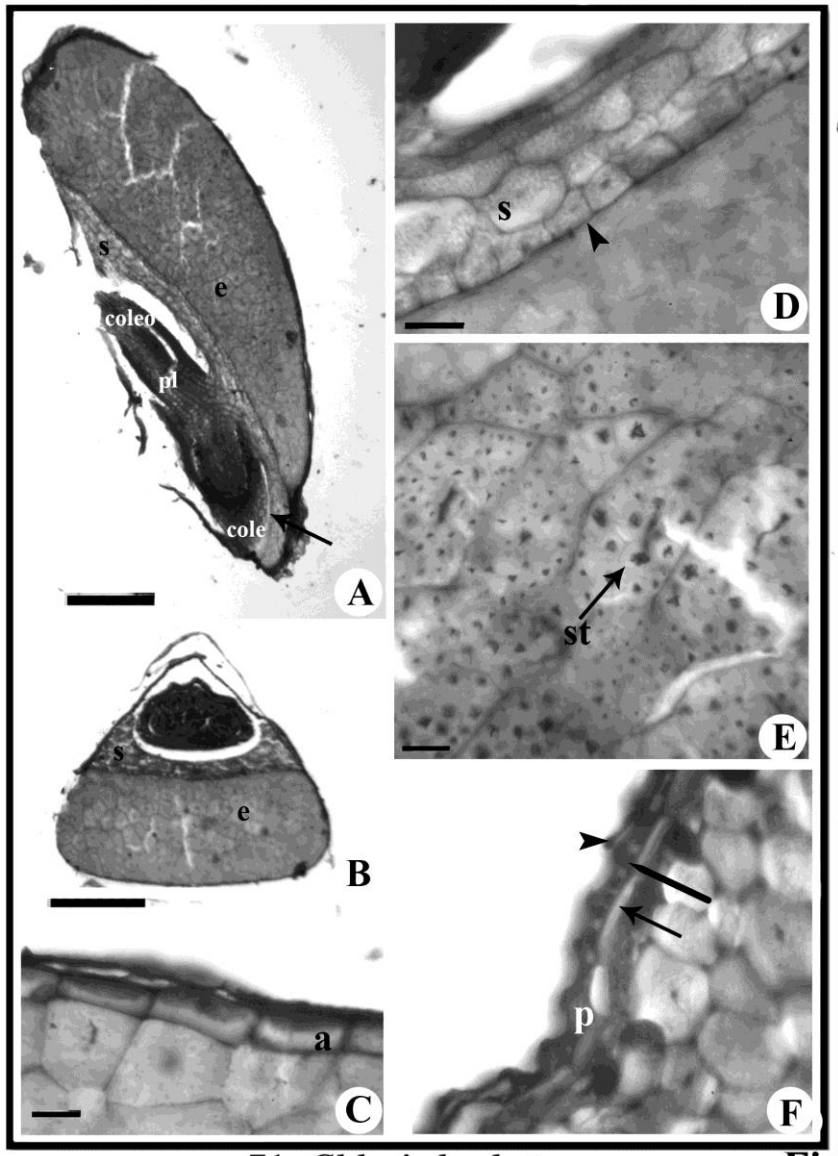
Starch grain: Simple circular and polygon starch grains present (Fig. E).

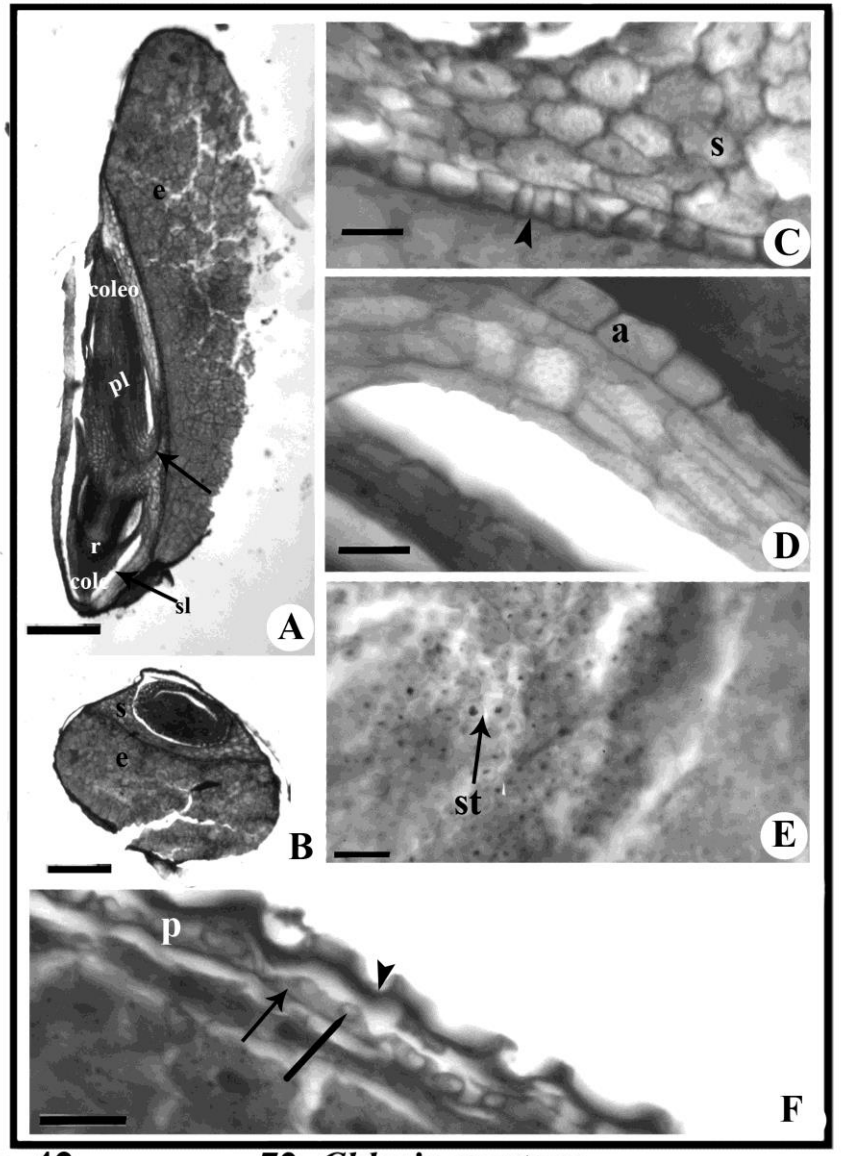
No. of starch grains per endosperm cell: 49±7 **Starch grain size:** 4.86±2.04 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. D).

Caryopsis type and formula: Bambusoid type and having formula P+PP.

Bar Size: A, B =125 µm, C-F =12.5 µm





71. *Chloris barbata* **Fig. 42** 72. *Chloris montana*

73. *Chloris virgata* (Fig. 43(73) A-F)

Shape: Circular to oval shaped with convex anterior side and circular posterior side in transaction and having size 0.62 (L) X 0.52 (B) mm (Fig. B).

Pericarp: Type B (Fig. F; epidermis (arrowhead), nucellus (arrow), cross cells (arrow)).

Embryo: Type C-Embryo placed an angle 172.3°(Fig. A). Type-III- Epiblast Present.

Scutellum: Δ shaped: Type – Δ2 (Fig. B), having an angle of 48.92°. Scutellum slit is present and it is present at the side of the coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. D), depletion layer is also present (Fig. D, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 154.7°**,** Type – C.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon starch grains present (Fig. E).

No. of starch grains per endosperm cell: 63±12 **Starch grain size:** 6.25±1.83 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. C).

Caryopsis type and formula: Bambusoid type and having formula P+PP.

Bar Size: A, B =125 µm, C-F =12.5 µm

Differentiating features:

Caryopsis type- Chloridoid-Eragrostoid...……..*C. barbata*

Caryopsis type- Bambusoid

Epiblast type- II…….……*C. montana*

Epiblast type- III……..……*C. virgata*

74. *Cynodon dactylon* (Fig. 43(74) A-E)

Shape: Oblong to oval shaped with flat anterior side and circular posterior side in transaction and having size 0.58 (L) X 0.52 (B) mm (Fig. B).

Pericarp: Type A (Fig. E; epidermis cells (arrow), crushed parenchyma (arrowhead), nucellus (line)).

Embryo: Type B - Embryo placed an angle of 144.2° (Fig. A). Type - II- Epiblast is Present.

Scutellum: Δ shaped: Type – Δ4 (Fig. B). Scutellum cleft/slit is present and it is covers the whole coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. C) and depletion layer is also present (Fig. C, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 132.9°**,** Type – B.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

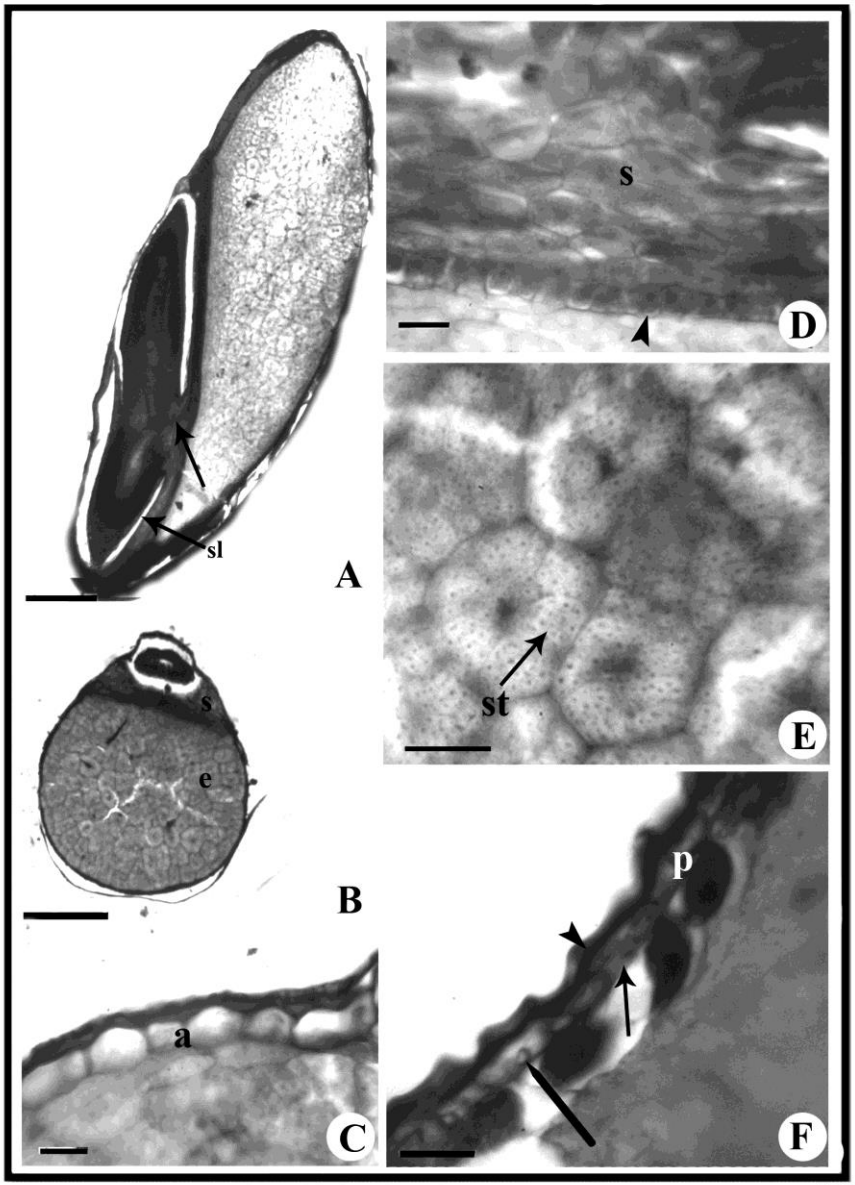
Starch grain: Simple circular and polygon starch grains present (Fig. D).

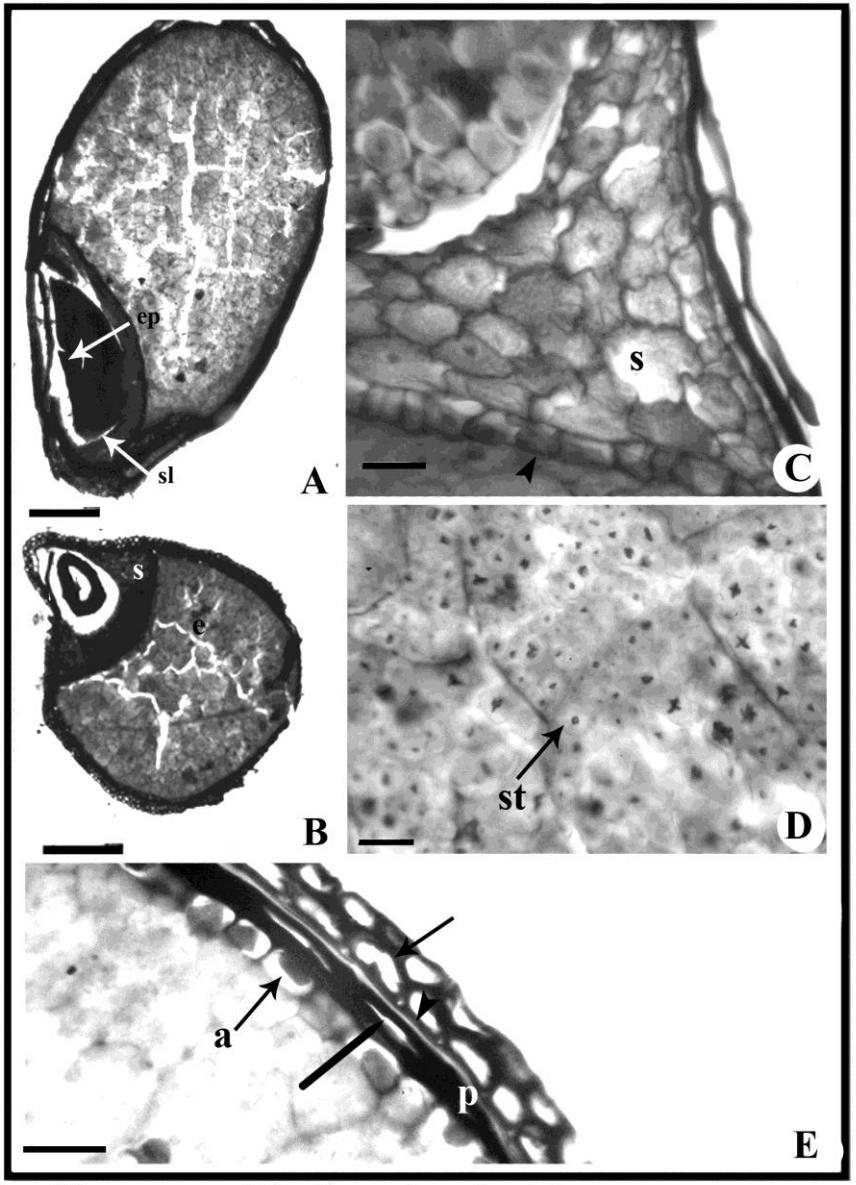
No. of starch grains per endosperm cell: 58±9 **Starch grain size:** 1.97±0.22 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. E).

Caryopsis type and formula: Chloridoid-Eragrostoid type, having formula P+PF.

Bar Size: A, B =125 µm, C-E =12.5 µm





73. *Chloris virgata* Fig. 43 74. *Cynodon dactylon*

75. *Melanocenchris jaequemontii* (Fig. 44(75) A-F)

Shape: Oblong to oval shaped in transaction with convex anterior side and having size 0.20 (L) X 0.32 (B) mm (Fig. B).

Pericarp: Type D (Fig. F; epidermis (arrowhead), cross cells (arrow)).

Embryo: Type C - Embryo placed an angle of 165.4° (Fig. A). Epiblast is absent.

Scutellum: "U" shaped: Type U2-3 (Fig. B), having an angle of 66.24°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. E), depletion layer is present (Fig. E, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 163.3°**,** Type – C.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Some cells have simple circular shaped starch grains and some cells have simple circular shaped and compound starch grains are present together (Fig. D).

No. of starch grains per endosperm cell: 58±9 **Starch grain size:** 1.97±0.22 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. C).

Caryopsis type and formula: Arundinoid-Danthonioid type and having formula P-PF.

Bar Size: A, B =125 µm, C-F =12.5 µm

76. *Oropetium villosulum* (Fig. 44(76) A-F)

Shape: Oblong to oval shaped in transaction and having size 0.20 (L) X 0.18 (B) mm (Fig. A).

Pericarp: Type C (Fig. E; epidermis (arrowhead), cross cells (arrow)).

Embryo: Type C - Embryo placed an angle of 175.5° (Fig. A). Epiblast is absent.

Scutellum: "U" shaped: Type U2-3 (Fig. B), having an angle of 41.9°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. D), depletion layer is present (Fig. D).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 172.5°**,** Type – D.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

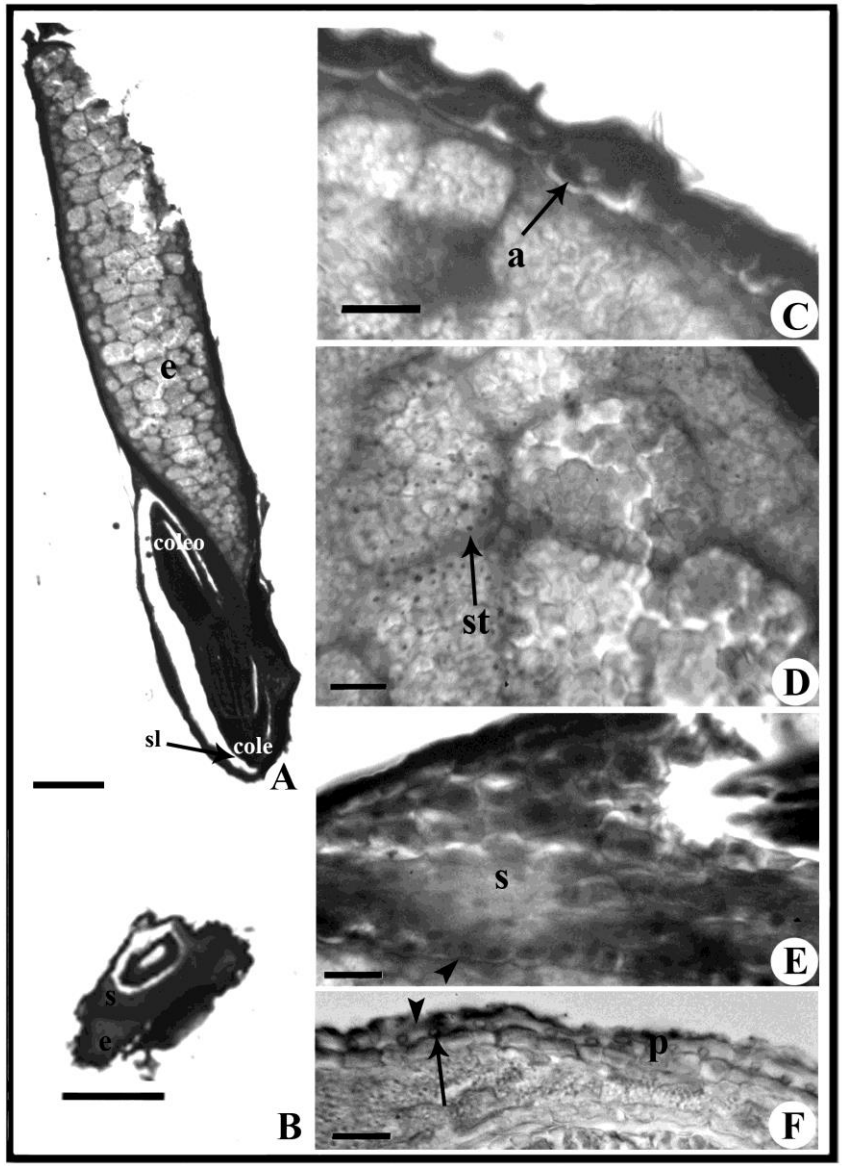
Starch grain: Simple circular and polygon shaped starch grains (Fig. F).

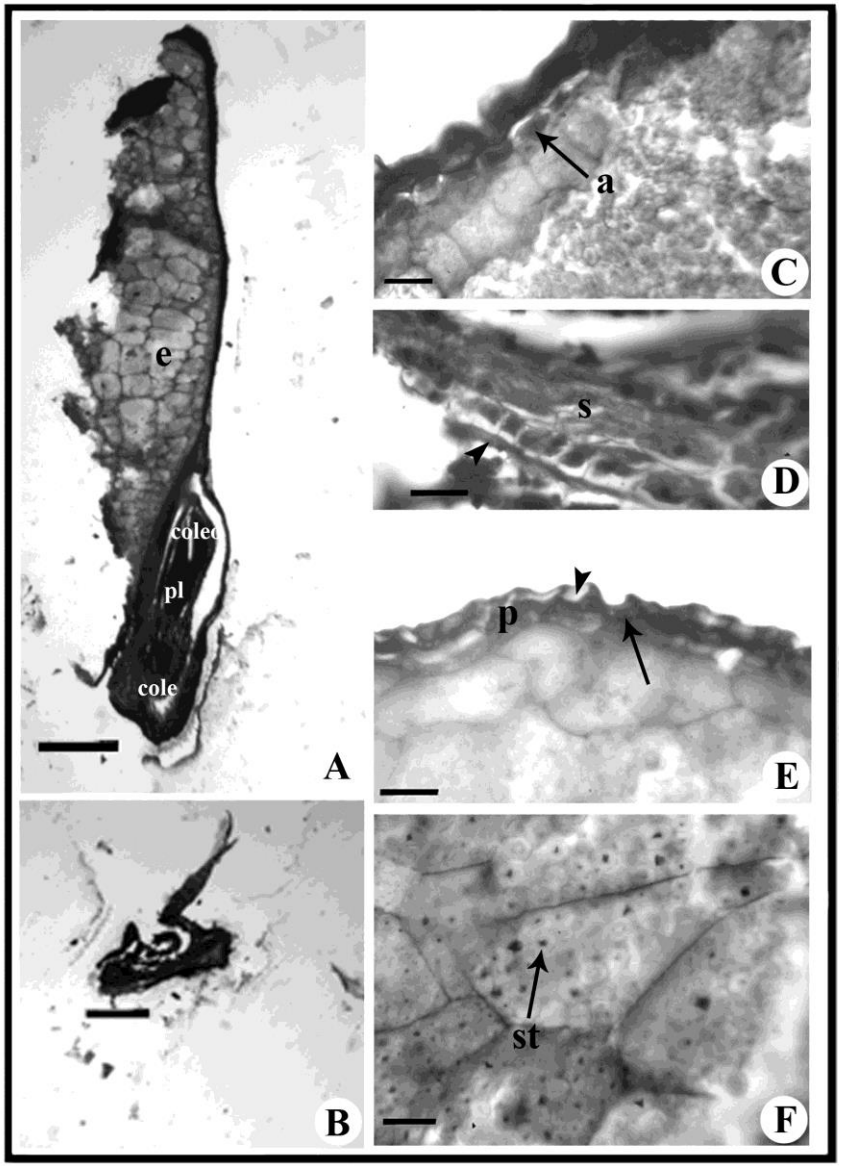
No. of starch grains per endosperm cell: 51±8 **Starch grain size:** 5.56±1.37 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. C).

Caryopsis type and formula: Arundinoid-Danthonioid type, having formula P-PF.

Bar Size: A, B =125 µm, C-F =12.5 µm





75. *Melanocenchris jaequemontii* **Fig. 44** 76. *Oropetium villosulum*

77. *Schoenefeldia gracilis* (Fig. 45(77) A-F)

Shape: Oval to circular shaped with convex anterior side and circular posterior side in transaction and having size 0.68 (L) X 0.41 (B) mm (Fig. C).

Pericarp: Type A (Fig. F; epidermis (arrowhead), nucellus (arrow), crushed parenchyma (line)).

Embryo: Type C - Embryo placed an angle of 174.7 ° (Fig. A). Type - IV- Epiblast is Present (Fig. B).

Scutellum: Δ shaped: Type – Δ3 (Fig. C), having an angle of 42.61°. Scutellum cleft/slit is present; it is covering the whole coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. D), depletion layer is also present (Fig. D, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 170.6°**,** Type – D.

Pattern of embryonic leaf: P- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Compound polygon shaped starch grains present (Fig. E).

No. of starch grains per endosperm cell: 39±8 **Starch grain size:** 5±2.36 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. F).

Caryopsis type and formula: Bambusoid type and having formula P+PP.

Bar Size: A-C =125 µm, D-F =12.5 µm

Tetrapogon

78. *Tetrapogon tenellus*

79. *Tetrapogon villosus*

78. *Tetrapogon tenellus* (Fig. 45(78) A-F)

Shape: Rectangular shaped with convex anterior side and concave posterior side in transaction and having size 0.49 (L) X 0.47 (B) mm (Fig. C).

Pericarp: Type C

Embryo: Type C - Embryo placed an angle of 172.3° (Fig. A). Type - II- Epiblast is Present (Fig. B).

Scutellum: Δ shaped: Type – Δ3 (Fig. C), having an angle of 32.26°. Scutellum cleft/slit is present; it is present at the side of the coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. D), depletion layer is also present (Fig. D, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 158.1°**,** Type – C.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

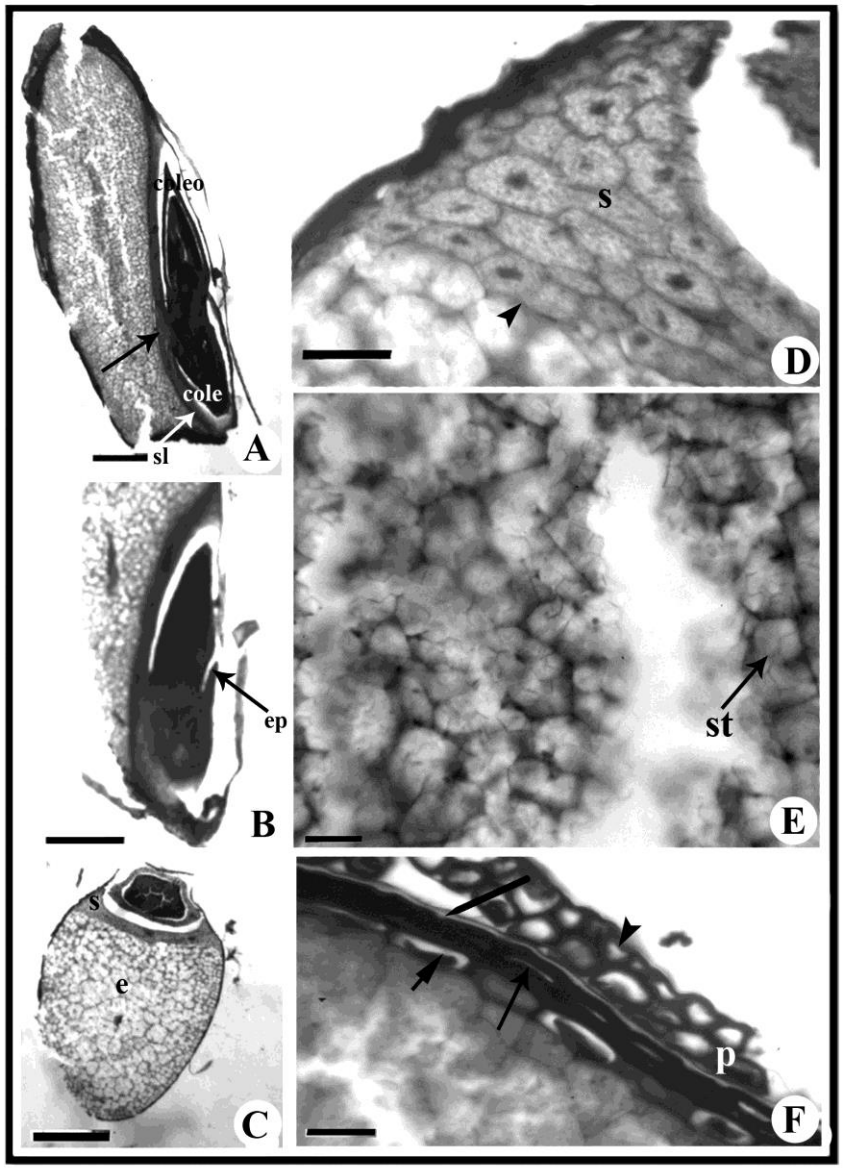
Starch grain: Simple circular and polygon starch grains present (Fig. E).

No. of starch grains per endosperm cell: 13±5 **Starch grain size:** 5.29±1.89 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. F).

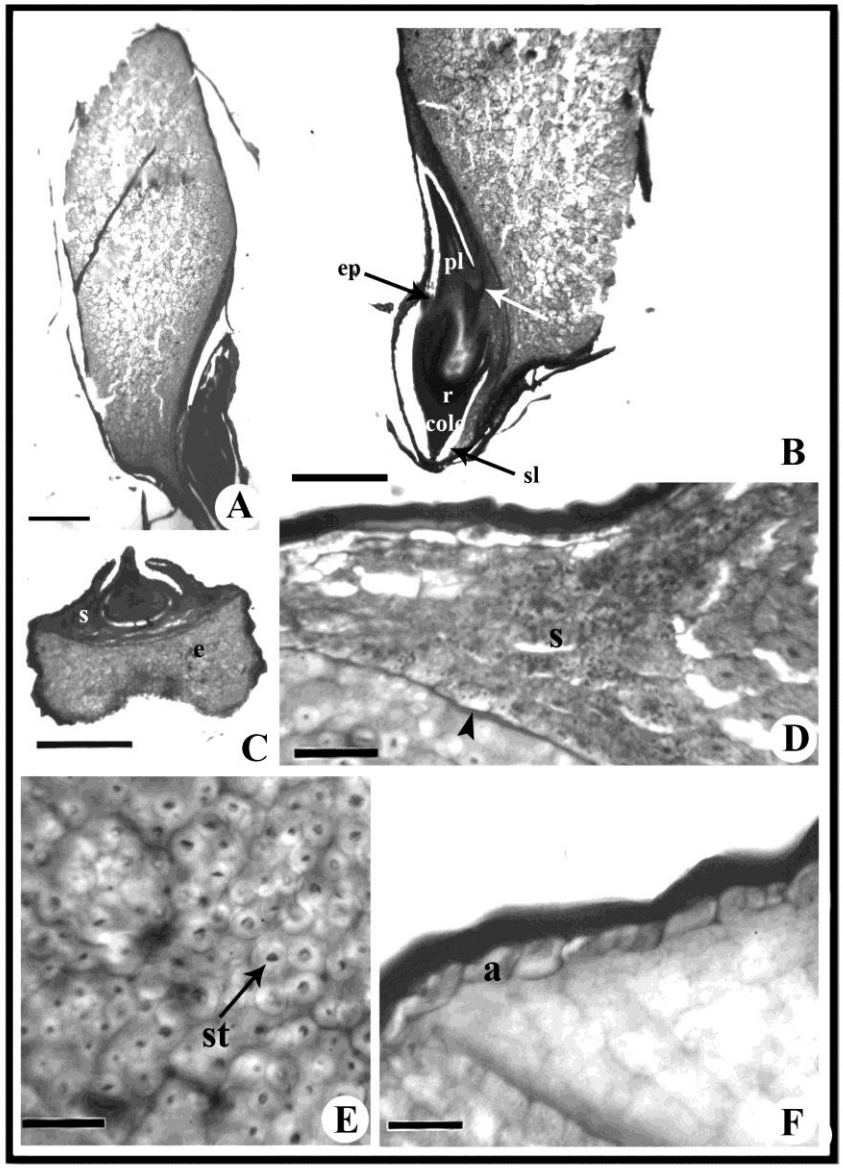
Caryopsis type and formula: Chloridoid-Eragrostoid type, having formula P+PF.

Bar Size: A-C =125 µm, D-F =12.5 µm



77. *Schoenefeldia gracilis*

Fig. 45



78. *Tetrapogon tenellus*

79. *Tetrapogon villosus* (Fig. 46(79) A-F)

Shape: Rectangular shaped with curved angles and having convex anterior side and concave posterior side in transaction and having size 0.44 (L) X 0.79(B) mm (Fig. C).

Pericarp: Type C

Embryo: Type C - Embryo placed an angle of 169.4° (Fig. A). Type - III- Epiblast is Present.

Scutellum: V shaped: Type – V7 (Fig. C), having an angle of 69.5°. Scutellum cleft/slit is present; it is covering the whole coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. D), depletion layer is also present (Fig. D, arrowhead).

Vascularisation: Type of vascularisation: Panicoid (Fig. B)

Angle of vascularisation: 156.7°**,** Type – C.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon starch grains present (Fig. F).

No. of starch grains per endosperm cell: 16±4 **Starch grain size:** 7.03±3.16 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. E).

Caryopsis type and formula: Chloridoid-Eragrostoid type, having formula P+PF.

Bar Size: A-C =125 µm, D-F =12.5 µm

Differentiating features:

Epiblast type- II, Scutellum type- Δ3……..……*T. tenellus*

Epiblast type- III, Scutellum type- V7 ……*T. villosus*

80. *Acrachne racemosa* (Fig. 46(80) A-G)

Shape: Kidney shaped in transaction with flat anterior side and concave posterior side and having size 0.27 (L) X 0.51 (B) mm (Fig. D).

Pericarp: Type D (Fig. G; epidermis (arrowhead), nucellus (arrow)).

Embryo: Type C - Embryo placed an angle of 175.1° (Fig. A). Type -V – Epiblast (Fig. B).

Scutellum: "U" shaped: Type U2-1(Fig. D), having an angle of 62.18°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. F). Depletion layer is present (Fig. F, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 151.0°**,** Type – C.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

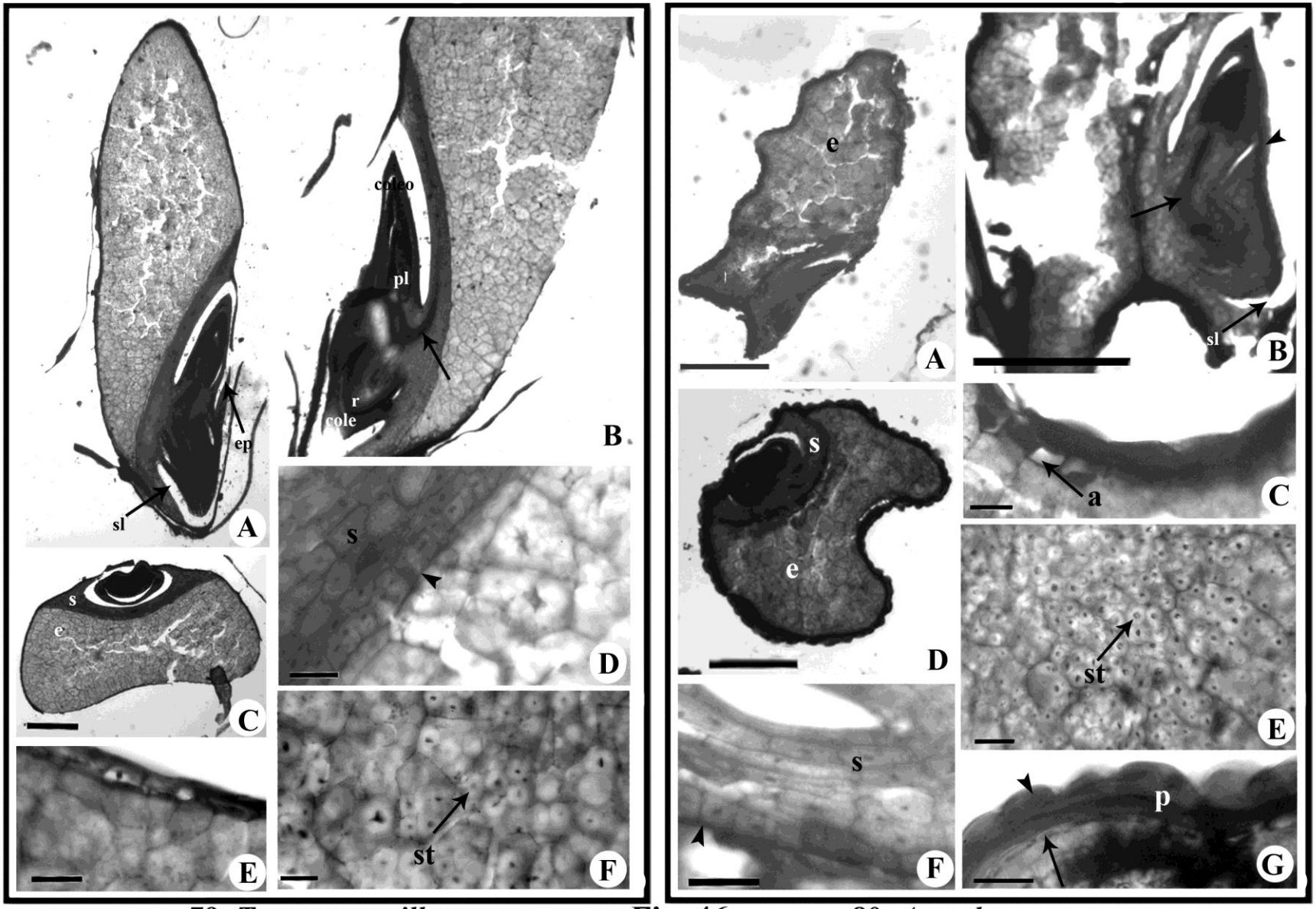
Starch grain: Simple circular and polygon starch grains present (Fig. E).

No. of starch grains per endosperm cell: 17±5 **Starch grain size:** 5.47±1.53 (µm)

Aleurone layer: Tangentially elongated rectangular and square aleurone cells (Fig. C).

Caryopsis type and formula: Chloridoid-Eragrostoid type, having formula P+PF.

Bar Size: A, B, D =125 µm, C, E-G =12.5 µm



79. *Tetrapogon villosus* Fig. 46 80. *Acrachne racemosa*

Dactyloctenium

81. *Dactyloctenium aegyptium*

82. *Dactyloctenium scindicus*

81. *Dactyloctenium aegyptium* (Fig. 47(81) A-G)

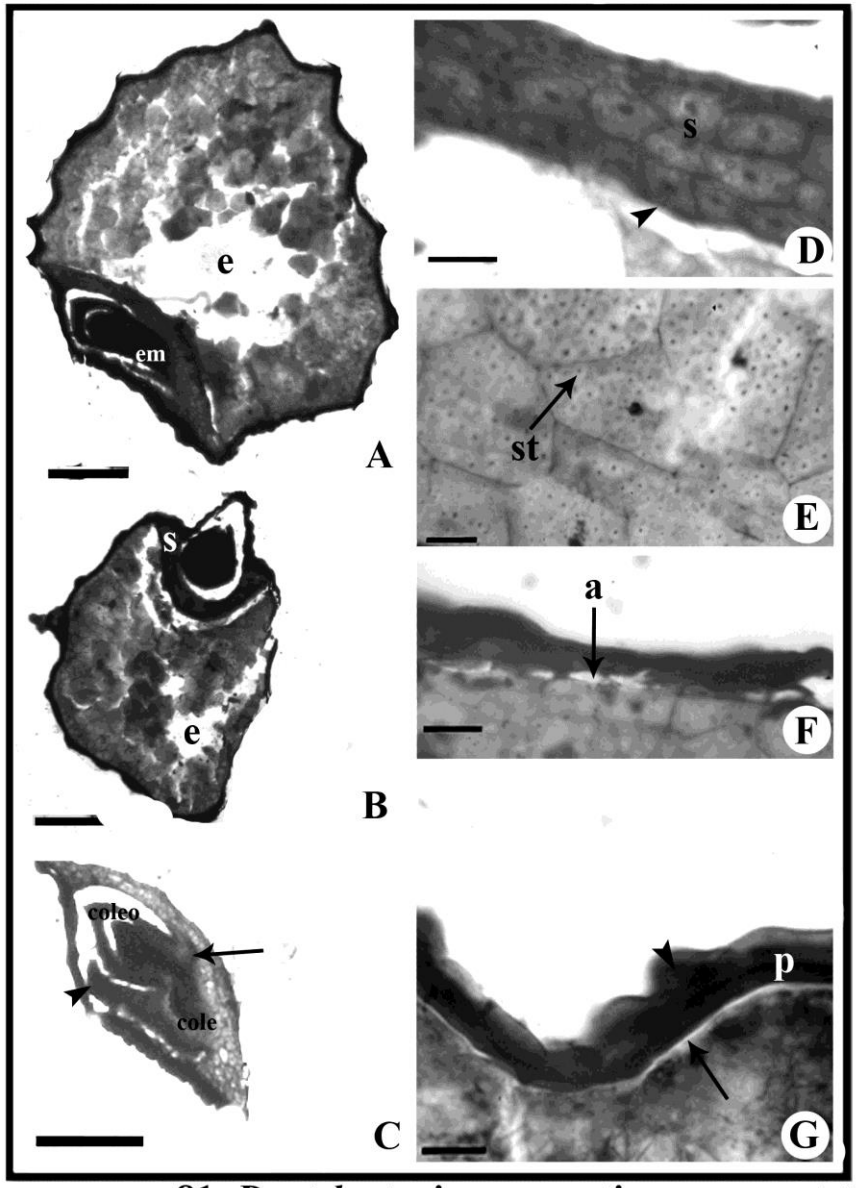
Shape: Rectangular shaped with curved margins and convex anterior side in transaction and having size 0.75 (L) X 0.58 (B) mm (Fig. B).
Pericarp: Type B (Fig. G; epidermis (arrow), nucellus(arrowhead)).
Embryo: Type B - Embryo placed an angle of 141.3° (Fig. A). Type V epiblast (Fig. C, arrowhead).
Scutellum: "V" shaped: Type V4-2 (Fig. B), having an angle of 44.76°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. D), depletion layer is present (Fig. D, arrowhead).
Vascularisation: Type of vascularisation: Panicoid (Fig. B, arrow)
Angle of vascularisation: 123.6°**,** Type – A.
Pattern of embryonic leaf: F- type
Endosperm: Polygon shaped endospermic cells.
Starch grain: Some cells have simple circular shaped starch grains and some cells have simple circular shaped and compound starch grains are present together (Fig. E).
No. of starch grains per endosperm cell: 53±7 **Starch grain size:** 3.13±1.05 (µm)
Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. F).
Caryopsis type and formula: Chloridoid-Eragrostoid type, having formula P+PF.
Bar Size: A, B =125 µm, C-E =12.5 µm

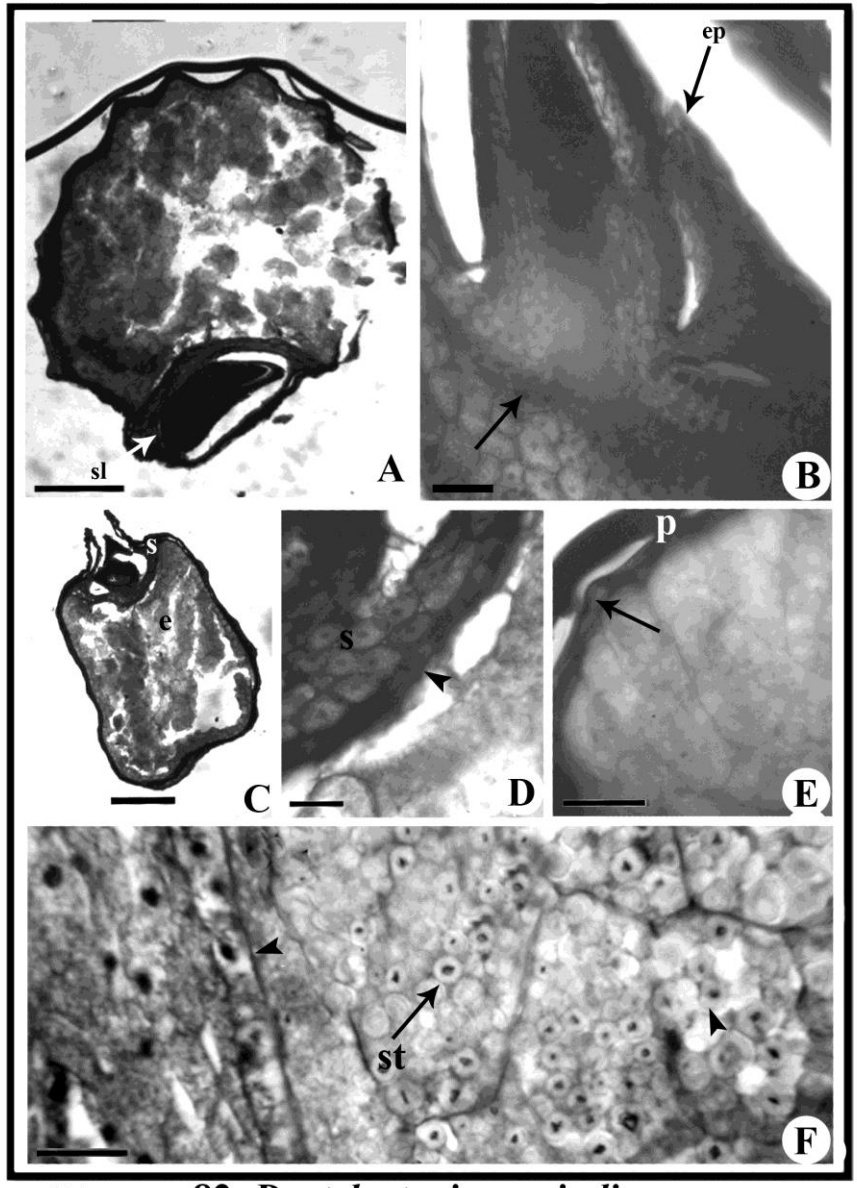
82. *Dactyloctenium scindicus* (Fig. 47(82) A-F)

Shape: Rectangular shaped with convex anterior side and concave posterior side in transaction and having size 0.81 (L) X 0.58 (B) mm (Fig. C).
Pericarp: Type D (Fig. E; nucellus (arrow))
Embryo: Type C - Embryo placed an angle of 160.8° (Fig. A). Type – V Epiblast is Present (Fig. B).
Scutellum: Δ shaped: Type – Δ5 (Fig. C), having an angle of 55.78°. Scutellum slit is present; it is present at the side of the coleorhiza. Oval shaped, compactly arranged scutellum cells (Fig. D), depletion layer is also present (Fig. D, arrowhead).
Vascularisation: Type of vascularisation: Panicoid
Angle of vascularisation: 159.75°**,** Type – C.
Pattern of embryonic leaf: F- type
Endosperm: Polygon shaped endospermic cells.
Starch grain: Simple circular and polygon shaped (arrowhead) starch grains (Fig. F).
No. of starch grains per endosperm cell: 52±5 **Starch grain size:** 3.34±0.97 (µm)
Aleurone layer: Tangentially elongated rectangular shaped aleurone cells.
Caryopsis type and formula: Chloridoid-Eragrostoid type, having formula P+PF.
Bar Size: A, C =125 µm, B, D-F =12.5 µm

Differentiating features:

Angle of vascularisation type- A, embryo type- B, Scutellum type- V4-2…….
……..….*D. aegyptium*
Angle of vascularisation type- C, embryo type- B, Scutellum type- Δ5…...*D. sindicus*





81. *Dactyloctenium aegyptium* **Fig. 47** 82. *Dactyloctenium scindicum*

83. *Desmostachya bipinnata* (Fig. 48(83) A-G)

Shape: Square shaped with curved margins in transaction and having size 0.37 (L) X 0.26 (B) mm (Fig. D).

Pericarp: Type B (Fig. G; nucellus (arrow), cross cells (arrowhead)).

Embryo: Type C - Embryo placed an angle of 174.8° (Fig. A). Type II epiblast (Fig. B, arrow).

Scutellum: "U" shaped: Type U2-3 (Fig. D), having an angle of 65.83°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. F). Depletion layer is present (Fig. F, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 168.5°**,** Type – C.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple polygon shaped starch grains (Fig. E).

No. of starch grains per endosperm cell: 15±3 **Starch grain size:** 2.88±1.13 (µm)

Aleurone layer: Vertically elongated rectangular shaped aleurone cells (Fig. C).

Caryopsis type and formula: Chloridoid-Eragrostoid type, having formula P+PF.

Bar Size: A, D =125 µm, B,C, E-G =12.5 µm

84. *Dinebra retroflexa* (Fig. 48(84) A-F)

Shape: Oblong shaped in transaction and having size 0.42 (L) X 0.47 (B) mm (Fig. B).

Pericarp: Type B (Fig. F; cross cells (arrowhead), nucellus (arrow)).

Embryo: Type A - Embryo placed an angle of 126.37° (Fig. A). Type I epiblast (Fig. A).

Scutellum: "V" shaped: Type V8-2 (Fig. B), having an angle of 66.81°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. C). Depletion layer is present (Fig. C, arrowhead).

Vascularisation: Type of vascularisation: Panicoid (Fig. A, arrow)

Angle of vascularisation: 127.63°**,** Type – A.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

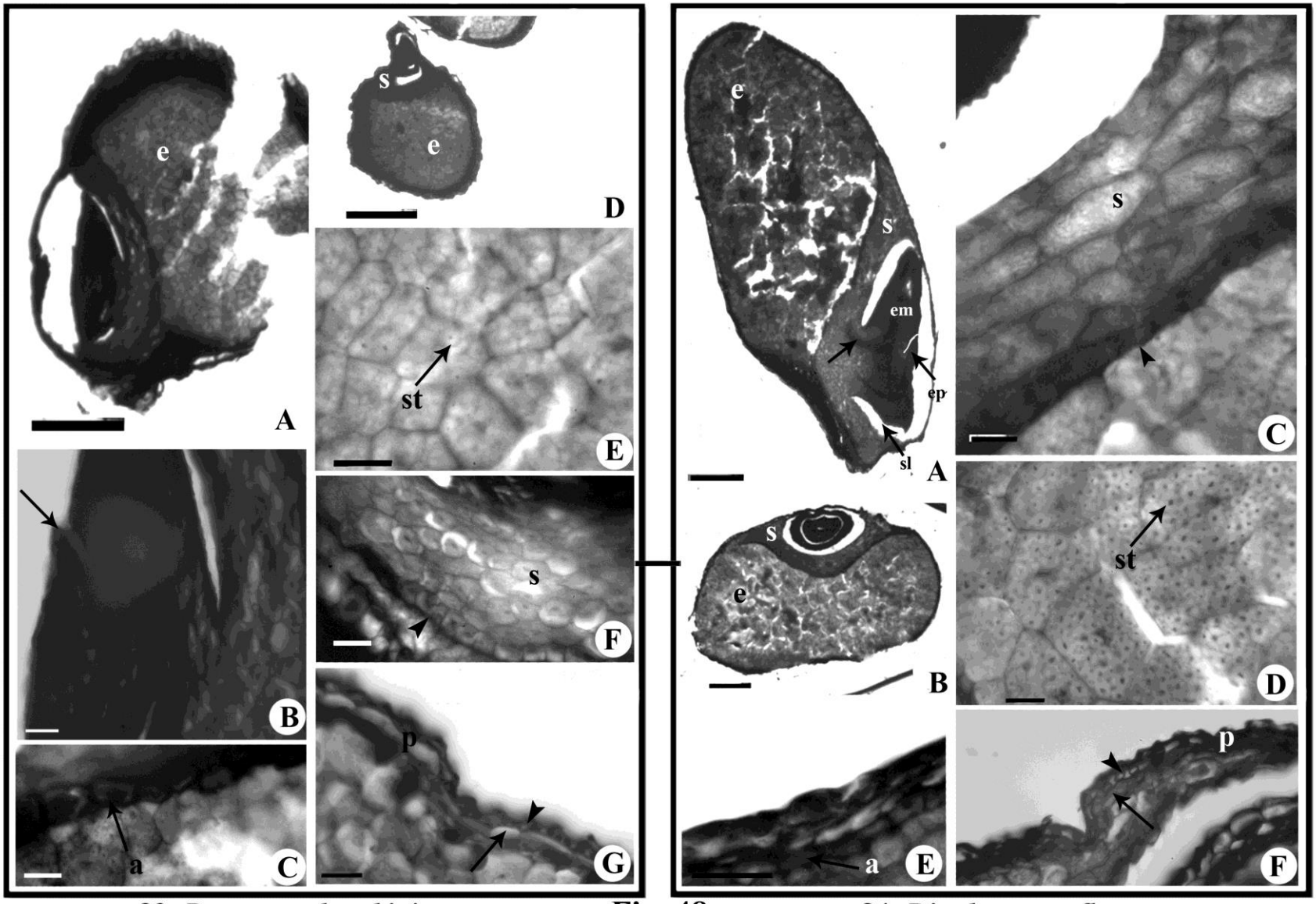
Starch grain: Some cells have simple circular shaped starch grains and some cells have simple circular shaped and compound starch grains are present together (Fig. D).

No. of starch grains per endosperm cell: 44±9 **Starch grain size:** 4.69±1.74 (µm)

Aleurone layer: Tengentially elongated aleurone cells (Fig. E).

Caryopsis type and formula: Oryzoid-Olyroid type and having formula F+PP.

Bar Size: A, B =125 µm, C-F =12.5 µm



83. *Desmostachya bipinnata* **Fig. 48** 84. *Dinebra retroflexa*

85. *Eleusine indica* (Fig. 49(85) A-F)

Shape: Kidney shaped in transaction with concave posterior end and having size 0.46 (L) X 0.60 (B) mm (Fig. B).

Pericarp: Type D (Fig. E; cross cells (arrow), crushed parenchyma (arrowhead)).

Embryo: Type B - Embryo placed an angle of 132.6° (Fig. A). Type V epiblast (Fig. C, arrow).

Scutellum: "U" shaped: Type U2-1 (Fig. B), having an angle of 55.36°. Scutellum cleft/slit is present. Oval shaped scutellum cells. Depletion layer is present.

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 104.8°**,** Type – A.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon starch grains present (Fig. F).

No. of starch grains per endosperm cell: 32±8 **Starch grain size:** 4.17±2.04 (µm)

Aleurone layer: Tangentially elongated rectangular and square aleurone cells (Fig. D).

Caryopsis type and formula: Chloridoid-Eragrostoid type, having formula P+PF.

Bar Size: A-C =125 µm, D-F =12.5 µm

Eragrostiella

86. *Eragrostiella bachyphylla*

87. *Eragrostiella bifaria*

86. *Eragrostiella bachyphylla* (Fig. 49(86) A-F)

Shape: Circular to oval shaped in transaction and having size 0.32 (L) X 0.35 (B) mm (Fig. B).

Pericarp: Type D (Fig. D; cross cells (arrowhead), nucellus (arrow)).

Embryo: Type B - Embryo placed an angle of 143.9° (Fig. A). Type V epiblast (Fig. A).

Scutellum: "U" shaped: Type U2-3 (Fig. B), having an angle of 58.74°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. C). Depletion layer is present (Fig. C, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 154.4°**,** Type – C.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

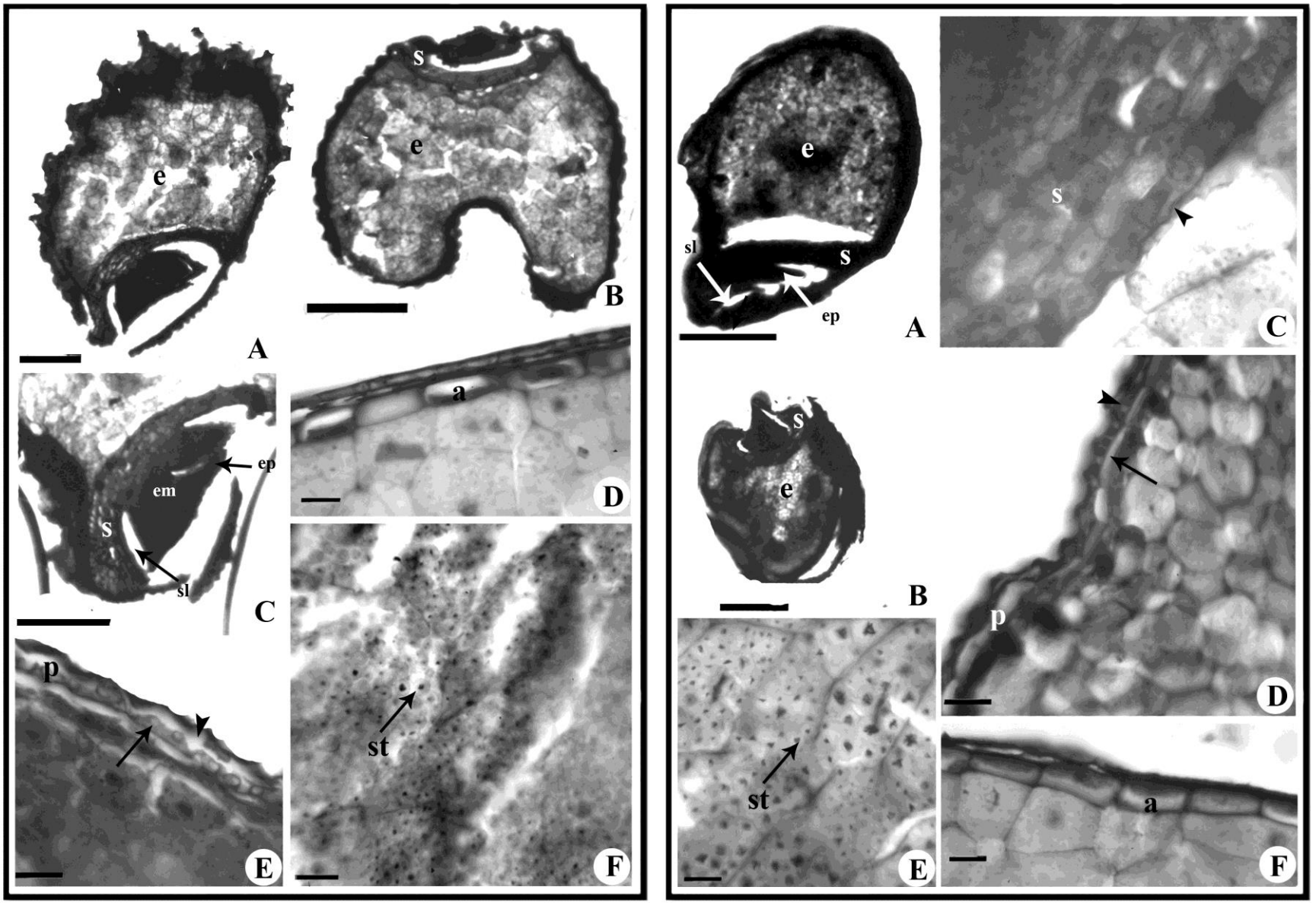
Starch grain: Simple circular and polygon starch grains present (Fig. E).

No. of starch grains per endosperm cell: 45±6 **Starch grain size:** 8.34±3.77 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. F).

Caryopsis type and formula: Chloridoid-Eragrostoid type, having formula P+PF.

Bar Size: A, B =125 µm, C-F =12.5 µm



85. *Eleusine indica* **Fig. 49** 86. *Eragrostiella bachyphylla*

87. *Eragrostiella bifaria* (Fig. 50(87) A-F)

Shape: Rectangular to oval shaped in transaction and having size 0.27 (L) X 0.18 (B) mm (Fig. B).

Pericarp: Type D (Fig. F; cross cells (arrow), epidermis (arrowhead)).

Embryo: Type B - Embryo placed an angle of 146.1° (Fig. A). Type V epiblast (Fig. A).

Scutellum: "U" shaped: Type U2-3 (Fig. B), having an angle of 60.53°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. E). Depletion layer is present (Fig. E, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 152.6°**,** Type – C.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple circular and polygon shaped starch grains present (Fig.)D.

No. of starch grains per endosperm cell: 21±8 **Starch grain size:** 5±2.48 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. C).

Caryopsis type and formula: Chloridoid-Eragrostoid type and having formula P+PF.

Bar Size: A, B =125 µm, C-F =12.5 µm

Differentiating features:

Number of starch grains per endospermic cell are 45±6..……..*E. bachyaphylla*

Number of starch grains per endospermic cell are 21±8……..*E. bifaria*

Eragrostis

88. *Eragrostis cilianensis*

89. *Eragrostis ciliaris*

90. *Eragrostis japonica*

91. *Eragrostis nutans*

92. *Eragrostis pilosa*

93. *Eragrostis tenella*

94. *Eragrostis tremula*

95. *Eragrostis unioloides*

96. *Eragrostis viscosa*

88. *Eragrostis cilianensis* (Fig. 50(88) A-F)

Shape: Oblong to oval shaped in transaction with convex anterior side and concave posterior side and having size 0.52 (L) X 0.53 (B) mm (Fig. B).

Pericarp: Type B (Fig. E; epidermis cells (arrowhead), crushed parenchyma (arrow)).

Embryo: Type B - Embryo placed an angle of 146.2° (Fig. A). Type V epiblast (Fig. A).

Scutellum: "U" shaped: Type U2-3 (Fig. B), having an angle of 68.43°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. D). Depletion layer is present (Fig. D, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 155.2°**,** Type – C.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

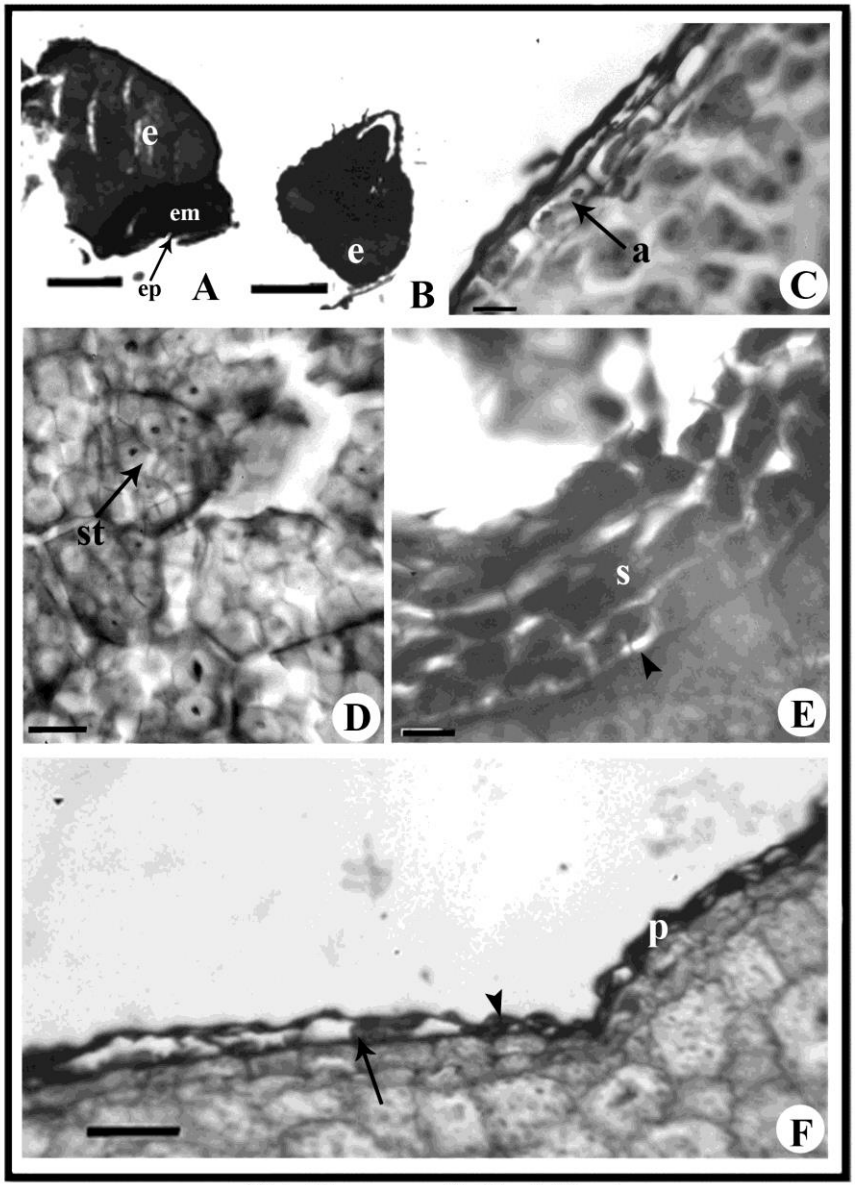
Starch grain: Simple polygon shaped starch grains present (Fig. C).

No. of starch grains per endosperm cell: 28±9 **Starch grain size:** 2.94±0.73 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. F).

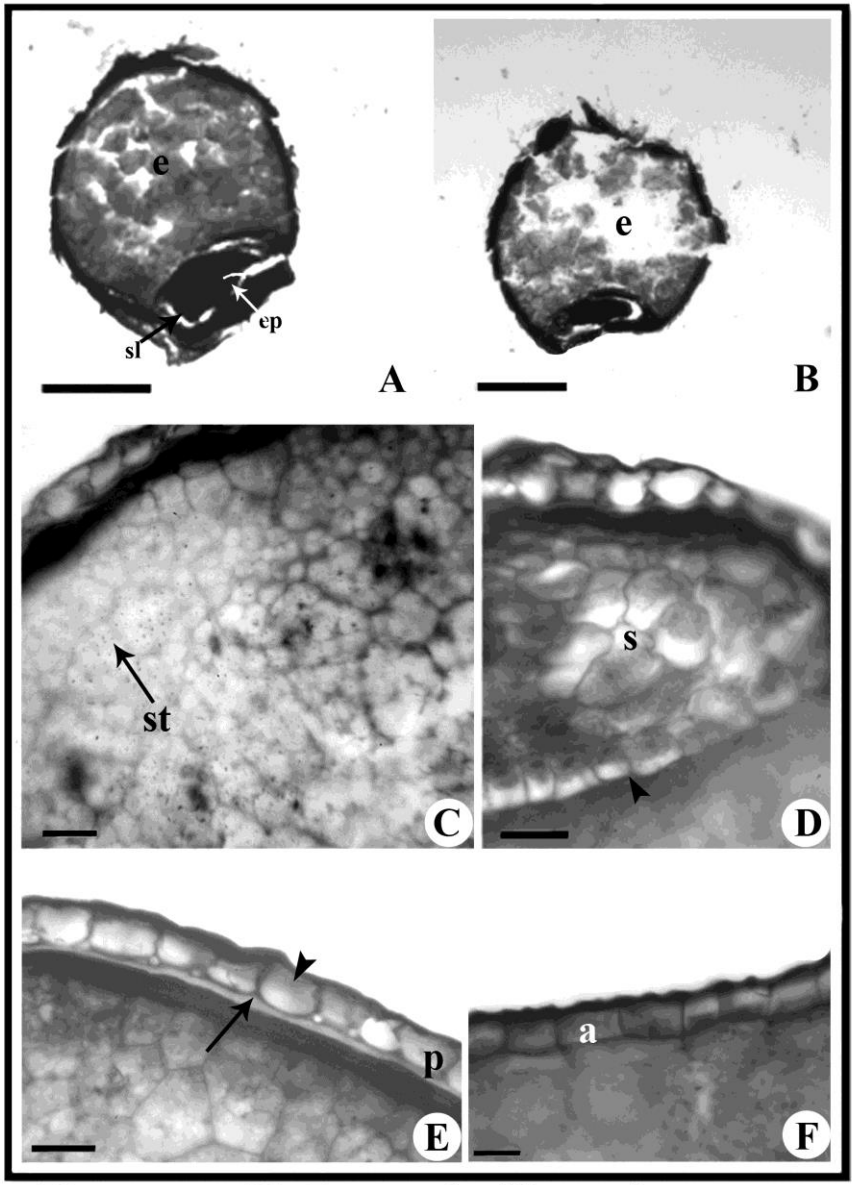
Caryopsis type and formula: Chloridoid-Eragrostoid type, having formula P+PF.

Bar Size: A, B =125 µm, C-F =12.5 µm



87. *Eragrostiella bifaria*

Fig. 50



88. *Eragrostis cilianensis*

89. *Eragrostis ciliaris* (Fig. 51(89) A-F)

Shape: Circular to oval shaped in transaction and having size 0.18 (L) X 0.18 (B) mm (Fig. B).

Pericarp: Type B (Fig. E; epidermis cells (arrowhead), crushed parenchyma (arrow)).

Embryo: Type B - Embryo placed an angle of 141.6° (Fig. A). Type V epiblast (Fig. A).

Scutellum: "U" shaped: Type U2-3 (Fig. B), having an angle of 61.9°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. F). Depletion layer is present (Fig. F, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 145.0°**,** Type – B.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple polygon shaped starch grains present (Fig. C).

No. of starch grains per endosperm cell: 23±9 **Starch grain size:** 5.56±1.63 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. D).

Caryopsis type and formula: Chloridoid-Eragrostoid type and having formula P+PF.

Bar Size: A, B =125 µm, C-F =12.5 µm

90. *Eragrostis japonica* (Fig. 51(90) A-G)

Shape: Oblong to oval shaped in transaction and having size 0.24 (L) X 0.15 (B) mm (Fig. C).

Pericarp: Type B (Fig. G; epidermis cells (arrowhead), nucellus(arrow)).

Embryo: Type B - Embryo placed an angle of 142.4° (Fig. A). Type II epiblast.

Scutellum: "U" shaped: Type U2-3 (Fig. C), having an angle of 62.7°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. E). Depletion layer is present (Fig. E, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 148.8°**,** Type – B.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

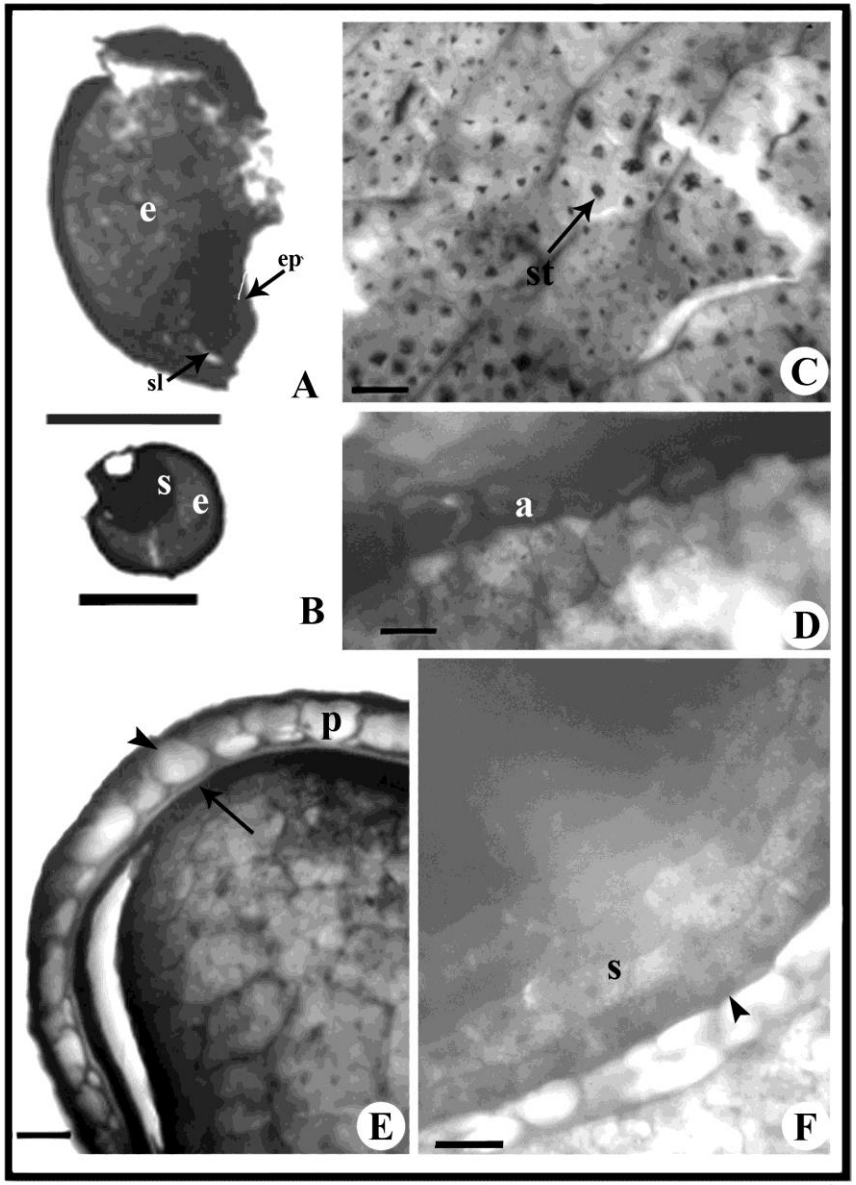
Starch grain: Simple polygon shaped starch grains present (Fig. E, arrow).

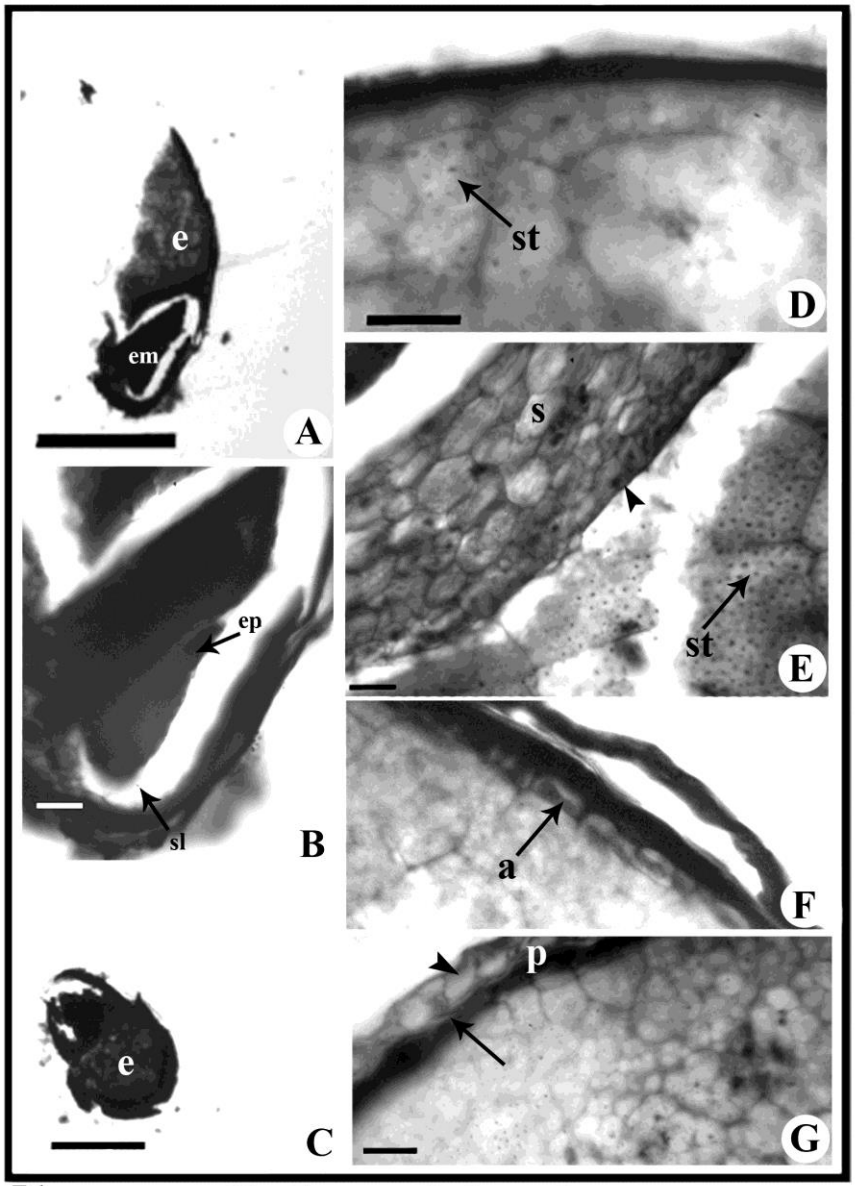
No. of starch grains per endosperm cell: 34±7 **Starch grain size:** 1.67±0.08 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. F).

Caryopsis type and formula: Chloridoid-Eragrostoid type and having formula P+PF.

Bar Size: A, C =125 µm, B, D-G =12.5 µm





89. *Eragrostis ciliaris* **Fig. 51** 90. *Eragrostis japonica*

91. *Eragrostis nutans* (Fig. 52(91) A-G)

Shape: Oval to oblong shaped in transaction and having size 0.32 (L) X 0.19 (B) mm (Fig. C).

Pericarp: Type B (Fig. G; epidermis cells (arrowhead), nucellus (arrow)).

Embryo: Type B - Embryo placed an angle of 149.5° (Fig.)A. Type II epiblast (Fig. B).

Scutellum: "U" shaped: Type U2-3 (Fig. C), having an angle of 57.26°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. F). Depletion layer is present (Fig. F, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 152.4°**,** Type – C.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple polygon shaped starch grains present (Fig. D).

No. of starch grains per endosperm cell: 16±5 **Starch grain size:** 3.12±0.86 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. E).

Caryopsis type and formula: Chloridoid-Eragrostoid type and having formula P+PF.

Bar Size: A-C =125 µm, D-G =12.5 µm

92. *Eragrostis pilosa* (Fig. 52(92) A-E)

Shape: Rectangular shaped in transaction and having size 0.26 (L) X 0.25 (B) mm (Fig. B).

Pericarp: Type B (Fig. E; epidermis cells (arrowhead), nucellus (arrow))

Embryo: Type C - Embryo placed an angle of 161.6° (Fig. A). Type II epiblast (Fig. A).

Scutellum: "U" shaped: Type U2-3 (Fig. B), having an angle of 57.84°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. C). Depletion layer is present (Fig. C, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 157.9°**,** Type – C.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

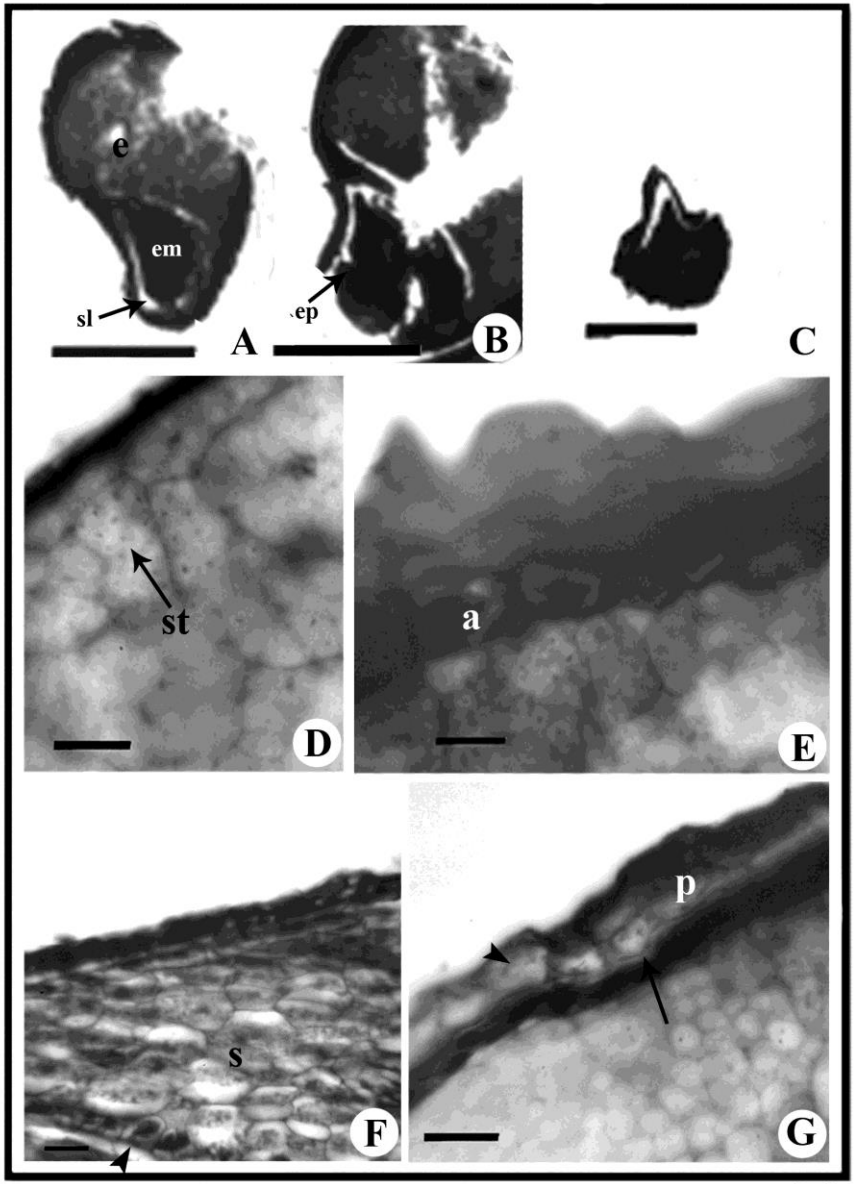
Starch grain: Simple polygon shaped starch grains present (Fig. E).

No. of starch grains per endosperm cell: 13±6 **Starch grain size:** 4.54±1.62 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. D).

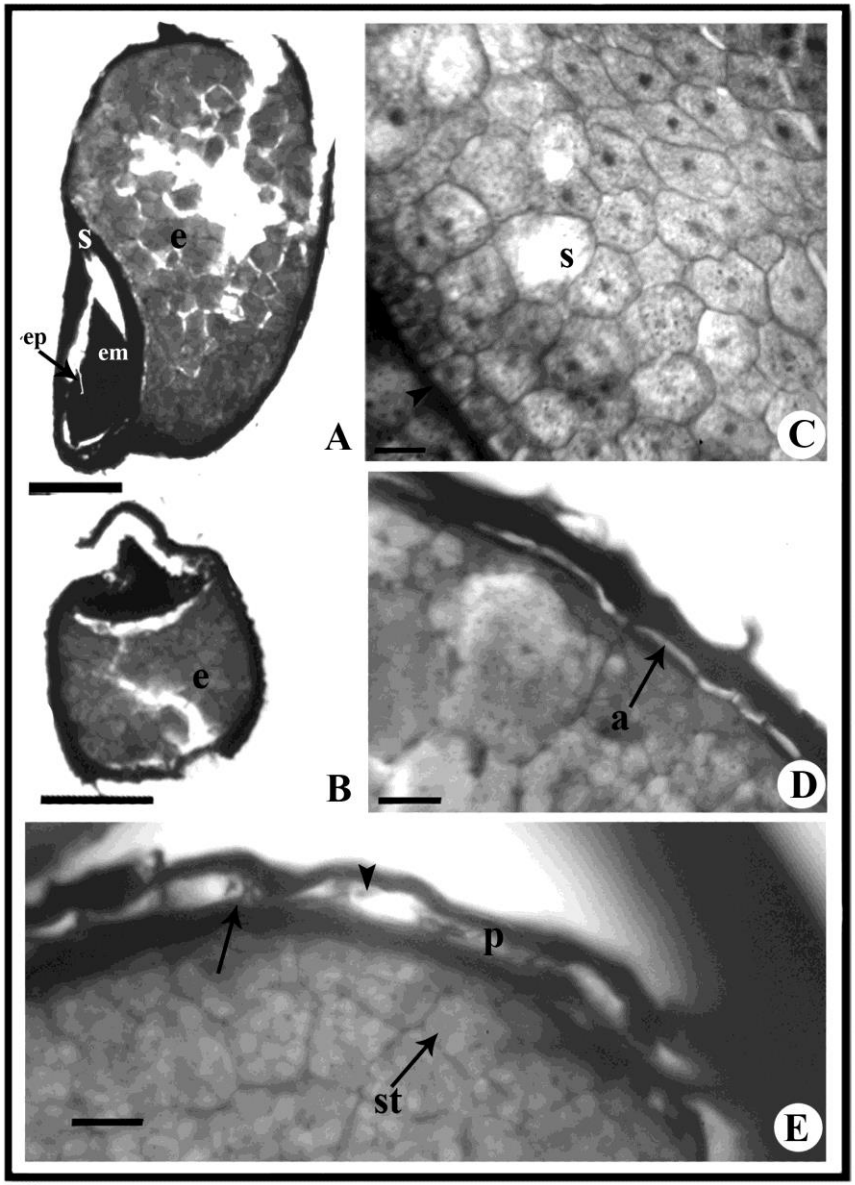
Caryopsis type and formula: Chloridoid-Eragrostoid type, having formula P+PF.

Bar Size: A, B =125 µm, C-E =12.5 µm



91. *Eragrostis nutans*

Fig. 52



92. *Eragrostis pilosa*

93. *Eragrostis tenella* (Fig. 53(93) A-F)

Shape: Oblong shaped in transaction and having size 0.48 (L) X 0.37 (B) mm (Fig. C).

Pericarp: Type B (Fig. F; epidermis cells (arrowhead), nucellus (arrow)).

Embryo: Type C - Embryo placed an angle of 161.1° (Fig. A). Type II epiblast (Fig. B).

Scutellum: "U" shaped: Type U2-3 (Fig. C), having an angle of 59.38°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. E). Depletion layer is present (Fig. E, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 150.3°**,** Type – C.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple polygon shaped starch grains present (Fig. D).

No. of starch grains per endosperm cell: 37±12 **Starch grain size:** 3.12±0.71 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. D).

Caryopsis type and formula: Chloridoid-Eragrostoid type and having formula P+PF.

Bar Size: A-C =125 µm, D-F =12.5 µm

94. *Eragrostis tremula* (Fig. 53(94) A-H)

Shape: Oblong shaped in transaction and having size 0.41(L) X 0.35 (B)mm (Fig. B).

Pericarp: Type B (Fig. H; epidermis cells (arrowhead), nucellus (arrow)).

Embryo: Type B - Embryo placed an angle of 155.4° (Fig. A). Type V epiblast (Fig. A).

Scutellum: "U" shaped: Type U2-3 (Fig. B), having an angle of 66.25°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. G). Depletion layer is present (Fig. G, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 156.5°**,** Type – C.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple polygon shaped starch grains present (Fig. F).

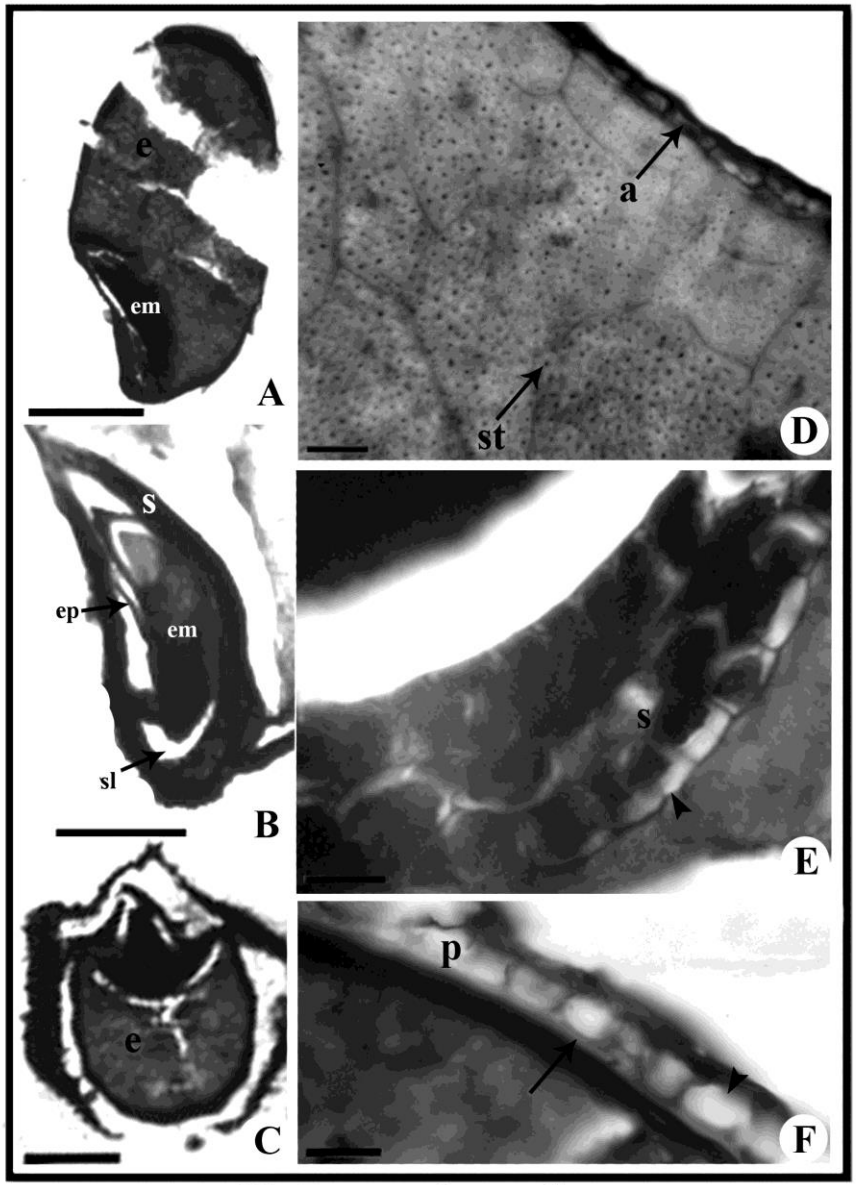
No. of starch grains per endosperm cell: 25±7 **Starch grain size:** 3.12±1.76 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. E).

Caryopsis type and formula: Chloridoid-Eragrostoid type, having formula P+PF.

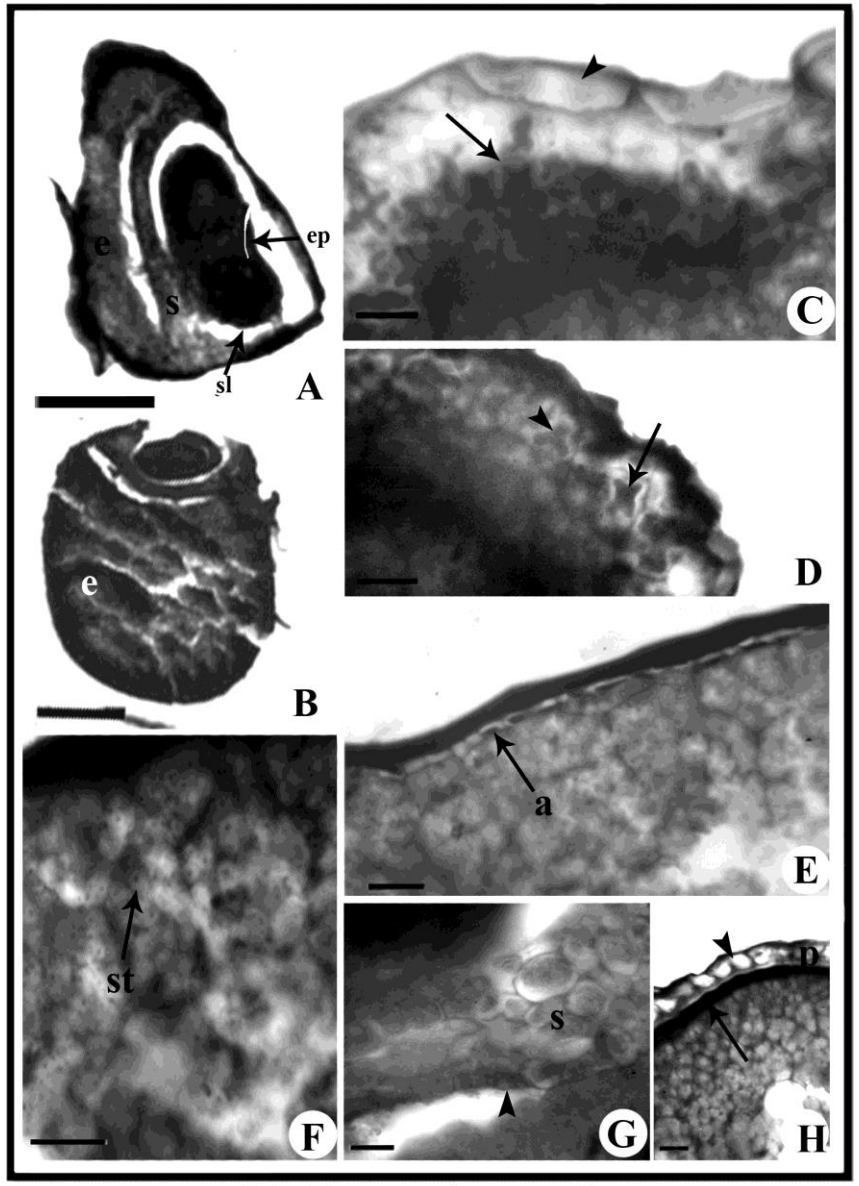
It shows slimy glands on embryo portion. Fig. C and D shows slime cells.

Bar Size: A, B =125 µm, C-H =12.5 µm



93. *Eragrostis tenella*

Fig. 53



94. *Eragrostis tremula*

95. *Eragrostis unioloides* (Fig. 54(95) A-F)

Shape: Oblong shaped in transaction and having size 0.48 (L) X 0.40 (B) mm (Fig. B).

Pericarp: Type B (Fig. D; cross cells (arrow), epidermis (arrowhead)).

Embryo: Type B - Embryo placed an angle of 154.1° (Fig. A). Type V epiblast (Fig. A).

Scutellum: "U" shaped: Type U2-3 (Fig. B), having an angle of 66.4°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. C). Depletion layer is present.

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 147.9°**,** Type – B.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple polygon shaped starch grains present (Fig. E).

No. of starch grains per endosperm cell: 19±7 **Starch grain size:** 2.68±0.83 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. F).

Caryopsis type and formula: Chloridoid-Eragrostoid type and having formula P+PF.

Bar Size: A, B =125 µm, C-F =12.5 µm

96. *Eragrostis viscosa* (Fig. 54(96) A-F)

Shape: Kidney shaped in transaction and having size 0.21 (L) X 0.25 (B) mm (Fig. B).

Pericarp: Type B (Fig. D; epidermis cells (arrowhead), nucellus (arrow)).

Embryo: Type B - Embryo placed an angle of 151.28° (Fig. A). Type V epiblast.

Scutellum: "U" shaped: Type U2-3 (Fig. B), having an angle of 59.28°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. F). Depletion layer is present.

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 145.63°**,** Type – B.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple polygon shaped starch grains present (Fig. E).

No. of starch grains per endosperm cell: 18±3 **Starch grain size:** 1.89±0.51 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. C).

Caryopsis type and formula: Chloridoid-Eragrostoid type and having formula P+PF.

Bar Size: A, B =125 µm, C-F =12.5 µm

Differentiating features:

Square shaped aleurone cells……..……..*E. pilosa*

Tangentially elongated aleurone cells

Epiblast type- II

Angle of vascularisation type- B……..……..*E. japonica*

Angle of vascularisation type- C

Embryo type- B…….*E. nutans*

Embryo type- C…….*E. tenella*

Epiblast type- V

Angel of vascularisation type- C

Absence of slimy glands on embryo……..*E. cilianensis*

Presence of slimy glands on embryo……..*E. tremula*

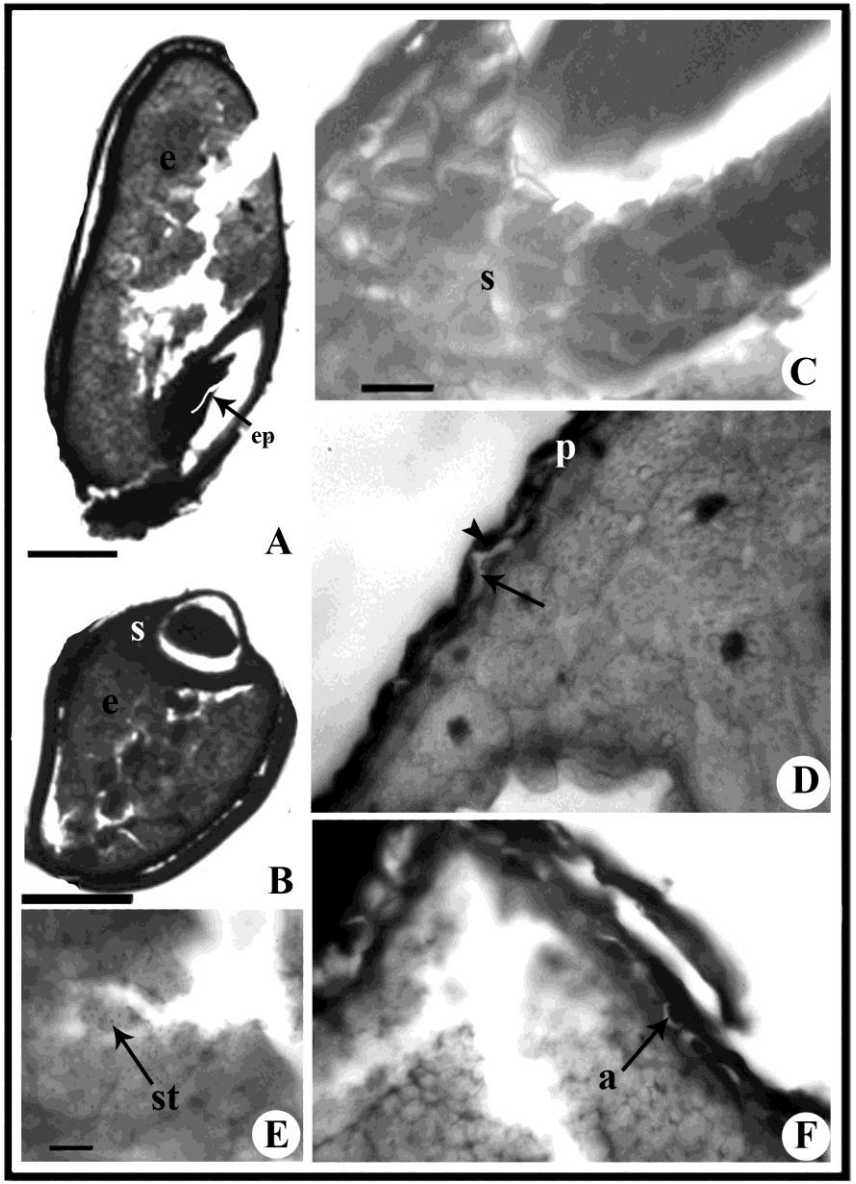
Angel of vascularisation type- B

Kidney shape in transection……..*E. viscosa*

Circular to oval or oblong in transection

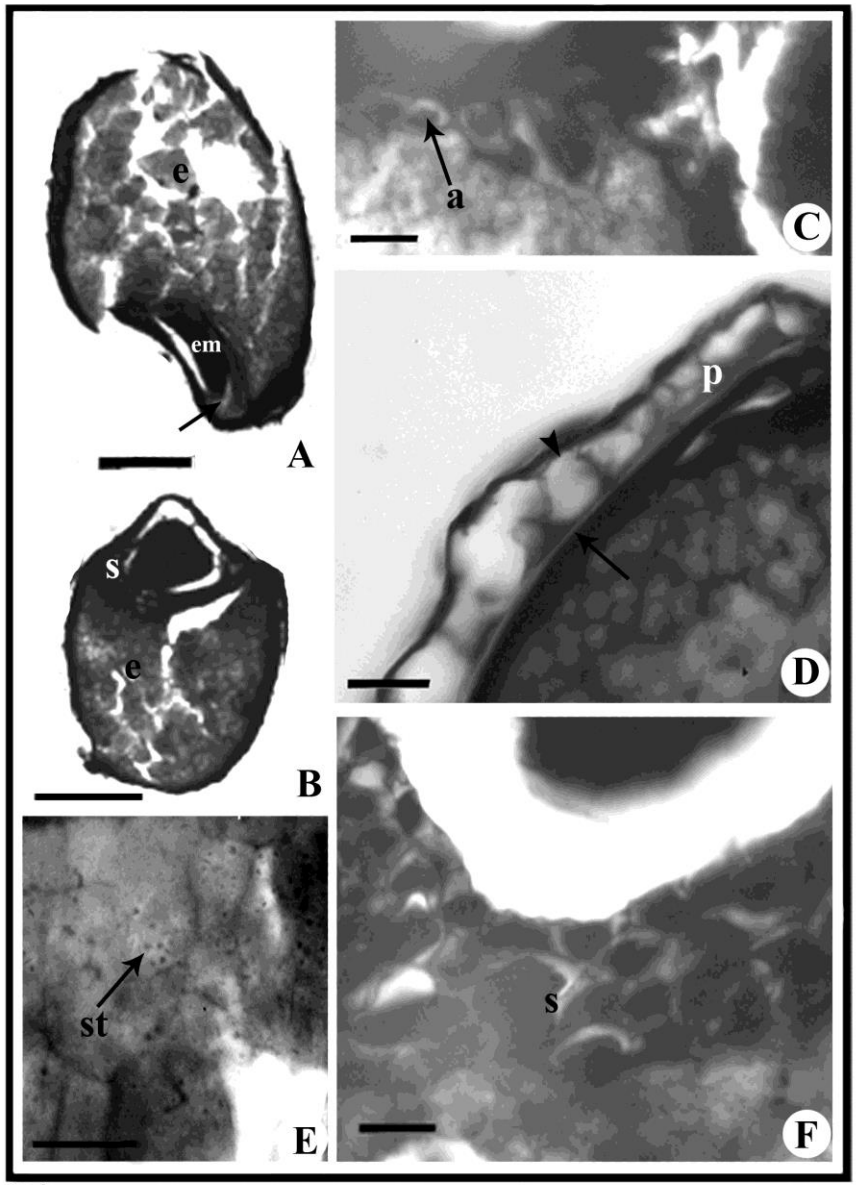
Circular to oval in transection with size 0.18 (L)x 0.18 (B) mm …….*E. ciliaris*

Oblong in transection with size 0.48 (L)x 0.40 (B) mm ……...…..*E. unioloides*



95. *Eragrostis unioloides*

Fig. 54



96. *Eragrostis viscosa*

Sporobolus

97. *Sporobolus coromandelianus*

98. *Sporobolus diander*

99. *Sporobolus indicus*

97. *Sporobolus coromandelianus* (Fig. 55(97) A-G)

Shape: Rectangular to oblong shaped in transaction and having size 0.55 (L) X 0.35 (B) mm (Fig. C).

Pericarp: Type D (Fig. D; epidermis cells (arrow), nucellus (arrowhead)).

Embryo: Type B - Embryo placed an angle of 147.36° (Fig. A). Type V epiblast (Fig. B).

Scutellum: "U" shaped: Type U2-3 (Fig. C), having an angle of 63.8°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. E). Depletion layer is present (Fig. E, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 138.36°**,** Type – B.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

Starch grain: Simple polygon shaped starch grains present (Fig. F).

No. of starch grains per endosperm cell: 15±6 **Starch grain size:** 4.69±1.28 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. G).

Caryopsis type and formula: Chloridoid-Eragrostoid type and having formula P+PF.

Bar Size: A-C =125 µm, D-G =12.5 µm

98. *Sporobolus diander* (Fig. 55(98) A-F)

Shape: Oval shaped in transaction and having size 0.58 (L) X 0.43 (B) mm (Fig. B).

Pericarp: Type C (Fig. E; epidermis cells (arrowhead), nucellus (arrow)).

Embryo: Type B - Embryo placed an angle of 145.26° (Fig. A). Type IV epiblast (Fig. A).

Scutellum: "U" shaped: Type U2-3 (Fig. B), having an angle of 41.9°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. D). Depletion layer is present (Fig. D, arrowhead).

Vascularisation: Type of vascularisation: Panicoid

Angle of vascularisation: 131.77°**,** Type – B.

Pattern of embryonic leaf: F- type

Endosperm: Polygon shaped endospermic cells.

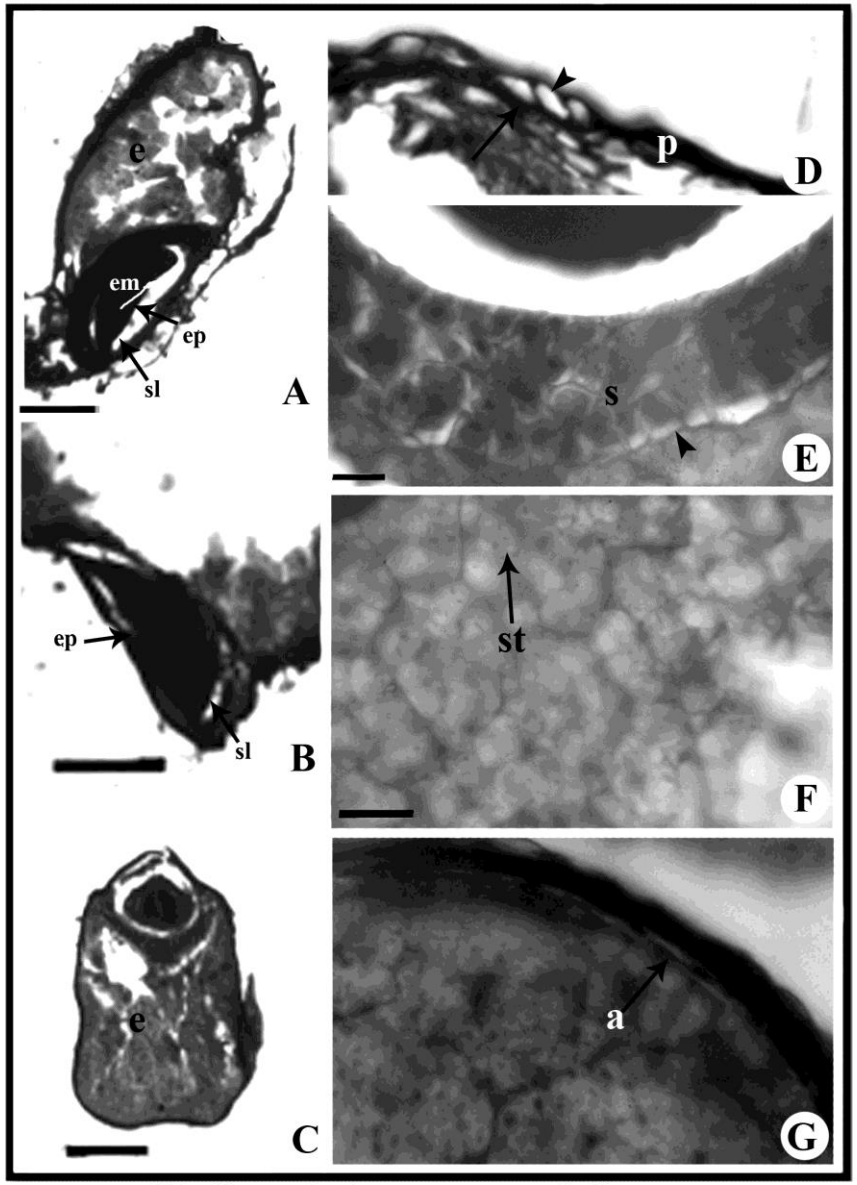
Starch grain: Simple polygon shaped starch grains present (Fig. F).

No. of starch grains per endosperm cell: 20±4 **Starch grain size:** 2.59±0.17 (µm)

Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. C).

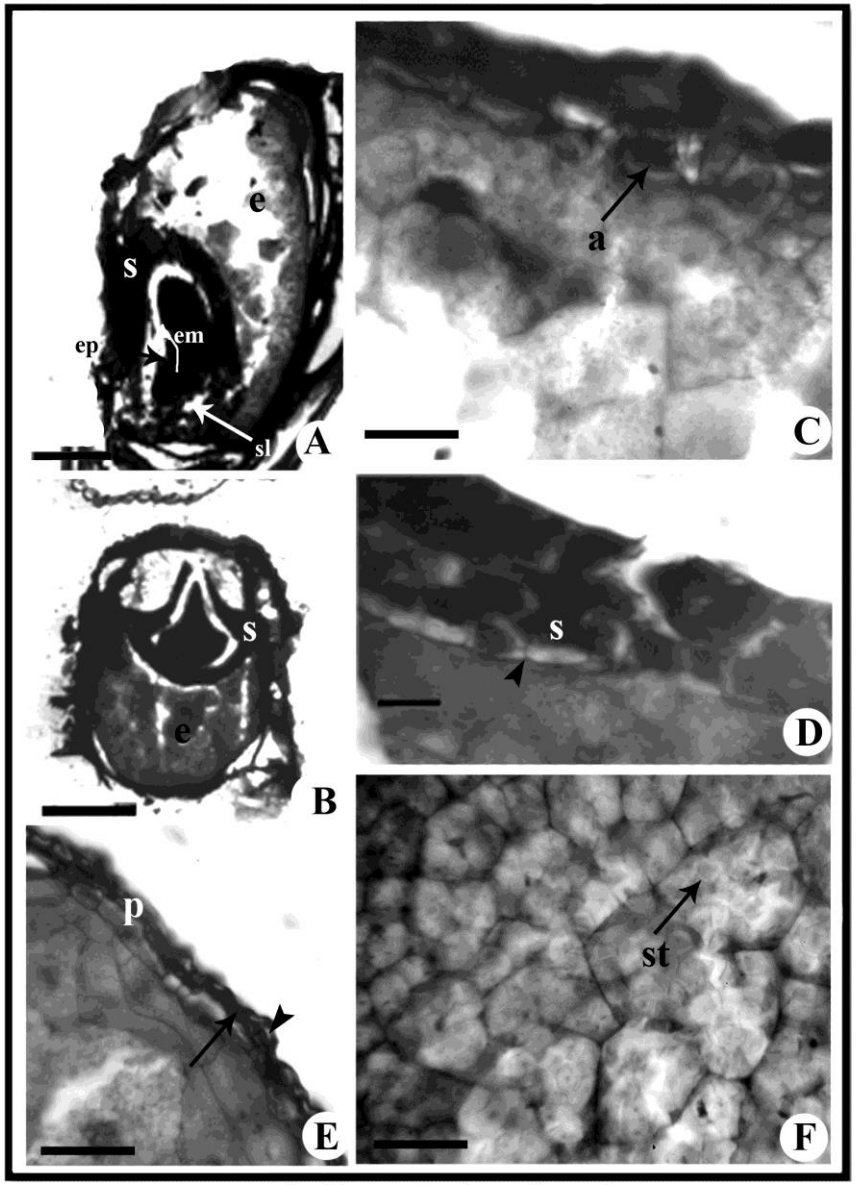
Caryopsis type and formula: Chloridoid-Eragrostoid type, having formula P+PF.

Bar Size: A, B =125 µm, C-F =12.5 µm



97. *Sporobolus coromandelianus*

Fig. 55



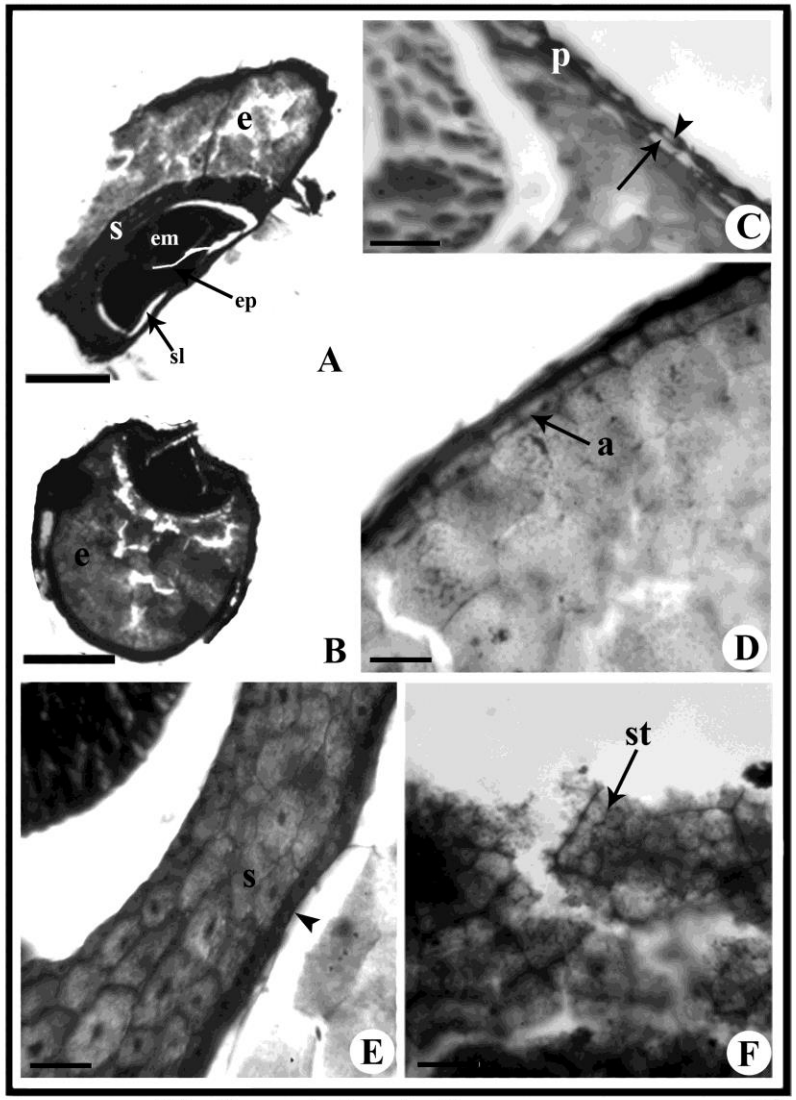
98. *Sporobolus diander*

99. *Sporobolus indicus* (Fig. 56(99) A-F)

Shape: Round shaped in transaction and having size 0.31 (L) X 0.25 (B) mm (Fig. B).
Pericarp: Type C (Fig. C; epidermis cells (arrow), nucellus (arrowhead)).
Embryo: Type B - Embryo placed an angle of 142.25° (Fig. A). Type V epiblast (Fig. A).
Scutellum: "U" shaped: Type U2-3 (Fig. B), having an angle of 60.23°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. E). Depletion layer is present (Fig. E, arrowhead).
Vascularisation: Type of vascularisation: Panicoid
Angle of vascularisation: 135.61°**,** Type – B.
Pattern of embryonic leaf: F- type
Endosperm: Polygon shaped endospermic cells.
Starch grain: Simple polygon shaped starch grains present (Fig. F).
No. of starch grains per endosperm cell: 16±4 **Starch grain size:** 2.5±0.93 (µm)
Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. D).
Caryopsis type and formula: Chloridoid-Eragrostoid type and having formula P+PF.
Bar Size: A, B =125 µm, C-F =12.5 µm
Differentiating features:
Square shaped aleurone cells……..……..*S. coromardelianus*
Tangentially elongated aleurone cells
Round shaped in transection with size 0.31 (L)x0.25 (B) mm..……..*S. indicus*
Oval shaped in transection with size 0.58 (L)x0.43 (B) mm…….……..*S. diander*

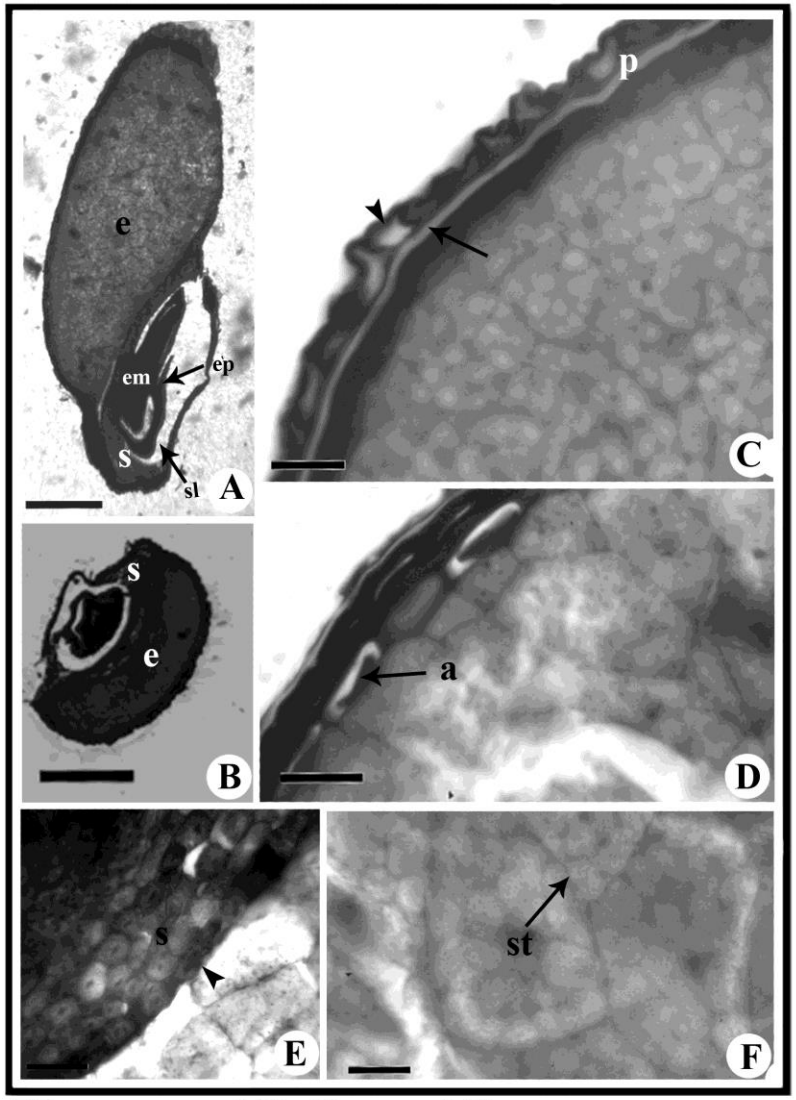
100. *Tragrus biflorus* (Fig. 56(100) A-F)

Shape: Oval shaped in transaction and having size 0.31 (L) X 0.42 (B) mm (Fig. B).
Pericarp: Type D (Fig. C; epidermis cells (arrow), nucellus (arrowhead))
Embryo: Type C - Embryo placed an angle of 163.7° (Fig. A). Type III epiblast.
Scutellum: "U" shaped: Type U2-3 (Fig. B), having an angle of 62.41°. Scutellum cleft/slit is present. Oval shaped scutellum cells (Fig. E). Depletion layer is present (Fig. E, arrowhead).
Vascularisation: Type of vascularisation: Panicoid
Angle of vascularisation: 162.9°**,** Type – C.
Pattern of embryonic leaf: F- type
Endosperm: Polygon shaped endospermic cells.
Starch grain: Simple polygon shaped starch grains present (Fig. F).
No. of starch grains per endosperm cell: 26±6 **Starch grain size:** 2.27±1.03 (µm)
Aleurone layer: Tangentially elongated rectangular shaped aleurone cells (Fig. D).
Caryopsis type and formula: Chloridoid-Eragrostoid type and having formula P+PF.
Bar Size: A, B =125 µm, C-F =12.5 µm



99. *Sporobolus indicus*

Fig. 56



100. *Tragrus biflorus*

Table 1: Quantitative and qualitative features of caryopsis (anatomy)

Sr. No	Name of Plant	A	B	C	D		E		F	G
					D1	D2	E1	E2		
Tribe: Maydeae										
1.	*Chionachne koenigii*	1.39 X 3.34± 0.27	2.32± 0.7	2.86 X 1.98± 1.4	24.76±2.54	459 ± 4.65	75.24±2.78	842± 8.54	165.6±1.05	172.8±4.09
2	*Coix lachryma-jobi*	2.57 X 4.38± 0.96	1.41± 0.8	2.1 X 1.4± 0.6	26.65±3.67	415±.45	73.37 ±5.84	943±16.3	177.9±0.94	163.9±1.87
Tribe: Andropogoneae										
3	*Andropogon pumilus*	0.27 X 0.45±0.07	3.74±1.28	4.68 X 9.32±1.68	40.51±1.75	69.18± 4.87	59.49±4.16	121.3±7.45	167.5±2.86	167.7±3.18
4	*Apluda mutica*	0.54 X 0.39± 0.14	6.25±2.54	7.42 X 9.23± 3.12	32.83±3.18	478.34±9.64	67.16±3.14	345.57±11.76	141.3±1.18	154.5±3.05
5	*Arthraxon lanceolatus*	0.38 X 0.31±0.12	3.96±0.42	10.7 X 10.2±2.75	48.29±2.96	352.69±7.53	51.70±2.19	327.89±5.46	168.5±3.02	170.5±4.51
6	*Bothriochloa pertusa*	0.35 X 0.67± 0.09	3.24±1.89	13.6 X 11.7±4.78	55.89±4.18	302.65±13.76	44.09±3.87	404.23±11.78	156.5±3.18	161.2±2.94
7	*Capillipedium hugelii*	0.42X0.70±0.19	5.29±1.38	6.36X13.79±2.88	57.94±2.67	501.38±16.37	42.05±2.49	319.36±10.67	167.0±2.15	154.5±3.87
8	*Chrysopogon fulvus*	1.14X0.59±0.73	3.29±0.8	6.43X1.38±2.67	40.17±3.09	490.26±13.68	59.83±5.12	438.98±7.42	149.9±5.08	173.1±2.16
9	*Cymbopogon martini*	0.36X0.69±0.18	3.74±1.07	6.78X11.86±3.78	37.01±2.06	528.78±16.34	62.98±3.32	486.78±17.78	164.2±1.94	172.6±2.19
10	*Dichanthium annulatum*	0.47X0.71±0.21	6.47±2.35	3.56X8.45±1.98	37.46±3.18	418.78±7.45	62.51±5.16	308.67±12.80	177.5±4.97	159.4±2.19
11	*Dichanthium caricosum*	0.47X0.93±0.18	3.79±1.06	8.45X1.59±3.80	42.22±2.93	629.56±14.65	58.44±1.73	447.62±7.24	169.9±1.16	161.42±3.7
12	*Hackelochloa granularis*	0.19X0.72±0.13	2.86±1.77	3.13X5.93±1.37	59.82±4.53	485.92±3.48	40.18±3.88	286.2±3.84	152.5±2.29	158.6±2.86
13	*Heteropogon contortus var. genuinus sub var. typicus*	0.54X0.60±0.18	3.07±1.74	3.58X4.69±1.73	43.07±6.08	563.43±14.78	56.80±3.06	432.78±17.93	177.9±4.03	178.8±3.64

Sr. No	Name of Plant	A	B	C	D		E		F	G
					D1	D2	E1	E2		
14	*Heteropogon contortus var. genuinus sub var. hispidissimus*	0.75X0.83±0.24	3.25±1.36	3.72X9.79±0.83	44.02±4.04	528.76±9.38	55.98±4.05	442.87±13.64	178.4±4.69	175.7±4.74
15	*Heteropogon ritchiei*	0.52X0.51±0.27	3.59±0.73	4.12X7.24±2.84	42.16±4.18	223.56±7.23	63.68±8.45	290.67±11.64	177.8±3.16	176.9±2.68
16	*Heteropogon triticeus*	1.25X1.23±0.65	1.2±0.96	7.76X1.28±4.26	45.13±2.59	1778.57±6.83	57.19±4.13	1284.6±21.54	146.4±4.87	169.9±3.57
17	*Imperata cylindrical*	0.19X0.24±0.04	2.99±1.04	2.49X5.22±1.74	41.73±7.28	80.57±14.83	58.27±6.32	80.57±10.37	152.3±3.28	163.7±3.81
18	*Ischaemum indicus*	0.41X0.71±0.23	5.73±1.64	9.23X1.24±3.76	28.41±4.53	328.67±6.34	71.59±3.18	338.34±11.46	167.3±1.17	171.2±2.74
19	*Ischaemum molle*	0.67X0.76±0.14	6.96±0.94	13.56X16.56±5.12	40.5±3.19	468.32±24.37	59.50±6.13	374.78±18.34	170.34±1.04	173.4±3.47
20	*Ischaemum pilosum*	0.91X1.03±0.37	3.79±1.87	6.23X14.21±2.73	40.32±3.75	932.47±7.23	59.68±4.84	451.87±20.45	144.8±3.19	172.1±4.74
21	*Ischaemum rugosum*	0.91X1.34±0.26	5.49±2.17	5.72X16.23±1.58	35.48±4.03	462.67±13.76	64.52±3.68	640.63±8.39	173.8±3.09	174.5±5.12
22	*Iseilema laxum*	0.38X0.79±0.26	5.03±1.39	7.42X19.42±2.16	34.06±2.13	514.27±21.68	65.94±4.63	329.08±17.56	166.4±2.09	171.8±3.83
23	*Ophiuros exaltatus*	0.69X0.83±0.36	6.27±2.96	9.41X13.73±1.76	37.39±3.89	693.76±18.54	62.61±2.67	421.67±15.97	167.3±3.08	168.7±1.02
24	*Rottboellia exaltata*	2.00X2.35±0.73	7.48±3.72	13.75X12.51±3.54	21.57±4.16	1883.8±27.76	78.43±6.07	1220.3±41.36	165.3±1.16	173.3±3.45
25	*Saccharum spontanum*	0.54 X 0.67± 0.13	1.27±0.35	2.87 X 3.42± 1.27	58.23±2.38	482.67±2.78	41.76±2.53	281.67±13.27	169.8±1.93	171.4±2.67
26	*Sehima ischaemoides*	0.30X0.97±0.27	4.72±1.38	4.24X8.23±2.49	32.85±2.14	672.46±11.36	67.15±6.74	521.78±8.37	157.1±3.05	169.9±5.42
27	*Sehima nervosum*	0.47X0.97±0.33	4.97±2.06	11.2X12.5±4.18	31.97±1.82	462.28±7.18	68.03±3.69	526.8±1.92	177.1±2.05	174.2±4.18

Sr. No	Name of Plant	A	B	C	D		E		F	G
					D1	D2	E1	E2		
28	*Sehima sulcatum*	1.87X1.69±0.27	7.71±1.08	7.22X11.92±2.43	39.49±5.72	376.3±5.03	60.51±2.19	413.9±1.93	171.3±1.68	177.8±3.61
29	*Sorghum halepense*	1.87X1.69±0.92	6.47±1.53	9.46X18.16±2.17	30.57±4.13	633.14±4.57	69.43±6.19	427.20±5.13	157.5±3.67	170.1±4.36
30	*Thelepogn elegans*	1.19X1.53±0.04	11.2±2.32	9.46X18.16±2.17	31.79±3.21	1160.38±7.82	68.21±7.18	787.71±8.32	145.2±1.03	167.7±3.14
31	*Themeda cymbaria*	0.63 X 0.38±0.16	3.82±1.03	9.23 X 14.57±2.87	44.51±5.41	443.23±7.34	55.49± 2.74	390.85±6.23	163.3±1.32	171.4±2.93
32	*Themeda laxa*	0.36X0.64±0.11	4.73±0.87	5.2X10.45±1.87	34.24±8.34	672.0±15.14	65.76±12.18	500.0±11.72	168.7±4.32	173.2±5.26
33	*Themeda triandra*	0.65X0.73±0.27	3.73±1.83	5.72X16.43±3.83	41.58±2.73	546.31±7.82	58.42±3.16	441.29±6.73	164.4±3.68	172.7±2.83
34	*Themeda quadrivalvis*	0.85 X 0.98± 0.08	4.35±1.68	9.56X13.54± 0.21	47.36±4.67	877.3±7.63	52.64±8.15	607.43±5.19	168.5±1.64	173.1±2.43
35	*Triplopogon ramosissimus*	0.48X0.95±0.23	6.23±2.67	3.48X4.98±2.16	40.45±5.72	451.61±7.36	59.55±6.78	462.28±6.15	166.5±4.13	172.1±3.26
36	*Vetivaria zizanioides*	0.96X0.60±0.08	5.22±1.84	4.27X6.28±1.94	37.84±5.12	338.67±7.38	62.16±3.14	278.09±10.71	167.90±2.18	171.1±4.73
Tribe: Paniceae										
37	*Alloteropsis cimicina*	0.34X3.45±7.13	6.47±3.89	4.73X12.19±1.72	45.58±2.73	348.59±8.71	54.35±4.73	387.04±8.19	141.7±3.51	166.7±2.19
38	*Brachiaria distachya*	0.52 X 1.50± 0.13	3.16± 0.8	4.92 X 5.17± 1.09	22.79±5.72	335.8±11.21	77.21±8.13	440.76±7.81	154.0±3.34	166.8±1.14
39	*Brachiaria eruciformis*	0.36 X 0.67± 0.21	2.90±1.07	2.71X 3.03± 1.98	38.43±5.62	326.67±12.04	61.57±8.92	171.34±7.42	168.8±1.34	170.3±1.21
40	*Brachiaria ramosa*	0.62 X 1.35± 0.08	1.18± 0.6	2.69X4.23± 0.85	23.75±9.18	897.71±23.63	76.25±8.23	467.61±9.12	152.38±1.19	160.3±3.92
41	*Brachiaria reptans*	0.43X1.42±0.17	5.48±2.15	7.47X11.91±1.94	26.72±3.19	473.90±13.16	73.28±6.19	462.28±11.10	156.2±4.62	173.2±3.12
42	*Cenchrus biflorus*	0.82X1.34±0.52	3.22±0.73	3.48X9.95±0.97	38.43±5.62	415.23±5.61	71.54±6.13	322.48±4.74	164.1±3.17	172.7±3.94
43	*Cenchrus*	0.52X0.64±0.27	3.24±1.07	3.73X11.21±1.43	43.55±3.17	245.90±3.91	56.45±2.98	471.81±7.18	167.8±3.98	172.9±1.71

Sr. No	Name of Plant	A	B	C	D		E		F	G
					D1	D2	E1	E2		
	ciliaris									
44	*Cenchrus setigerus*	0.83X1.39±0.32	3.73±1.26	5.22X10.77±2.19	27.85±2.18	709.52±10.34	72.15±7.11	556.38±17.83	146.3±2.10	166.2±3.43
45	*Digitaria ciliaris*	0.62X0.98±0.43	6.51±2.71	4.28X11.48±1.86	47.26±2.80	516.75±14.69	52.74±3.17	256.34±6.32	145.45±2.62	157.76±1.41
46	*Digitaria granularis*	0.49X0.64±0.23	1.99±0.73	3.74X10.71±1.43	51.9±2.93	520.19±7.83	48.15±3.63	153.14±6.27	142.5±1.34	148.2±3.19
47	*Digitaria longiflora*	0.70X1.13±0.07	8.64±2.83	5.63X15.21±2.14	49.73±4.32	505.56±10.12	50.27±3.83	392.16±11.03	146.1±5.62	163.4±2.17
48	*Digitaria stricta*	0.47X0.78±0.18	4.89±2.07	3.74X13.68±1.72	53.76±7.14	435.04±7.83	46.24±5.20	342.47±10.12	143.4±2.16	162.1±3.12
49	*Echinochloa colonum*	0.88X1.42±0.34	6.22±1.09	9.21X14.43±3.46	29.51±1.71	725.71±6.82	70.49±3.46	639.61±7.42	131.3±3.10	163.8±1.31
50	*Echinochloa crusgalli*	0.93X1.67±0.51	4.25±0.13	8.96X23.39±4.36	23.85±0.81	548.0±4.38	76.15±2.77	447.24±4.62	143.5±1.16	163.4±3.23
51	*Echinochloa stagnina*	1.25X2.33±0.46	6.79±2.03	14.45X20.5±5.21	21.65±3.16	874.85±6.34	78.35±3.84	971.61±7.82	143.6±3.71	163.2±4.83
52	*Eremopogon foveolatus*	0.5 X 1.54± 0.48	1.78±0.76	3.71 X 4.21± 1.04	68.42±5.63	521.52±8.12	31.58±2.17	344.78±12.63	155.0±1.15	167.9±2.36
53	*Eriochloa procera*	0.64 X 1.83± 0.07	4.34±2.34	3.89X3.09± 1.68	42.76±3.55	897.71±9.24	57.24±4.83	467.7±14.13	154.1±2.13	160.2±4.27
54	*Oplismenus burmannii*	0.39X0.55±0.17	5.22±3.45	4.73X10.21±2.89	54.62±8.72	737.71±18.61	45.38±3.77	302.47±7.81	150.2±1.46	154.4±1.38
55	*Oplismenus compositus*	0.52X0.94±0.07	4.98±2.63	4.24X13.43±1.93	42.44±2.64	396.70±6.45	57.56±6.72	398.86±8.25	154.7±2.41	164.9±3.43
56	*Panicum antidotale*	0.58X0.89±2.74	4.97±1.54	5.2X8.95±0.82	39.43±5.87	487.43±9.87	60.57±4.62	423.05±16.73	132.2±4.36	164.4±2.27
57	*Panicum maximum*	0.57X1.07±0.37	2.73±1.68	2.72X7.71±0.93	40.43±2.77	542.09±10.22	59.57±5.84	391.04±7.87	157.5±2.65	174.7±2.93
58	*Panicum miliaceum*	1.07X1.82±0.86	4.24±2.08	4.48X13.91±1.67	24.54±1.58	989.14±11.69	75.46±3.46	553.71±8.10	155.3±4.63	165.7±2.93
59	*Panicum*	0.68X1.49±0.05	3.74±1.07	6.47X9.95±3.34	23.85±2.34	779.42±19.36	76.15±7.66	446.09±7.63	131.1±3.73	157.7±1.9

Sr. No	Name of Plant	A	B	C	D		E		F	G
					D1	D2	E1	E2		
	trypheron									
60	*Paspalidium flavidum*	0.67 X 1.62± 0.18	4.67±1.95	4.34 X3.32± 1.8	22.89±0.70	927.24±8.31	77.11±3.39	437.93±9.13	156.4±3.75	147.2±4.62
61	*Paspalidium geminatum*	0.44X1.107±0.28	6.47±2.24	5.98X11.31±2.06	35.32±3.68	601.14±15.02	64.68±7.08	358.85±11.58	167.2±1.75	162.5±1.83
62	*Paspalum scrobiculatum*	1.08X2.25±0.62	3.32±1.37	2.66X10.29±1.05	43.43±2.46	1333.14±15.9	56.57±3.39	532.19±5.23	135.5±2.12	152.2±3.16
63	*Pennisetum setosum*	0.52X0.59±0.09	2.98±1.85	3.48X7.96±2.15	55.18±6.93	519.81±5.89	44.81±3.77	173.34±3.77	160.02±3.39	164.8±3.73
64	*Setaria glauca*	0.53X1.08±0.78	1.49±0.65	3.73X9.21±1.65	22.68±4.72	560.38±16.78	77.32±8.42	237.90±14.83	144.1±4.56	155.7±5.69
65	*Setaria tomentosa*	0.91X0.66±0.21	2.33±0.56	3.32X12.28±2.69	29.98±3.18	473.14±20.56	70.02±6.22	220.38±8.34	142.1±2.45	167.1±2.23
66	*Setaria verticillata*	1.06X1.24±0.75	2.85±0.34	2.99X13.61±1.89	24.72±4.56	612.76±13.65	75.28±2.75	333.34±15.78	135.8±1.43	141.8±2.74
Group: Pooideae										
Tribe: Isachneae										
67	*Isachne globosa*	0.68X0.91±0.48	5.47±2.78	6.47X11.21±3.82	68.35±4.57	628.95±17.63	31.65±2.85	177.34±4.65	99.0±1.72	108.8±2.45
Tribe: Aristideae										
68	*Aristida adscensionis*	0.43X0.35±0.21	3.48±1.67	3.11X7.72±1.76	75.19±8.62	345.09±6.27	24.81±5.18	142.76±7.85	149.98±2.92	153.73±3.2
69	*Aristida funiculata*	0.44X0.42±0.17	4.98±1.63	3.48X6.96±2.59	58.47±6.30	296.73±46.21	41.53±8.75	139.21±8.45	148.38±3.73	152.3±4.48
Tribe: Perotideae										
70	*Perotis indica*	0.26X0.28±0.17	4.25±2.76	3.24X5.98±1.39	64.17±7.63	193.52±9.36	35.83±5.18	157.34±6.38	163.7±3.37	167.0±3.20
Tribe: Chlorideae										
71	*Chloris barbata*	0.38X0.46±012	2.98±0.83	3.48X7.53±2.97	38.37±2.51	298.28±10.42	61.63±4.78	315.81±16.32	166.1±4.29	176.0±3.93
72	*Chloris montana*	0.49X0.69±0.08	7.71±2.41	2.24X8.22±1.77	16.63±2.65	439.42±12.76	82.37±6.38	286.28±3.56	152.5±2.987	170.7±2.65
73	*Chloris virgata*	0.62X0.52±0.28	3.98±0.38	5.98X12.45±2.17	23.53±1.58	451.62±9.37	76.47±5.83	241.90±7.29	154.7±5.27	172.3±4.27

Sr. No	Name of Plant	A	B	C	D		E		F	G
					D1	D2	E1	E2		
74	*Cynadon dactylon*	0.58X0.52±0.16	7.96±1.86	4.72X9.21±2.76	51.08±8.74	249.71±5.27	48.92±3.04	314.48±7.57	132.9±3.76	144.2±2.59
75	*Melanocenchris jaequemontii*	0.20X0.32±0.11	2.98±0.74	2.94X6.82±1.39	46.24±2..67	298.28±8.96	53.76±4.78	278.09±4.26	163.3±3.56	165.4±1.28
76	*Oropetium villosulum*	0.20X0.18±0.05	2.99±0.84	3.74X6.96±0.65	69.47±6.26	88.76±4.92	30.53±2.18	92.76±8.23	172.5±3.19	175.5±2.94
77	*Sachoenefeldia gracilis*	0.68X0.41±0.31	4.48±2.17	3.73X5.98±1.78	47.26±2.46	632.57±10.43	52.74±3.83	241.71±5.28	170.6±1.68	174.7±2.29
78	*Tetrapogon tenellus*	0.49X0.47±0.11	5.98±1.75	5.74X8.96±2.75	38.63±2.63	836.38±21.76	61.37±5.72	360.19±6.46	158.1±4.18	172.3±2.87
79	*Tetrapogon villosus*	0.44X0.79±0.21	2.49±0.54	3.98X10.95±1.65	44.68±6.29	221.52±8.23	55.32±3.18	314.47±56.28	156.7±3.28	169.4±1.37
Tribe: Eragrosteae										
80	*Acrachne Racemosa*	0.27X0.51±0.07	3.74±1.72	4.24X8.46±1.68	41.74±2.36	423.43±24.82	58.26±3.27	177.34±6.29	151.0±1.26	175.1±4.79
81	*Dactyloctenium aegyptium*	0.75X0.58±0.41	3.99±0.84	5.22X10.51±1.94	51.22±4.62	351.58±11.39	48.78±2.62	189.34±4.89	123.6±2.92	141.3±3.17
82	*Dactyloctenium sindicus*	0.81X0.58±0.38	3.97±1.59	4.24X9.21±2.26	61.48±8.78	384.71±9. 41	38.52±1.63	237.71±7.13	159.75±3.09	160.8±2.19
83	*Desmostachya bipinnata*	0.37X0.26±0.16	3.24±1.62	4.73X6.22±1.64	54.28±2.83	276.38±6.37	45.72±6.28	205.71±4.72	168.5±4.89	174.8±5.83
84	*Dinebra retroflexa*	0.42X0.47±0.15	3.14±0.93	3.78X8.27±2.61	57.13±6.18	427.73±14.48	48.29±2.73	316.35±18.63	127.63±3.18	126.37±5.37
85	*Eleusine indica*	0.46X0.60±0.21	6.96±2.71	5.72X9.96±2.87	64.28±5.92	665.34±18.58	35.72±2.88	201.52±5.92	104.8±1.37	132.6±3.42
86	*Eragrostiella bachyphylla*	0.32X0.35±0.18	1.74±0.06	2.64X6.62±1.53	59.37±8.92	383.05±6.63	40.63±2.93	128.95±4.82	154.5±0.28	143.9±2.83
87	*Eragrostiella bifaria*	0.27X0.18±0.09	3.73±1.02	4.98X7.72±2.71	63.53±4.61	256.35±4.85	36.47±1.84	144.96±7.37	152.6±3.72	146.1±1.43
88	*Eragrostis cilianensis*	0.52X0.53±0.28	3.72±1.78	2.49X0.70±1.05	66.73±3.27	427.05±8.65	33.27±4.83	116.95±7.28	155.2±5.75	146.2±4.39

Sr. No	Name of Plant	A	B	C	D		E		F	G
					D1	D2	E1	E2		
89	*Eragrostis ciliaris*	0.18X0.18±0.05	3.24±1.37	2.49X3.99±1.68	62.74±4.56	120.95±4.83	37.26±2.46	84.57±9.02	145.0±2.34	141.6±2.32
90	*Eragrostis japonica*	0.24X0.15±0.04	4.21±1.94	3.74X5.98±1.03	65.73±4.80	261.86±5.98	34.27±4.68	108.7±5.90	148.8±2.96	142.4±2.67
91	*Eragrostis nutans*	0.32X0.19±0.17	3.23±0.86	3.48X4.97±0.94	59.74±3.74	214.78±7.72	40.26±5.37	112.76±7.53	152.4±4.89	149.5±1.63
92	*Eragrostis pilosa*	0.26X0.25±0.07	5.47±2.81	3.23X6.47±1.28	36.28±2.85	544.38±12.36	63.72±7.34	173.34±6.53	157.9±4.69	161.6±3.04
93	*Eragrostis tenella*	0.48X0.37±0.15	3.47±1.02	2.15X5.82±1.46	48.71±3.48	355.85±7.37	51.29±3.60	157.34±3.457	150.31±3.64	161.1±4.55
94	*Eragrostis tremula*	0.41X0.35±0.41	4.24±1.67	1.99X4.97±0.51	43.18±2.41	394.85±6.29	56.82±2.93	177.34±6.18	156.54±6.28	155.4±7.43
95	*Eragrostis unioloides*	0.48X0.40±0.27	2.98±0.85	1.76X5.22±0.38	53.73±3.87	254.09±5.83	46.27±2.45	133.14±5.94	147.9±4.73	154.1±5.81
96	*Eragrostis viscosa*	0.21X0.25±0.07	2.64±0.36	1.61X6.02±0.83	33.58±1.43	272.46±9.32	66.42±4.27	142.74±4.38	145.63±3.72	151.28±4.61
Tribe: Sporoboleae										
97	*Sporobolus coromardelianus*	0.55X0.35±0.38	3.11±1.78	2.51X5.97±1.20	52.27±8.75	238.36±9.63	47.73±3.87	137.83±7.84	138.36±4.87	147.36±2.29
98	*Sporobolus diander*	0.58X0.43±0.28	2.96±1.04	2.11X5.38±1.83	48.16±6.73	193.26±17.54	51.84±3.46	115.72±7.41	131.77±1.36	145.26±4.42
99	*Sporobolus indicus*	0.31X0.25±0.16	3.03±1.37	2.31X4.28±1.26	50.72±2.68	216.27±11.72	49.28±276	128.27±7.59	135.61±5.28	142.25±6.41
Tribe: Zoysieae										
100	*Tragrus biflorus*	0.31X0.42±0.17	7.21±2.72	4.97X8.96±1.73	51.74±3.86	443.43±7.81	48.26±1.83	233.90±4.28	162.9±3.84	163.7±5.17

A: Cross section size (µM), B: Seed coat thickness (µM), C: Aleurone cell size (µM), D1: Occupied % of endosperm, D2: thickness of endosperm (µM), E1: Occupied % of embryo, E2: Thickness of embryo (µM), F: Angle of vascularisation (in °), G: Angle of embryo in caryopsis (in °)

Discussion

Anatomically all the (100 species) grass caryopses studied showed variations in the histo architecture on the basis of which a distinct identification could be done. Based on the diagnostic characteristic features a key to the identification of all the 100 species has been prepared.

Anatomical features of caryopsis in a few grass species have been documented by different authors. Grass species included in the present study have been compared with these species and discussed here.

Anatomically grass caryopsis showed three genetically distinct compartments the Pericarp, the embryo and a prominent and persistant endosperm for which grass seeds have been domesticated (Hands *et al.,* 2012). Irving (1983) worked on anatomy and histochemistry of *Echinochloa turnerana* (Channel millet). He described the major typical structural characteristics of Gramineae like aleurone cells, transfer cells, type of embryo, scutellum, prescence of protein and starch grains, etc. In the present study, three different species of *Echinochloa* was studied i.e *Echinochloa colona, Echinochloa crushgalli, Echinochloa stagnina*. All three species showed Type C embryo, "V" shaped scutellum, simple circular and polygon shaped starch grains and Type B pericarp i.e epidermis, hypodermis, cross cells and nucellus layers of pericarp.

Narayanswami S. (1954) worked on structure and development of the caryopsis in *Paspalum scorbiculatum*. Mature caryopsis consists of the suberised nucellar epidermis forming the perisperm, pericarp and insertion region of the inner integument. Pericarp consists epidermis, hypodermis and nucellus. In the present study the pericarp consists of epidermis, crushed parenchymatous cells and nucellus. Narayanswami (1956) described the caryopsis in *Setaria italica* with an absence of epiblast, single layered aleurone layer and cellular endosperm. These same features were observed in the *Setaria gluca, Setaria tomentosa* and *Setaria verticillata* of the present study. Rost (1973) described the anatomy of the caryopsis coat in mature caryopsis of the yellow foxtail grass (*Setaria lutescens*). He concluded that several layers of cells from parent plant subcircular the developing caryopsis; nucellus, integuments and pericarp. Pericarp showed the different layers- epidermis, crushed parenchyma, cross cells, nucellus. Pericarp in *Setaria* species also showed the same anatomical features. Eichemberg and Scatena (2013) studied morphology and anatomy of the diaspores and seedling of *Paspalum* (Poaceae, Poales). They described caryopses in species *Paspalum dilatatum, Paspalum mandiocanum, Paspalum pumilum, Paspalum urvillei* to be albuminous, with a starchy endosperm and one aleurone layer in the peripheral region. Embryo in the four species have a slit scutellum and epiblast is absent. Vascularisation of the embryos is of the panicoid type. These features hae been noted in the *Paspalum scorbiculatum* included in the present study.

Osman *et al.* (2012) studied anatomy of 31 different grass species belonging to different tribes and concluded that the unique anatomical structure of the very marked caryopsis, by its general construction or even by each of its components singly, can serve significantly for identifying a plant group. *Aristida adscensionis* included in present study had 6.03 µm thick seedcoat, trasverselly rectangular shaped aleurone

cells and starchy endosperm, as also recorded by Osman *et al*. (2012) but seedcoat thickness was 3.48 µm. Cross section of *Aristida funiculata* was circled linear with two folded pointed ends, but in the present study, cross section appeared oblong shaped with a convex anterior and posterior side. *Dactyloctenium aegyptium* showed characters like thin, rectangular shaped aleurone cells, 8.50 µm seed coat thickness and polygonal in outline, but in the present study it was rectangular shaped with curved margins and convex anterior side in cross section and tangentially elongated rectangular shaped aleurone cells with seedcoat of 3.99 µm thickness. According to Osman, *Eragrostis cilianensis* showed characters like circule outline, rectangular shaped aleurone cells, but in the present study the cross section was oblong to oval shaped and tangentially elongated rectangular shaped aleurone cells. Similarly *Cenchrus ciliaris* showed anatomical characters like oval shaped in outline, not completely compressed pericarp, but in the present study showed that cross section was oblong to oval shaped and pericarp showed epidermis, cross cells and nucellus. *Echinochloa colona* showed characters like triangular in cross section, horizontally rectangular shaped aleurone cells and well compressed pericarp layers and in the present study cross section was oblong shaped with convex anterior and concave posterior side, tangentially elongated rectangular shaped aleurone cells and well developed pericarp.

Seed coat anatomy is species specific and can serve as an aid in identification and taxonomy (Carlquist *et al.*, 1997). Seed coat of Gramineae plants under investigation appeared with a uniform structure, the whole seed coat thickness showed a great variation among taxa at a specific level and even between genera. Many light microscopy studied have been conducted both to determine the development of the coat and to examine its mature structure. Some representative studies include those mentioned below: Harrington and Crocker (1923) were the first to describe the caryopsis coat, caryopsis coat consists of pericarp, seed coat and nucellus (Rost *et al*., 1984). Morrison and Dashnicky (1982) worked on structure of the covering layers of the *Avena fatua* caryopsis and he told that seed coat envelopes the entire caryopsis. This seed coat continuous through entire length of the grain. Bechtel and Pomereanz (1977) studied rice caryopsis coat. He reported that surcircularing the rice caryopsis was the pericarp, seed coat and nucellus layers. Interior to the pericarp was a single crushed layer of cells, the seed coat and with a thick cuticle located to the inner side of crushed cells.

The anatomy of the seed coat in mature caryopses is remarkabley similar in the studied grass species. The coat is continous acircular the entire caryopsis except at the point where it is connected to the axis of the inflorescence. The exterior of the caryopsis is covered by a thick cuticle layer. The pericarp derived from the ova ry of the flower, may be a thin membrane, or it may be composed of one or several layers. In the studied 100 species, four different types of pericarp were observed. Few members of group Panicoideae showed “A” type of Pericarp (*Heteropogon triticeus, Ischaemum molle, Sehima spp., Themeda spp., Erichloa procera, Paspalidium spp.,* etc.) while from group Pooideae *Cynadon datylon, Sachoenefeldia gracilis* showed

"A" type of pericarp. Other studied species from different types of pericarp i.e. B/C/D. Both the members of tribe Maydeae showed "B" type of pericarp.

Caryopsis showed two major portions: embryo and endosperm. Embryos of grasses are considered to be unique, because they are highly complex, possessing a leaf like coleoptile, a coleorhiza, up to six leaf primodia and a characteristic prominent outgrowth termed a scutellum that has not been recorded in other families and has been hypothesized to represent a modified cotyledon (Sargaut and Robertson, 1905; Reeder, 1953; Shah and Sreekumari, 1980; Negbi, 1984; Rudall et al., 2005). Variation in embryo structure is related to the presence or absence of mesocotyl, the epiblast, the scutellum cleft i.e. whether or not scutellum is fused to the coleorhiza and whether the first leaf is rolled or followed and allows an evolutionary sequence of embryo types to be recognized (Renvoize, 2002; David, 2009). Epiblast was a peculiar organ, which was situated opposite to scutellum. Its occurance was much greater frequency than is generally supposed. Few workers studied grass caryopsis (Warming and polter, 1895) but they did not mention epiblast. Scutellum which showed vascular system but epiblast did not showed vascular system. Might be epiblast occur many instances of reduced organs without fibrovascular systems. It was very small structure in comparison with the scutellum, but there are many grasses in which it reaches considerable sizes.

It has been observed that with an increase in the percentage of embryo the perecentage of endosperem decreases and viceversa i.e. *Aristida adscensionis* showed lowest embryo % (24.81%) and highest endosperm % (75.19%) while *Chloris Montana* showed highest embryo % (82.37%) and lowest endosperm % (16.63%). With in the caryopsis, embryos of the different species were positioned at different angles with respect to the anterio-posterior axis of the caryopsis. On the basis of this embryo was categorized into three different types: Type A (less than 130° angel), Type B (angle between 130° to upto 160°) and Type C (angle between 160° to upto 190°). Among the 100 species *Isachne globosa* and *Dinebra retroflexa* showed "A" type of embryo, while the 28 species were showed "B" type of embryo and 70 species were showed "C" type of embryo.

Among the studied species, few species showed absence of epiblast and few species showed prescence of epiblast. In the present study, epiblasthas been classified in five different categories. Characteristic features of epiblast varied tribe wise which facilitated in characterizing different groups and tribes. Group Panicoideae members, showed absence of epiblast, except *Chionachne koenigii* which showed Type I epiblast. From group Pooideae, members of tribe Ischaneae and Aristideae showed absence of epiblast. Apart from this, *Melanocenchris jaquemontii* and *Oropetium villosum* from tribe Chlorideae showed absence of epiblast. Other species of group Pooideae showed prescence of epiblast. Tribe Sporoboleae members (like *Sporobolus coromardelianus, Sporobolus diander, Sporobolus indicus*) showed Type II epiblast. Members of Eragrostideae tribe showed two types of epiblast: Type II and IV. Species like *Acrachne racemosa, Dactyloctenium, Eleusine indica, Eragrostiella, Eragrostis cilianensis, Eragrostis ciliaris, Eragrostis tremula, Eragrostis unioloides, Eragrostis viscosa,* etc. had Type V epiblast while species like *Eragrostis japonica, Eragrostis*

nutans, Eragrostis pilosa, Eragrostis tenella, Dinebra retrofelxa, Desmostachya bipinnata had Type II epiblast. Tribe Chlorideae contian eight species, out of that *Tetrapogon villosus* and *Chloris virgata* had Type III epiblast, *Sachoenefeldia gracilis* and *Perotis indica* had Type IV epiblast while *Tetrapogon tenellus, Chloris barbata, Chloris montana, Cynadon dactylon* had Type II epiblast.

Negbi (1984) described vascular system of the scutellum. Geneus like *Zea* showed the maing connecting the embryonal axis with the scutellum traves from the mesocotul almost to the scutellar tip where manu of their turn downward like a weeping willow. The vascular system in the scutellum of *Hordeum vaulgare* has a double main bundle but wild variety showed single main bundle. In many grasses, there were also bundles that supply the posterior scutellar appendices. Four types of angle of vascularisation were present among the studied species. Only three species showed "A" type (i.e. angle was less than 130°) of angel of vascularisation, viz. *Isachne globosa* (99.0°), *Dactyloctenium aegyptium* (123.6°) and *Eleusine indica* (104.8°). Tribe Sporoboleae, includes three species and all three species had "B" type (angle between 130°-150°) of angle of vascularisation. Tribe Eragrostideae showed "A", "B" and "C" type of vascularisation. Species like *Eragrostis ciliaris* (145.0°), *Eragrostis japonica* (148.8°), *Eragrostis unioloides* (147.9°) and *Eragrostis viscosa* (145.6°) showed "B" type of angle of vascularistion. *Eleusine indica* and *Dactyloctenium aegyptium* showed "A" type of angle of vascularisation. Tribe Chlorideae members showed "B"/ "C"/ "D" type of angle of vascularisation present. Group Panicoideae members showed "B"/ "C"/ "D" type of angle of vascularisation. "A" type of vascularisation was not observed in any species of Panicoideae group.

Scutellum is the single cotyledon of embryo in the caryopsis. It lies in contact with the endosperm (Kar et al., 2002). In the caryopsis scutellum, there is no starch grains (swift and O'Brien, 1972a, 1972b). Negbi (1984) described four type of scutellum on the basis of development of scutellum during caryopsis maturation. (i) scutellum Sensu Stricto: in which scutellum maintain the shield like structure during germination and early seedling growth. This type of scutellum is found in major grass species like *Oropetium, Coix, Sorghum, Triticum, Oryza, Zea, Lolium, Oryzopsis* etc. (ii) The *Avena* kind of scutellum: has a shield like shape only in the mature grain. During germination and early seedling development the tip of the scutellum elongates inside the bulk of the storage endospserm. (iii) The *Zizania* kind of scutellum: this kind of scutellum is that of *Zizania aqatica.* It is also found in *Spartina.* During grain development the scutellum reaches the distal end of the embryo sac, and sometimes even turns backwards the very long tip of this scutellum is linear and is apressed to the aleurone layer with its adaxial surface, while its abaxial surface is appressed to the hard endosperm. The length of diffusion pathways in the caryopsis of *Zizania* must be similar to that of the *Avena* kind and hence shorter than in the scutellum Sensu Stricto. (iv) The *Melocanna* kind of scutellum: this kind of scutellum is quite dissimilar in structure and function from that of the other three kinds. It was found in genera of bamboos like *Ochlandra, Dinochloa.* Caryopses of these species were relatively large and had a thick pericapr. Most of seed cavity is taken up by large scutellum, which is supplied with vascular system. Majorly three types of scutellum shaped were

observed in studied species. Group Panicoideae members majorly showed either "U" shaped or "V" shaped scutellum, "Δ" shaped scutellum was observed only in five species of group Panicoideae members and species like *Imperata cylindrica, Ischaemum pilosum, Saccharum spontanum, Sehima nervosum, Vetivaria zinzanoides.* Tribe Maydeae sepceies, *Chionachne koenigii* and *Coix lachryma jobi* showed "U" shaped scutellum. Group Pooideae members showed all three type of scutellum. Tribe Chlorideae members majorly showed "Δ" shaped scutellum, and species were *Chloris barbata, Chloris montana, Chloris virgata, Cynodon dactylon, Schoenefeldia gracilis* and *Tetrapogon tenellus* had "Δ" shaped scutellum. *Melanocenchris jaquemontii* and *Oropetium villosulum* had "U" shaped scutellum. Tribe Aristideae members, like *Aristida adscendionis* and *Aristida funiculata* showed "Δ" shaped scutellum.

Next to the nucellar region the aleurone layer is present, which is outermost endosperm tissue. Aleurone cells are thick walled and rectangular in outline, containing closely packed protein grains (Bechtel and Pomeranz, 1977). Aleurone layer is not continuous acircular the entire caryopsis (Harrington and Crocker, 1923; Artschwager *et al.*, 1929). Aleurone layer consists protein bodies. It is important for both the developing seed and the mature plant. The aleurone tissue accumulates large quantities of oils and lipids, which are userful during seed development. In some species, it also accumulates minerals, which functions in seed dormancy. Aleurone layer performs a variety of functions to help maintain proper development of the seed. Aleurone layer releases organic and phosphoric acid in order to keep the pH of the endosperm between pH of 3.5 and 4 (Bradford and Nonogaki, 2007). During seed germination, the plant embryo produces the hormone gibberellin which triggers the aleurone for the hydrolysis of starch, proteases and storage proteins into endosperm (Taiz and Zeiger, 2002). Species like *Holcus*, *Saccharum*, etc. have an opening called the hilar orifice which is made up of densely packed thick walled, collapsed dark pigmented cells. Four types of aleurone cells were present in studied species: (i) tangentially elongated and rectangular shaped (ii) vertically elongated and rectangular shaped (iii) square shaped cells and (iv) both rectangular shaped and square shaped aleurone cells. Majority of the studied species show tangentially elongated recatangular shaped aleurone cells. Group pooideae did not showed vertically elongated recatangular shaped aleurone cells but they showed other three types of aleurone cells. From the tribe Sporoboleae, *Sporobolus coromardelianus* had square shaped aleurone cells while other species showed tangentially elongated rectangular shaped aleurone cells. Likewise from tribe Eragrostideae, only one species *Eleusine indica* showed square shaped scutellum. Two species of tribe Eragrostideae *Acrachne ramosa, Desmostachya bipinnata* showed both the type of aleurone cells. Other than these species, all species of the tribe Eragrostideae showed tangentially elongated rectangular shaped aleurone cells. All the species of tribe Chlorideae, Perotideae, Aristideae members showed tangentially elongated rectangular shaped aleurone cells. *Ischane globosa* (Tribe Ischaneae) had both the type of aleurone cells. Tribe Maydeae species, like *Chionachne koenigii* and *Coix lachryma jobi* showed vertically elongated rectangular shaped aleurone cells.Tribe Andropogoneae members showed tangentially elongated rectangular shaped aleurone cells/vertically elongated rectangular

shaped/both types of aleurone cells. *Dicanthium annulatum, Imperata cylindrica, Rottbelia exaltata* showed vertically elongated rectangular shaped aleurone cells while *Ischaemum indicus, Ischaemum rugosum, Ophiuros exaltatus* showed both the type of aleurone cells. All other species of tribe Andropogoneae had tangentially elongated rectangular aleurone cells. Tribe Paniceae showed tangentially elongated aleurone cells, square shaped aleurone cells and both type of aleurone cells. *Panicum trypheron* had square shaped aleurone cells, *Alloteropis cimicina, Echinochloa stagnina* and *Pennisetum setosum* showed both the type of aleurone cells. Other species of tribe Paniceae showed tangentially elongated rectangular aleurone cells. Aleurone cells were typically cuboid in shape with much thicker cell walls because they contain large amount of protein bodies and oil, they also releases organic acids (Burton and Fincher, 2014).

Majority of monocot seeds were endospermic, eg. Wheat, Maize, etc. and it occupies greater portion of the seed (Kar *et al.*, 2002). Endosperm constitutes a main portion for storing the food material even with the supply from the mother plant. The endosperm was considered to be starchy, according to Olsen *et al.* (1999) and Olsen (2001), functioned for reserving large amount of starch granules which are consumed by the embryo upon germination and development. These components are characterized by their appearance where in they appear with light colour, unstained or white colour as quoted by Zeleznak and Varriano-Marsteon (1982), Irving (1983) and Jane (2004). Choi *et al.* (2004) observed the starch granules of *Setaria italica*, Panicoideae. According to them, Panicoideae tribe has large, simple granules with a wide range of shapes from spherical/ovoid to regular polyhedrons. In the present study most of the Panicoideae members showed simple circular or polygon starch grains. Endosperm showed polygon shaped cells, which contains the different shaped starch grains. *Sehima sulcatum, Pasaplum scorbiculatum* and *Cymbopogon martini* showed only simple circular shaped starch grains while species like *Dicanthium caricosum, Digitaria stricta, Oplismenous burmanii, Paspalidium geminatum, Perotis indica* and *Chloris barbata* showed simple pent to hexagonal shaped starch grains. Few species showed mixture of simple and compound starch grains (eg. *Chionachne koenigii, Bothriochloa pertusa, Dicanthium annulatum, Heteropogon triticeus, Ischaemum pilosum, Sehima ischaemoides, Sehima nervosum, Thelepogon elegans, Melanocenchris jaquemontii, Schoenefeldia gracilis* and *Dactloctenium aegyptium*). All the other species showe combination of a simple circular and polygon shaped starch grains. Shapter et al. (2008) studied on endosperm and starch granule morphology in wild cereal relatives. They worked on 19 Australian native wild grass species. They reported that *Setaria italica* showed compound starch grains but in the present study *Setaria gluca, Setaria tomentosa* and *Setaria verticillata* showed simple starch grains with circular and polygon shapes. There were a specific numbers of starch granules per endospermic cell and the number showed great variation. From the group Panicoideae, *Coix* showed around 87 starch granules per endospermic cell and *Hackelochloa granularis* showed around 11 starch granules per endospermic cell. Among the group Pooideae, *Chloris virgata* showed 68 starch granules while *Eragrostis pilosa* and *Tetrapogon tenellus* showed 13 starch granules per endospermic

cell. When numbers of starch granules more per endospermic cell than size of starch granules are less and vice versa. *Coix* which have more number of starch granules than it showed around 2.08 µm sizes of starch granule and *Vetiveria zinzanoides* showed 10 µm size of starch granule from the group Panicoideae. Among the group Pooideae, *Eragrostiella bachyphylla* had around 8.34 µm size of starch granule while *Eragrostis japonica* had 1.67 µm size of starch granule.

Rheeder (1957) classified caryopsis into six different groups and nine different formulas on the basis of the type of embryo. Decker (1964), Barker *et al.* (1999), Gopal and Ram (1985) studied systematic significane of mature embryo in the systematic of bamboos. All the species of bamboos sowed same basic pattern of embryo organization. The scutellum and coleoptilar bundles were not separated by an internode, lower portion of the scutellum and the coleorhiza were separated by a cleft and the margins of embryonic leaves overlapped.

In the studied 100 species five different caryopsis formula (like P-PP, P+PF, P+PP, F+PP, P-PF) and five different caryopsis types (like True festucoids, True panicoids, Chloridoid-Eragrostoid, Bambusoid, Oryzoid-Olyroid, Arundinoid-Danthonioid) could be identified. In general, Group Panicoideae, members showed only P-PP caryopsis formula a characteristic features of true panicoids, while group Pooideae members showed Bambusoid, Arundinoid-Danthonioid or Chloridoid-Eragrostoid caryopsis type. Exceptions were observed among a few. In the group Panicoideae, only *Chionachne koenigii* showed F+PP caryopsis formula and Oryzoid-Olyroid caryopsis type. In Tribe Andropogoneae and tribe Paniceae members showed P-PP caryopsis formula i.e. True Panicoids. In Group Pooideae only *Ischanae globosa* the single genera of tribe Ischaneae showed P-PP caryopsis formula and the true Panicoids type of caryopsis. Few species of group Pooideae like *Aristida adscensionis* and *Aristida funiculata* of Tribe Aristideae, *Melanocenchris jaquemontii, Oropetium villosum* of the Tribe Chlorideae showed P-PF caryopsis type and characteristic Arundinoid-Danthonioid caryopsis. *Chloris montana, Chloris virgata, Sachoenefeldia gracilis* of Tribe Chlorideae had P+PP caryopsis formula and type of caryopsis Bambusoid. Other members of group Pooideae had characteristic features of Chloridoid-Eragrostoid type and P+PF caryopsis formula.

Key criterias used to describe the characteristic features in the works on grass systematics by Stebbins (1956), Reeder (1957), Brown (1958), Stebbins and Crampton (1961), Arber (2010) included leaf anatomy, epidermal cells, lodicules and embryo, identification of non kranz and kranz syndromes based predictably on combination of anatomical and photosynthetic attritretes and cytological data such as chromosome size and number. In the classification put forward by the grass pylogeny work group (GPWG, 2001), characters related to fruit and embryo (Reeder, 1957), leaf anatomy (Ellis, 1986), biochemistry of photosynthesis (Brown, 1977; Hattersley, 1986) and structure of reproductive units, both flowers ans spikelets were some of the major characteristic features considered.

'Genera Graminum' (Clayton and Renvoize, 1986), Clayton *et al.* (2002) were responsible for the development of the project 'Grass Base'. The online World Grass

Flora (http://www.key.org/data/grasses_db/.html) uses 1,081 descriptions, most of them morphological, but some also related to geographic distribution, for describing the members of Poaceae species using the Delta system (Dallwits *et al.*, 1993).

Based on the characteristic features a dichotomous key for the studied species has been prepared.

1. U and Δ shaped scutellum……..……**2**
1. V shaped scutellum……..……**52**
2. Caryopsis formula: F+PP……..…….…….. ***Chionachne koenigii***
2. Caryopsis formula: P-PP/P+PF/P+PP/P-PF……..……**3**
3. Caryopsis type: Arundinoid-Danthonioid……..……..……..**4**
3. Caryopsis type: True panicoids/Chloridoid-Eragrostoid/Bambusoid…..…..**7**
4. Δ shaped scutellum……...……..**5**
4. U shaped scutellum……..…….....……**6**
5. Circular shaped in transection and embryo % occupied: 24.81±5.18……...…….……***Aristida adscensionis***
5. Oblong shaped in transection and embryo % occupied: 41.53±8.75……..…….……...…...…... ***Aristida funiculata***
6. Angle of vascularisation: Type C……....….. ***Melanocenchris jaequemontii***
6. Angle of vascularisation: Type D……...……. ***Oropetium villosulum***
7. Δ shaped scutellum……...……..**8**
7. U shaped scutellum……..…….....……**20**
8. Epiblast is absent……..……...…**9**
8. Epiblast is present……...…….……**13**
9. Vertically elongated rectangular shaped aleurone cells...***Imperata cylindrica***
9. Tangentially elongated rectangular shaped aleurone cells……...……**10**
10. Δ1 shaped scutellum……...……**11**
10. Δ3/Δ5 shaped scutellum…….……**12**
11. Angle of vascularisation: Type C……...…….... ***Saccharum spontaneum***
11. Angle of vascularisation: Type D…….…….... ***Sehima nervosum***
12. Δ5 shaped scutellum…….……...…...…… ***Vetivaria zinzanoides***
12. Δ3 shaped scutellum…….……..…..…… ***Ischaemum pilosum***
13. Embryo Type B……....…….. ***Cynodon dactylon***
13. Embryo Type C……..……**14**
14. Angle of vascularisation: Type D……....… ***Schoenefeldia gracilis***
14. Angle of vascularisation: Type C…….……..**15**
15. Caryopsis formula: P+PF…….……..**16**
15. Caryopsis formula: P+PP……..…..……**17**
16. Type II epiblast……...…… ***Choris montana***

16. Type III epiblast……..…….. ***Chloris virgata***
17. Type D Pericarp…….…… ***Dactyloctenium scindicus***
17. Type C pericarp……..……**18**
18. Δ6 shaped scutellum…… ***Chloris barbata***
18. Δ3 shaped scutellum……...……**19**
19. Type II epiblast……...……. ***Tetrapogon tenellus***
19. Type III epiblast……...……... ***Perotis indica***
20. U1 shaped scutellum……..…...….**21**
20. U2 shaped scutellum……..……**27**
21. Vertically elongated rectangular shaped aleurone cells……..……..
.....***Coix lachryma-jobi***
21. Tangentially elongated rectangular shaped aleurone cells……...…..**22**
22. U1-1 shaped scutellum……..…….**23**
22. U1-2 shaped scutellum……..…….**24**
23. Angle of vascularisation: Type B……...….. ***Heteropogon triticeus***
23. Angle of vascularisation: Type D……...……
……..….***Heteropogon contortus var. genuinus sub var. hispidissimus***
24. Angel of vascularisation: Type C……...……**25**
24. Angel of vascularisation: Type B/D……...…..…..…**26**
25. Type A Pericarp……....…. ***Themeda cymbaria***
25. Type B Pericarp……..…… ***Themeda laxa***
26. Angle of vascularisation: Type B…….. ***Digitaria longiflora***
26. Angle of vascularisation: Type D……..…..… ***Heteropogon ritchiei***
27. Caryopsis type: True panicoids……..……...……**28**
27. Caryopsis type: Chloridoid-Eragrostoid …..……...…..……**34**
28. Angle of vascularisation: Type B……...……..……..**29**
28. Angle of vascularisation: Type C……...……**30**
29. Embryo Type C……...…….. ***Panicum maximum***
29. Embryo Type B……...…… ***Setaria verticillata***
30. U2-2 shaped scutellum……..…….**31**
30. U2-3 shaped scutellum……..…….**32**
31. Embryo Type C……..……..……. ***Triplopogon ramosissimus***
31. Embryo Type B……..……...…….. ***Oplismenus burmannii***
32. Embryo Type C…..……..……. ***Dichanthium caricosum***
32. Embryo Type B……..…….....…….. **33**
33. Type C Pericarp…..……. ***Capillipedium huegelii***
33. Type A Pericarp……..……. ***Paspalidium flavidum***
34. Type III epiblast……..……...…… ***Tragrus biflorus***

34. Type II/V epiblast……..……..……..**35**
35. Angle of vascularisation: Type A…..…….. ***Eleusine indica***
35. Angle of vascularisation: Type B/C……..…….……**36**
36. Square shaped aleurone cells……...……..…….**37**
36. Tangentially elongated rectangular/square and rectangular both shaped aleurone cells…...……..……..……**38**
37. Type B pericarp ……..……..…… ***Eragrostis pilosa***
37. Type D pericarp ….....……..… ***Sporobolus coromandelianus***
38. Rectangular and square both shaped aleurone cells……..…....**39**
38. Tengentially elongated rectangular shaped aleurone cells…..……...……**40**
39. Type II epiblast……..…….. ***Desmostachya bipinnata***
39. Type v epiblast…...……...…… ***Acrachne racemosa***
40. Embryo Type C……..……**41**
40. Embryo Type B……..……**42**
41. Type C Pericarp……..…… ***Dinebra retroflexa***
41. Type B Pericarp……...……..…… ***Eragrostis tenella***
42. Type II epiblast……...……..……..**43**
42. Type V epiblast……..……..……..**44**
43. Angle of vascularisation: Type B…...……...… ***Eragrostis japonica***
43. Angle of vascularisation: Type C……..……..… ***Eragrostis nutans***
44. Angle of vascularisation: Type C……...……**45**
44. Angle of vascularisation: Type B……...……**48**
45. Type D Pericarp……...……...……**46**
45. Type B Pericarp……...……...……**47**
46. Number of starch grains per endespermic cell- 21±8.. ***Eragrostiella bifaria***
46. Number of starch grains per endespermic cell- 45±6…….
……...***Eragrostiella bachyphylla***
47. Absence of slime glands on hilum surface...……. ***Eragrostis cilianensis***
47. Presence of slime glands on hilum surface.....……. ***Eragrostis tremula***
48. Type C Pericarp……...……..….**49**
48. Type B Pericarp……...…….……..**50**
49. Oval shaped in transection with size 0.58X0.43±0.28 mm..……..…….
……..*Sporobolus diander*
49. Round shaped in transection with size 0.31X0.25±0.16 mm……....
…….*Sporobolus indicus*
50. Embryo occupied more than 50% (66.42±4.27)…...….. ***Eragrostis viscosa***
50. Embryo occupied less than 50%.....…**51**

51. Circular to oval shaped in transection with size 0.18X0.18±0.05 mm …….. ***Eragrostis ciliaris***

51. Oblong shaped in transection with size 0.48X0.40±0.27mm…..…… ……...…***Eragrostis unioloides***

52. Epiblast is present……...……..……..**53**

52. Epiblast is absent……..……..**54**

53. Scutellum type V7……..…..…… ***Dactyloctenium aegyptium***

53. Scutellum type V4-2……..…..…… ***Tetrapogon villosus***

54. V6-V9 shaped scutellum type……..……..**55**

54. V1-V5 shaped scutellum type……..……...…**72**

55. Rectangular and square both shaped aleurone cells…..……...…..**56**

55. Tengentially elongated rectangular shaped aleurone cells…..……...…**60**

56. Embryo Type A……..……..….. ***Isachne globosa***

56. Embryo Type C……..……..…..**57**

57. Angle of vascularisation: Type C…..…….. ***Pennisetum setosum***

57. Angle of vascularisation: Type B……...……**58**

58. Type C Pericarp……..……...……. ***Alloteropsis cimicina***

58. Type B Pericarp……...……...……**59**

59. V7 shaped scutellum……..…… ***Ischaemum rugosum***

59. V8-1 shaped scutellum……...……... ***Echinochloa stagnina***

60. Angle of vascularisation: Type B……...……**61**

60. Angle of vascularisaton: Type C……..……..……**66**

61. Embryo Type B……..……...…….**62**

61. Embryo Type C……...……..….**63**

62. V7 shaped scutellum……..……...…. ***Digitaria ciliaris***

62. V8-3 shaped scutellum……..……..…….. ***Setaria glauca***

63. Type C pericarp……..…….…….. ***Cenchrus setigerus***

63. Type B/D pericarp……...……..……**64**

64. Type D Pericarp……..…… ***Digitaria stricta***

64. Type B Pericarp……...……...……**65**

65. V7 shaped scutellum……..……..… ***Echinochloa colona***

65. V8-2 shaped scutellum…...……... ***Echinochloa crusgalli***

66. Type C Pericarp……...…….……..**67**

66. Type B Pericarp……...……...…**69**

67. V8-1 shaped scutellum……..……. ***Bothriochloa pertusa***

67. V8-2/3 shaped scutellum……..……..…**68**

68. V8-2 shaped scutellum……...……..… ***Cenchrus ciliaris***

68. V8-3 shaped scutellum……...…….. ***Arthraxon lanceolatus***

69. V6/V9 shaped scutellum……..……..**70**
69. V7 shaped scutellum……..……**71**
70. V6 shaped scutellum……..…….. ***Panicum miliaceum***
70. V9 shaped scutellum……...…… ***Oplismenus composites***
71. Lanceolate in transection, aleurone cell size 4.24X8.23±2.49 µm……..…
……..…….***Sehima ischaemoides***
71. Oblong in transection, aleurone cell size 7.42X19.42±2.16 µm …...……
……...……..***Iseilema laxum***
72. Embryo Type B……..……..……..**73**
72. Embryo Type C……..……..……..**77**
73. V2 shaped scutellum type……...……..……..**74**
73. V3 shaped scutellum type……...……**75**
74. Square shaped aleurone cells…...……. ***Panicum trypheron***
74. Tangentially elongated rectangular shaped aleurone cells……....
……***Paspalum scrobiculatum***
75. Vertically elongated rectangular shaped aleurone cells…….
……***Dichanthium annulatum***
75. Tangentially elongated rectangular shaped aleurone cells……..……...**76**
76. Angle of vascularisation: Type B…...……...…… ***Apluda mutica***
76. Angle of vascularisation: Type C…...……..… ***Hackelochloa granularis***
77. Vertically elongated rectangular shaped aleurone cells…….
……..***Rottboellia exaltata***
77. Tangentially elongated rectangular/square and rectangular both shaped aleurone cells……...……**78**
78. Square and rectangular both shaped aleurone cells……...……....…**79**
78. Tangentially elongated rectangular shaped aleurone cells…..……...**81**
79. V1-2 shaped scutellum…...……...…… ***Ophiuros exaltatus***
79. V2/V3 shaped scutellum……..……..…**80**
80. V2 shaped scutellum……...……. ***Cenchrus biflorus***
80. V3 shaped scutellum……...……..… ***Ischaemum indicus***
81. Angle of vascularisation: Type B/D……...……**82**
81. Angle of vascularisation: Type C……...……**88**
82. Angle of vascularisation: Type B……...……**83**
82. Angle of vascularisation: Type D……...……**86**
83. Type B Pericarp……...……..……**84**
83. Type D Pericarp……...……..……**85**
84. V1-1 shaped scutellum……..……..….. ***Thelepogn elegans***
84. V4-2 shaped scutellum……...……...… ***Panicum antidotale***

85. V3-4 shaped scutellum……..…….. ***Setaria tomentosa***
85. V4-2 shaped scutellum…...…….. ***Chrysopogon fulvus***
86. V3-6 shaped scutellum…….……..
……***Heteropogon contortus var. genuinus sub var. typicus***
86. V3-1 shaped scutellum……..……**87**
87. Oval shaped in transection with size 0.67X0.76±0.14 µm……..…
…….***Ischaemum molle***
87. Kidney shaped in transection with size 1.87X1.69±0.27 µm ……...
…….***Sehima sulcatum***
88. Type D Pericarp……...……... ***Cymbopogon martini***
88. Type C/A Pericarp……...……...…**89**
89. Type A Pericarp……...……...…**90**
89. Type C Pericarp……...……...…**94**
90. V5 shaped scutellum…..…… ***Eriochloa procera***
90. V1/V3 shaped scutellum……..……..**91**
91. V1 shaped scutellum……..……..……..**92**
91. V3 shaped scutellum……..……..……..**93**
92. V1-1 shaped scutellum…...……...…… ***Sorghum halepense***
92. V1-2 shaped scutellum……...……... ***Paspalidium geminatum***
93. Simple polygonal shaped starch grains, thickness of endosperm:
546.31±7.82 µm..……..……...……***Themeda triandra***
93. Simple circular shaped starch grains, thickness of endosperm: 877.3±7.63
µm ...…….……***Themeda qurqdrivalvis***
94. V5 shaped scutellum……..……... ***Eremopogon foveolatus***
94. V3/V4 shaped scutellum……..……..…**95**
95. V4-2 shaped scutellum……...……...…… ***Digitaria granularis***
95. V3 shaped scutellum……..……**96**
96. V3-3 shaped scutellum……...……...……. ***Brachiaria reptans***
96. V3-4/5/6 shaped scutellum……...……..…**97**
97. V3-4 shaped scutellum……..……. ***Andropogon pumilus***
97. V3-5/6 shaped scutellum……..……..…**98**
98. V3-6 shaped scutellum…...…….. ***Brachiaria eruciformis***
98. V3-5 shaped scutellum……..……..…**99**
99. Endosperm thickness: 335.8±11.21 µm ……..***Brachiaria distachya***
99. Endosperm is very thick, almost three times more (897.71±23.63 µm)….
……..***Brachiaria ramosa***

3.2. Culm anatomy

Grasses are monocotyledonous flowering plants having hollow stem known as the culm which are divided into sections by solid nodes which bear the plant leaves. Variation in the internal anatomy of the internode may be taxonomically diagnostic and is most useful at the level of genus and species. Described below are the internal features of grass culm. Characteristic diagnostic anatomical features of internodal region observed in the studied grasses have been described.

GENERAL GRASS CULM ANATOMY

Internally the internodes may be solid throughout development, or may become hollow.

Epidermis

Epidermis is the outermost covering of the stem represented by a single layer of compactly arranged, barrel-shaped parenchyma cells. Intercellular spaces are absent. A cuticle is present. The epidermis contains stomata and silica.

Hypodermis

Hypodermis is a region that lies immediately below the epidermis. It is represented by a few layers of compactly arranged sclerenchyma or parenchyma cells.

Ground tissue

Ground tissue is a component of the stem. It is undifferentiated. The ground tissue is represented by several layers of loosely arranged parenchyma cells enclosing prominent intercellular spaces. The ground tissue is meant for storage of food.

Vascular bundles

Vascular bundles are found irregularly scattered in the ground tissue. Towards the periphery, the bundles are smaller in size while towards the centre, they are larger in size. The smaller bundles are younger, while the larger ones are older. Each vascular bundles has a covering called bundle sheath formed by a single layer of sclerenchyma cells. The vascular bundle encloses both xylem and phloem. Xylem is found towards the inner surface and phloem towards the outer surface. Cambium is absent. Hence the vascular bundles are described as conjoint, collateral and closed. There are two metaxylem and protoxylem vessels arranged in the shape of ‘Y’. The lower protoxylem vessel is non functional and remains as a water filled cavity called lysigenous cavity or protoxylem cavity. In the phloem, only sieve tubes, companion cells and phloem fibers are present. Culm anatomy has been described by a few authors. Grosser and Liese (1971) histologically compared 52 Bamboo species. Metcalfe (1960) studied 206 genera and 413 speceis examined and described culm anatomy of them. Description of the internal features of the studied culm internode has been done with help of characteristic features described by Grosser and Liese (1971) and Mecalfe (1960).

A general detailed description of the different characteristic features and their types noted in the 100 different species studied has been described in the first part followed by which the type of characteristic feature observed in each grass species has been discussed separately.

The anatomical structure of the culms is characterized exclusively by the collateral vascular bundles embedded in parenchymatous ground tissue which exhibits four basic types (Diagram 3):

Type I- consisting of one part (central vascular strand ie. CVB); supporting tissue only as sclerenchyma sheaths; intercellular space with tyloses.
Type II- consisting of one part (CVB); supporting tissue only as sclerenchyma sheaths; sheath at the intercellular space (protoxylem) strikingly larger than the other ones; intercellular space without tyloses.
Type III- consisting of two parts (CVB and one FS i.e. fiber strand); fiber strand inside the central strand; sheath at the intercellular space (protoxylem) generally smaller than the other ones.
Type IV- consisting of three parts (CVB and two FS); fiber strands outside and inside the central strand.

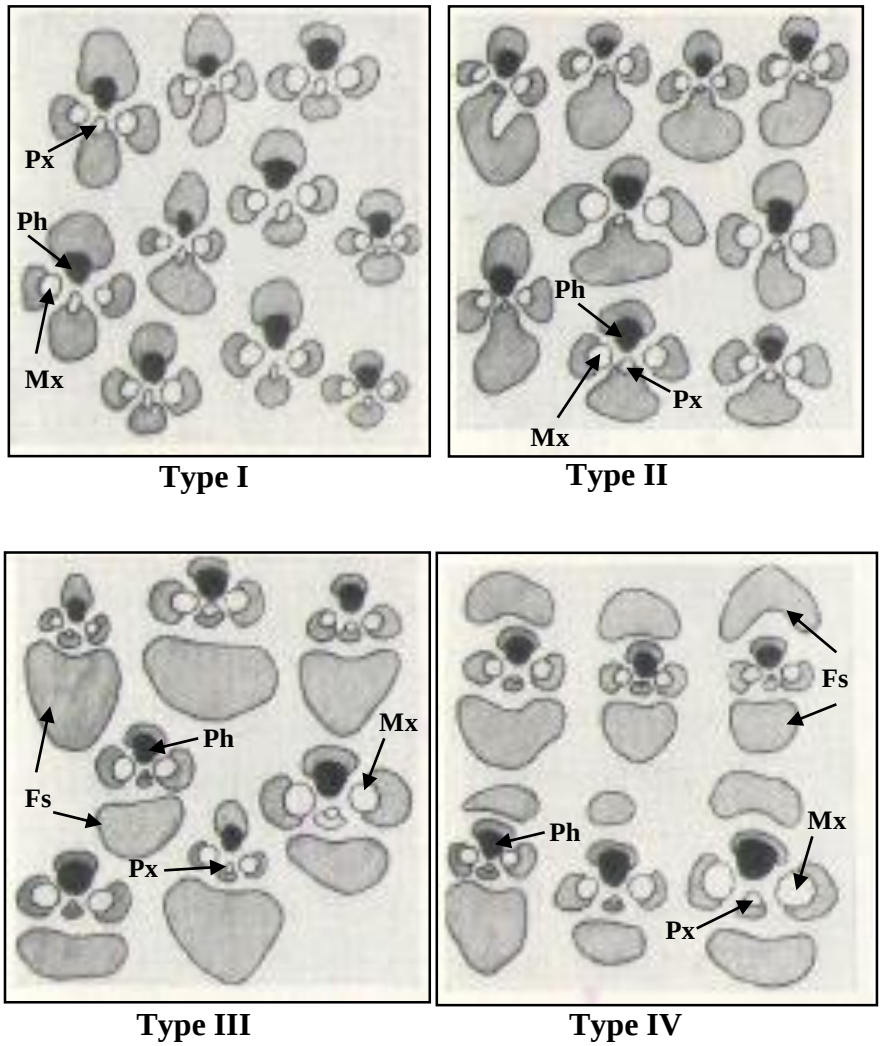


Diagram 3
(Adapted from Grosser and Liese, 1971)
(Fs=Fiber strand, Mx=Metaxylem, Px=Protoxylem, Ph=Phloem)

The culms of grasses are typically hollow cylinders interrupted at intervals by transverse partitions. The hollow units represent the internodes and transverse partition is at nodes. The diameter of the hollow centre may be large or small in relation to the total diameter of the culm. Sometimes few grass species have solid culm i.e. internodal region is occupied by ground tissues and culm is not hollow. Few

grasses show an intermediate state between the hollow and solid culm, in which tissue becomes loose and spongy without actually breaking down sufficiently to become hollow (Metcalfe, 1960).

Epidermis

It is outer most layer and is covered by cuticle. Epidermal cells are round to square shaped. Sometimes stomata and silica bodies are also present. Five different major types of epidermises were identified among the studied grass species on the basis of their shape and cuticularization which has been described with the help of diagrams below. Microphotographs depicting these characteristic features are represented in Fig. 58.

1. Barrel shaped (BS)

I. Big cells, tangential wall covered with evenly thickened outer and inner tangential wall, and only one of the radial walls is thickened (Fig 57 A).

II. Flattened cells with outer tangential wall covered with even thick cuticle which penetrate between radially two epidermal cells. Inner tangential wall is thin (Fig 57 B).

III. Outer tangential wall of epidermal cells covered with layer of thin cuticle (Fig 57 C)

IV. Small sized cells with outer tangential wall covered with layer of cuticle (Fig 57 D)

V. Tangential wall covered with very thick cuticle (Fig 57E).

2. Rectangular shaped (RS)

I. Tangential wall covered with very thin cuticle (Fig. 57

II. Flat cells, tangential wall with slightly thick cuticle (Fig. 57 G)

III. Tangential wall of cells covered with cuticle which penetrate 1/3rd portion between cells (Fig. 57 H)

3. Square shaped (SS)

I. Small cells, outer tangential wall and radial walls

II. Big cells, tangential wall covered with very thin cuticle (Fig 57 J).

III. Small cells, covered with thick cuticle and it penetrates between epidermal cell, thickness of cuticle is larger than the cell wall thickness (Fig 57 K).

4. Elongated shaped (ES)

I. Big cells, tangential wall covered with thick cuticle, Inner tangential wall arched or round (Fig 57 L).

II. Small cells, tangential wall covered with thin cuticle, inner tangential wall angular (Fig 57 M).

5. Round shaped epidermal cells, outer tangential wall covered with thick cuticle, cuticle penetrate between cell and forming triangular shaped thickening at the junction of two adjacent cells (Fig 57 N)

Ground tissue (Metcalfe, 1960)

Transverse sections of culm showed that the parenchymatous tissue is main component tissue which forms ground tissue. Sometimes few cells contain chloroplasts and serves for phytosynthesis; few cells become elongated and thickened walls and provide mechanical support. Within the ground tissue vascular bundles and other cells are arranged in different patterns.

Mechanical tissues are restricted towards the peripheral part of the culm where they provide effective support in resisting strains and stresses. They form a subepidermal ring in the form of a cylinder in which peripheral vascular bundles are present. Sclerenchymatous cylinder may be single termed **"Unicylindrical"** which is very commonly observed in grasses or it may be in two concentric rings separated by ground tissue and termed as **"Bicylindrical"**. Sometimes sclerenchyma forms **girder**. Other than this, the individual vascular bundles, even in the inner part of the culm and are accompanied by strands of thick walled fibers.

The distribution of sclerenchyma could be categorized as:

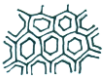
1. Type A: Where fibers are of medium thickness (Fig. 57 O, arrow)

2. Type B: Fibers are very thick walled, lumen almost completely occluded (Fig. 57 P, arrow)

3. Type C: Fiber walls thick, walled interrupted with pits (Fig. 58 Q, arrow)

4. Type D: not markedly thickened, penta to hexagonal shaped cells (Fig. 5 R)

5. Type E: thick cell wall, with big lumen (Fig. 57 S)



Intercellular cavities or canal were observed in the grasses which are aquatic or which are growing in moist area. They develop intercellular air cavities or canals which vary in size, shape and distribution in different species.

Mestome is formed by small, thick walled cells, similar to the sclerenchyma, surrounding the vascular bundles and occurring usually in a single layer. Mestome cells constitute the internal bundle sheath, and their size and shape are variable.

Vascular tissue:

Vascular bundles like any other monocot stem were found to be scattered and widely distributed irregularly throughout the cross sectional area of the culm. In few grass species the vascular bundles are in a single circle or a few concentric circles. The number of circles that are present is largely bound up with the diameter of the culm, and the proportion of its cross sectional area that is hollow. The vascular bundles nearest to the centers of the culms are much larger than those present next to the epidermis. The individual vascular bundles are usually circular or oblong to elliptical. Shapes vary considerably in grasses. Vascular bundles are collateral (phloem is present at the pole of the bundle towards the periphery of the culm), conjoint, endarch and closed.

Three types of vascular bundles are present:

(1) Internal vascular bundle (IVB)- I° and II° vascular bundles are present towards the center so they are known as IVB. I° and II°IVB are organized in one to three concentric circles.

(a) First order internal vascular bundles (I°IVB)- proto and metaxylem cells well developed. I°IVB are smaller in size and metaxylem vessels are not conspicuously larger in diameter than the neighbouring cells.

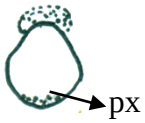
(b) Second order internal vascular bundles (II°IVB)- only metaxylem cells developed.

(2) Pheripheral vascular bundles (PVB)- vascular bundles are present towards the periphery. Third order pheripheral vascular bundles (III°PVB)- inconspicuous proto and metaxylem cells.

Vascular bundles could be differentiated on the basis of shapes in all three first and second order internal vascular bundles and the peripheral bundles. The shapes could be categorised as given below. Diagrammatic representations of the shapes are also given along with the description and figures 59A-X depict the microphotographs of the same. Pitted portion in the diagram represents sclerenchymatous cells.

1. Types of I°IVB:

Type A: Diamond shaped vascular bundle with round shaped metaxylem, sclerenchymatous sheath present towards phloem and small patch of sclerenchyma present towards protoxylem (Fig. 58 A)



Type B: Diamond shaped vascular bundle with elliptical shaped metaxylem, sclerenchymatous sheath present towards phloem (Fig. 58 B)

Type C: Triangular diamond shaped (Fig. 58 C)

Type D: Obovate shaped vascular bundle with a broad top and narrow base (Fig. 58 D)

Type E: Top shaped/Inverted triangular shaped vascular bundle (Fig. 58E)

Type F: Vertically elliptical shaped vascular bundle with sclerenchymatous patch present at both the polar ends of bundle (Fig. 58 F)

Type G: Inverted cork or bulb shaped vascular bundle (Fig. 58 G)

Type H: Round shaped vascular bundle (Fig. 58 H)

Type I: Oval shaped vascular bundle with broad base and narrow top (Fig. 58 I)

2. Types of II°IVB:

Type J: Oblong shaped vascular bundle (Fig. 58 J)

Type K: Oval shaped vascular bundle with very broad base and abrupt narrow tip (Fig. 58 K)

Type L: Triangular shaped vascular bundle, with sclerenchymatous sheath around xylem (Fig. 58 L)

Type M: Round shaped vascular bundle (Fig. 58 M).

Type N: Inverted triangular shaped vascular bundle with sclerenchyma cap ensheathing the entire vascular bundle except at the region of lysigenous cavity (arrow) (Fig. 58 N)

Type O: Round shaped, 2-3 layers of sclerenchymatous sheath encircling the entire vascular bundle (Fig. 58 O)

Type P: Dimond shaped vascular bundle

3. Type of III°PVB:

Type Q: Round shaped vascular bundle, with single layered sclerenchymatous sheath (Fig. 58 P)

Chlorenchyma tissue

The culms of few grass species shows presence of chlorenchyma. Where the peripheral tissues are largely fibrous it is usual to find that the chlorenchyma is in the form of longitudinal columns bounded externally by the epidermis and otherwise surrounded by or embedded in the peripheral sclerenchyma. Chlorenchyma cells are irregular in shape and arrangement. In some grasses, chlorenchyma may form a continuous cylinder subjacent to the epidermis or the cylinder may be traversed at intervals by girders of sclerenchyma, one of which often lies opposite each of the outermost vascular bundles and extends from these to the epidermis. In certain plants a layer of radially oriented mesophyll cells which surrounds the vascular bundles and it called this layer “kranz” (wreath) and the type of anatomy kranz type. Kranz type of anatomy includes both the mesophyll and bundle sheath and mostly found in C_4 plants. In culm antomy, chlorenchyma present surround the III°PVB (third order

peripheral vascular bundle), but it is not present in form of ring, it is in form of arc so it is known as kranz arc. This chlorenchyma is radial chlorenchyma.

The shape of Kranz arc was:

(i) straight (Fig. 58 Q, arrow)
(ii) half circle (Fig. 58 R, arrow)
(iii) horseshoe (Fig. 58 S, arrow)
(iv) circular shaped (Fig. 58 T, arrow)

Shape of the Kranz cells are:

(i) round to oval (Fig. 58 U, arrow)
(ii) square or trapezoid (Fig. 58 V, arrow)

Chloroplasts in the kranz cells were arranged in two ways:

(i) centripetal chloroplasts (chlorophyll present towards inner side of cell) (Fig. 58 W, arrow)
(ii) centrifugal chloroplasts (chlorophyll present towards the outer side/periphery of cell) (Fig.58 X, arrow)

Characteristic diagnostic features of observed in each grass species has been described below with the respective microphotographs on the opposite page. The quantitative features have been described in Table 3. Abbreviations used in the microphotographs represented as follows:

e-epidermis
c-cuticle
st-stomata
si-silica
ph-phloem
mx-metaxylem
px-protoxylem
pc-protoxylem cavity (lysigenous cavity)
pi-pth, p-parenchyma
ic-intercellular space
sc-sclerenchyma
I^o IVB-primary intercellular vascular bundle
II^o IVB-secondary intercellular vascular bundle
III^o PVB-tertiary pheripheral vascular bundle
kc-kranz cell
rc-radial chlorenchyma cells
m-mestome cells

Fig. 57: Different types of epidermises and sclerenchymatous cells

A-N: Different types of epidermal cells

A-E: Barrel shaped epidermal cell (BS)

A: BS –I, big cells with evenly thickened tangential wall

B: BS-II, flattened cells, cuticle penetrate between two epidermal cell

C: BS-III, tangential wall covered with thin cuticle

D: BS-IV, small sized cells

E: BS-V, cuticle and cell wall equal to greater them the depth of the average epidermal cell

F-H: Rectangular shaped epidermal cell (RS)

F: RS-I, tangential wall covered with very thin cuticle

G: RS-II, tangential wall covered with slightly thick cuticle

H: RS-III, tangential wall covered with cuticle and it penetrate between cells

I-K: Square shaped epidermal cells (SS)

I: SS-I, tangential wall covered with thick cuticle

J: SS-II, big cells, tangential wall covered with thin cuticle

K: SS-III, covered with thick cuticle and it penetrate between epidermal cell

L-M: Elongated shaped epidermal cell (ES)

L: ES-I, big cells, tangential wall covered with thick cuticle

M: ES-II, tangential wall covered with thin cuticle

N: Round shaped epidermal cells

O-S: Fiber cell types

O: Type A, fibers of medium thickness (arrow)

P: Type B, Fibers are very thick walled, lumen almost completely occluded (arrow)

Q: Type C, Fiber walls thick, walled interrupted with pits

R: Type D, Fiber walls not markedly thickened, penta to hexagonal shaped cells

S: Type E, Fiber walls having thick cell wall, with large lumen

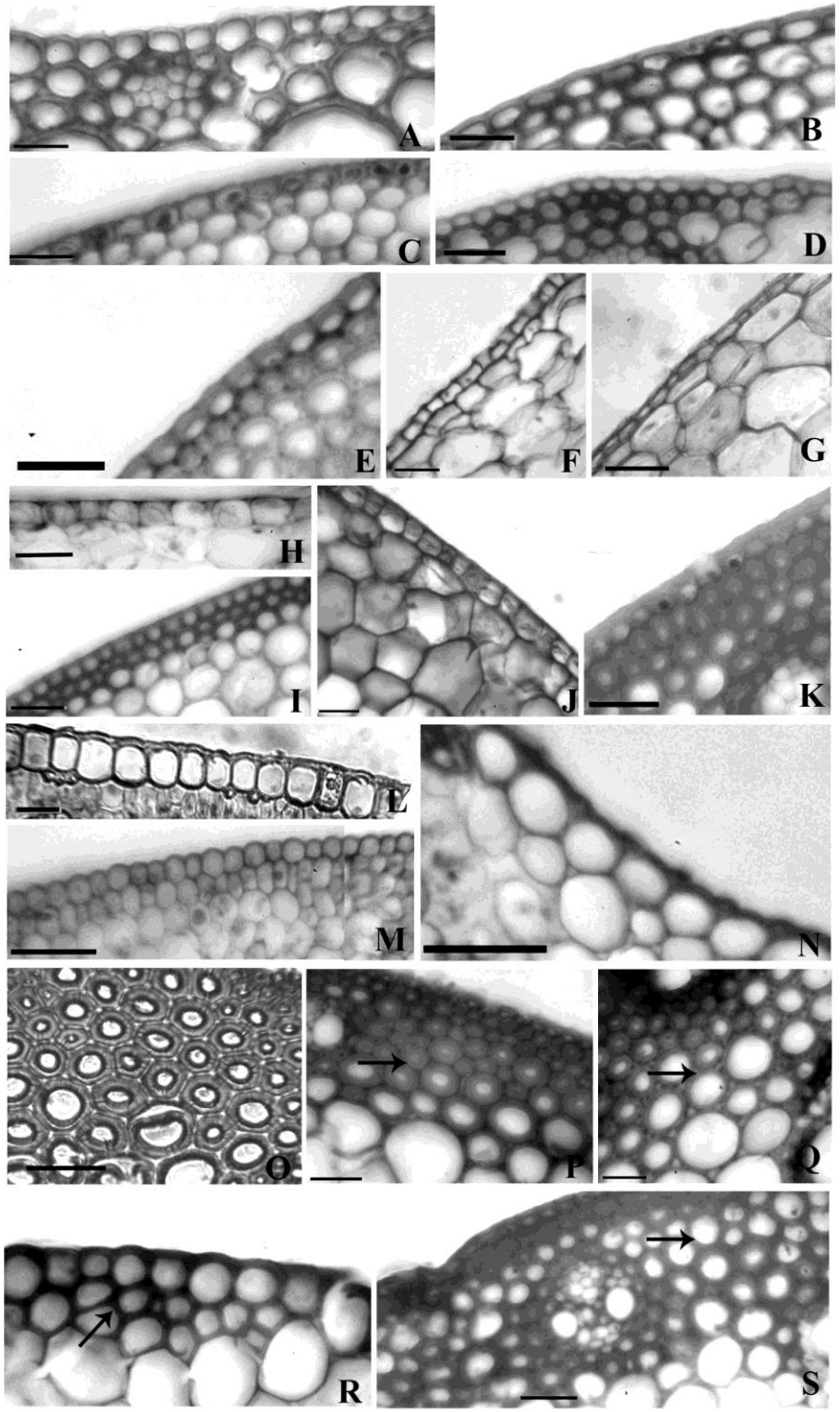


Fig. 57

Fig. 58: Different types of vascular bundles and kranz arc and kranz cell

A-P: Different types of vascular bundles

A-I: I°IVB,

A: Type A, Diamond shaped vascular bundle with round metaxylem

B: Type B, Diamond shaped vascular bundle with oval metaxylem

C: Type C, Triangular diamond shaped vascular bundle

D: Type D, Obovate shaped vascular bundle

E: Type E, Inverted triangular shaped vascular bundle

F: Type F, Vertically elliptical shaped vascular bundle

G: Type G, Inverted cork or bulb shaped vascular bundle

H: Type H, Round shaped vascular bundle

I: Type I, Oval shaped vascular bundle

J-O: II°IVB

J: Type J, Oblong shaped vascular bundle

K: Type K, Oval shaped vascular bundle

L: Type L, Triangular shaped vascular bundle, except phloem part vascular bundle covered with sclerenchyma

M: Type M, Round shaped vascular bundle

N: Type N, Triangular shaped vascular bundle, except lysogenous cavity part vascular bundle covered with sclerenchyma

O: Type O, Round shaped, whole vascular bundle covered with sclerenchyma

P- III°PVB

P: Type P, Round shaped vascular bundle

Q-T: Different types of kranz arc

Q: Straight kranz arc (arrow)

R: Horseshoe kranz arc (arrow)

S: Half circle kranz arc (arrow)

T: Circular shaped kranz arc (arrow)

U: Round to oval shaped kranz cells

V: Square to trapezoid shaped kranz cells

W: Centripetal arrangement of chloroplast in kranz cell

X: Centrifugal arrangement of chloroplast in kranz cell

Y: Type I kranz anatomy

Z: Type II kranz anatomy

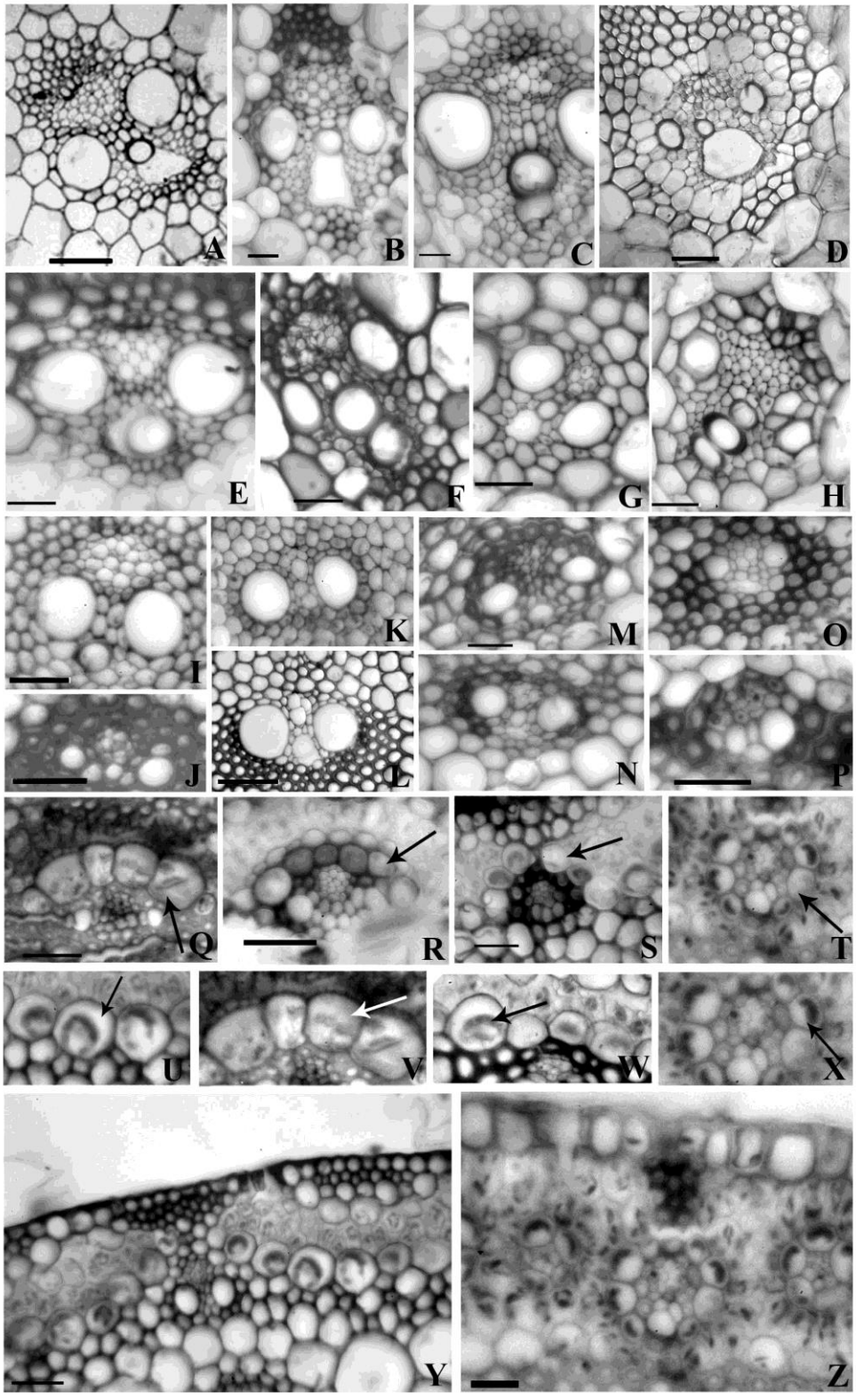


Fig. 58

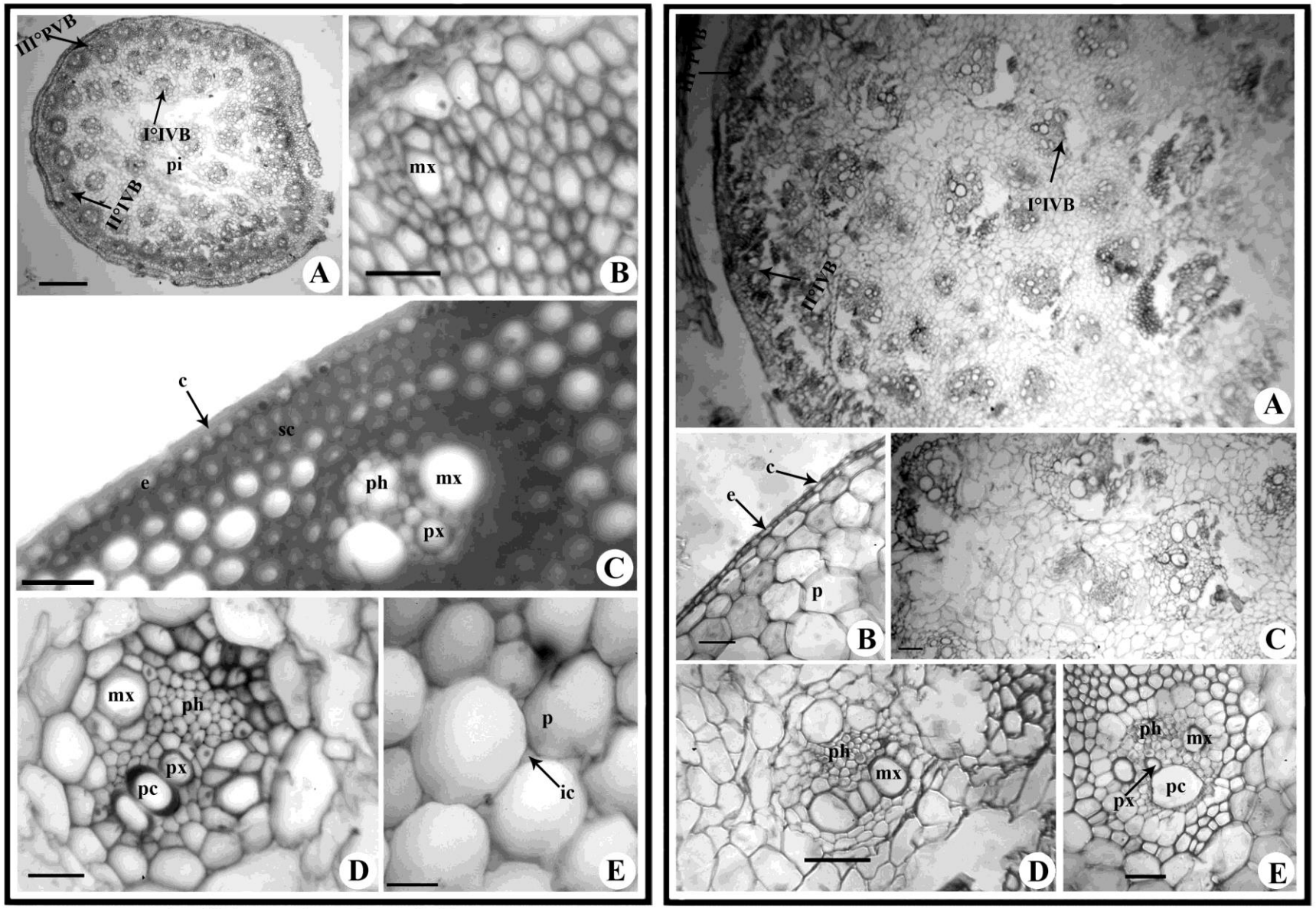
MORPHOMETRIC / HISTOARCHITECHTURAL ANALYSIS OF CULM ANATOMY

1. *Chionachnae koenigii* (Fig. 59(1) A-E)

Round in transection with slightly undulating surface (Fig. A)
Size: 295x275 ± 24.87 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Square Shaped-III (Fig. C)
Hypodermis: 3-4 layered sclerenchymatous
With III^{o} PVB embedded
Type-B sclerenchyma present
Ground tissue: Round to oval shaped Parenchymatous (Fig. E)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type I, sclerenchymatous cap present (Fig. D)
Size: 14.68 x 12.5 ±3.87 µm
II^{o} IVB: Type P (Fig. C)
Size: 7 x 9.67 ± 1.73 µm
III^{o} PVB: Type Q (Fig. B)
Size: 4.5 x 3 ± 0.84 µm
Bar size: A = 50 µm, B-E = 5 µm

2. *Coix lachryma-jobi* (Fig. 59(2) A-E)

Oval in transection with smooth surface (Fig. A)
Size: 923.07x646.15±31.49 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Rectangular Shaped-II (Fig. B)
Hypodermis: 5-6 layered parenchymatous
With III^{o} PVB embedded, below it 2-3 layered
Sclerenchyma present
Type-D sclerenchyma present
Ground tissue: Irregular shaped Parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type D, sclerenchymatous cap present (Fig. E)
Size: 17.78x15.56±2.32 µm
II^{o} IVB: Type K (Fig. D)
Size: 11.07x10.36±3.72 µm
III^{o} PVB: Type Q
Size: 7.34x6.27±1.47 µm
Bar size: A = 50 µm, B-E = 5 µm



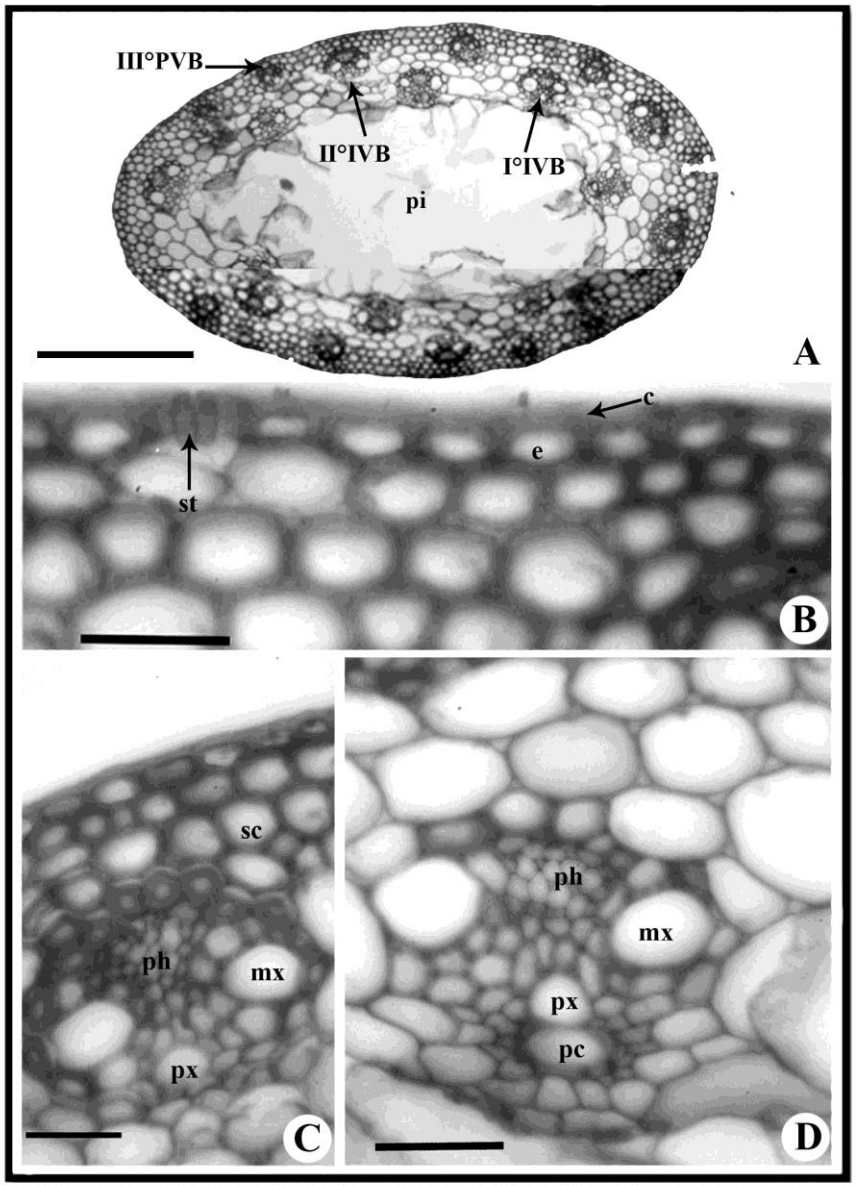
1. *Chionachne koenigii* **Fig. 59** 2. *Coix lachryma-jobi*

3. *Andropogon pumilus* (Fig. 60(3) A-D)

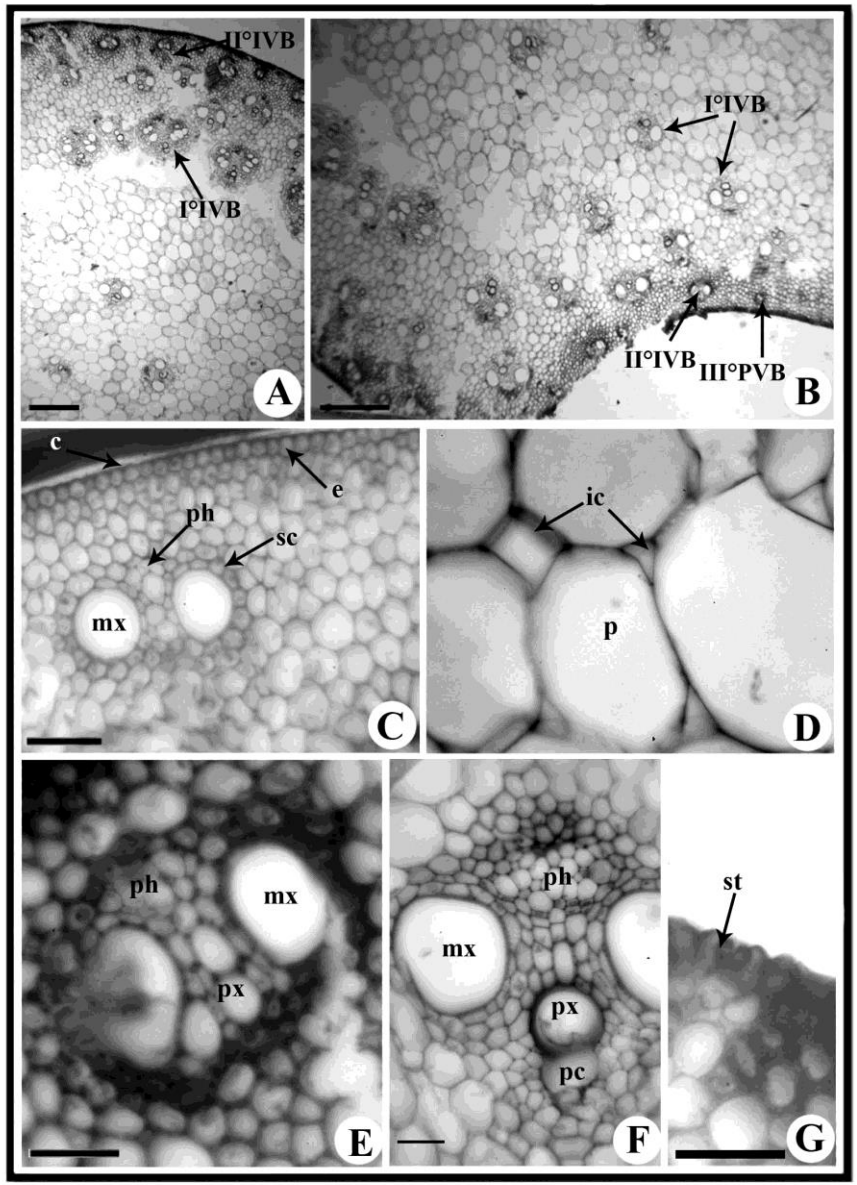
Oval in transection with slightly undulating surface (Fig. A)
Size: 161.17x91.67±18.37 µm, Hairs/Prickles absent.
Hollow internode i.e.hollow pith.
Epidermis: Barrel Shaped-II (Fig. B)
Hypodermis: 2-3 layered sclerenchymatous
With III^{o} PVB embedded
Type-E sclerenchyma present (Fig. C)
Ground tissue: Oval shaped Parenchymatous,
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type I (Fig. D)
Lysigenous cavity oval shaped
Size: 13.22x16.37±3.28 µm
II^{o} IVB: Type K
Size: 12.34x15.34±2.98 µm
III^{o} PVB: Type Q
Size: 3.62x4.82±.73 µm
Bar size: A = 50 µm, B-D = 5 µm

4. *Apluda mutica* (Fig. 60(4) A-G)

Round to oval in transection with smooth surface (Fig. A)
Size: 358.25x433.38±28.73µm, Hairs/Prickles present.
Solid internode with parechymatous pith.
Epidermis: Elongated Shaped-II (Fig. C)
Hypodermis: Angular parenchymatous zone
Interrupted by sclerenchymatous girder
Type-D sclerenchyma present
Ground tissue: Round to oval shaped Parenchymatous (Fig. B, D)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type C, Scatterly arranged (Fig. F)
Size: 35.71x31.43±6.42µm
II^{o} IVB: Type K (Fig. E)
Size: 15x18.21±3.72 µm
III^{o} PVB: Type Q (Fig. C)
Size: 7.08x14.17±1.38 µm
Bar size: A & B= 50 µm, C-G = 5 µm



3. *Andropogon pumilus*



4. *Apluda mutica*

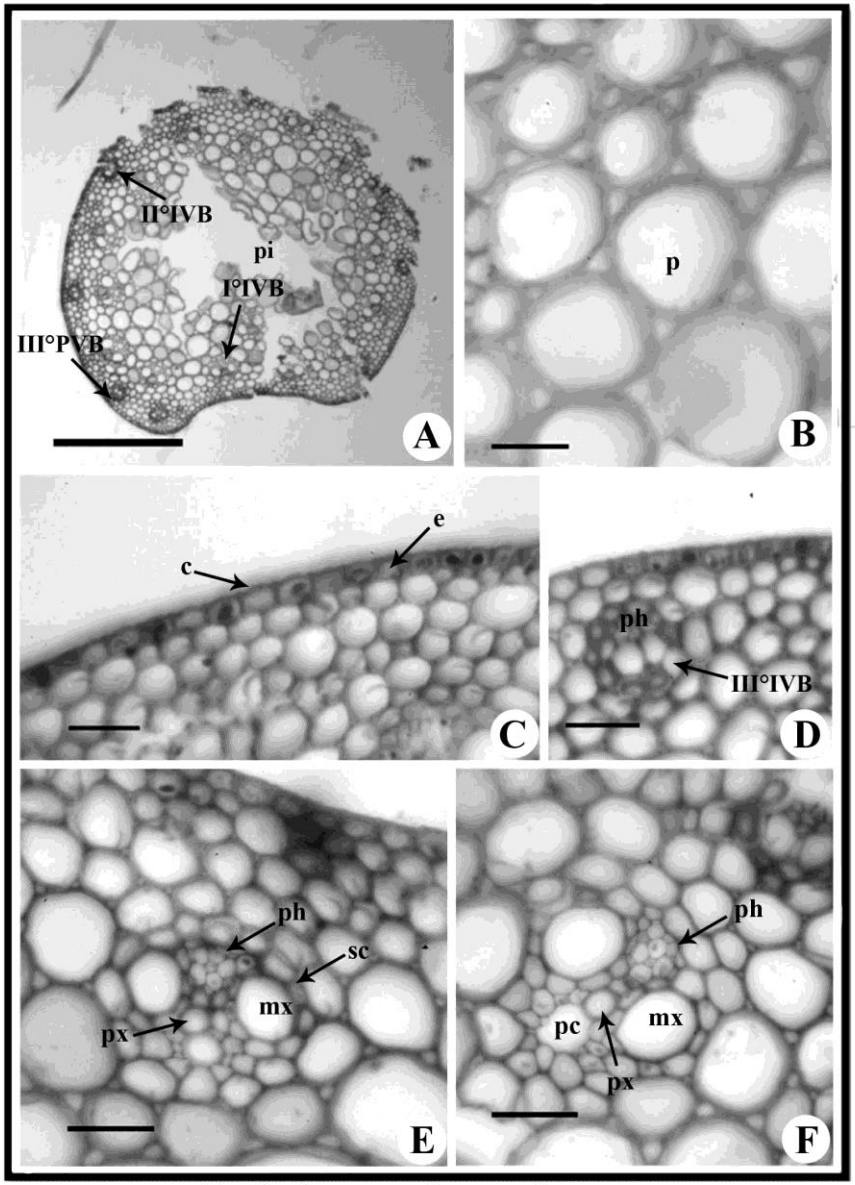
Fig. 60

5. *Arthraxon lanceolatus* (Fig. 61(5) A-F)

Round in transection with concave distal end (Fig. A)
Size: 116.67x138.09±17.82 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Barrel Shaped-III (Fig. C)
Silica bodies present
Hypodermis: 3-4 layered Parenchymatous
Interrupted by sclerenchymaotus cells
With III^{o} PVB embedded
Type-C sclerenchyma present
Ground tissue: Round to oval shaped Parenchymatous (Fig. B)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type G (Fig. F)
Lysigenous cavity bigger than the protoxylem
Size: 14x11.34±4.83µm
II^{o} IVB: Type M (Fig. E)
Size: 11.07x12.86±2.63 µm
III^{o} PVB: Type Q (Fig. D)
Size: 6.67x7.08±1.72 µm
Bar size: A = 50 µm, B-F = 5 µm

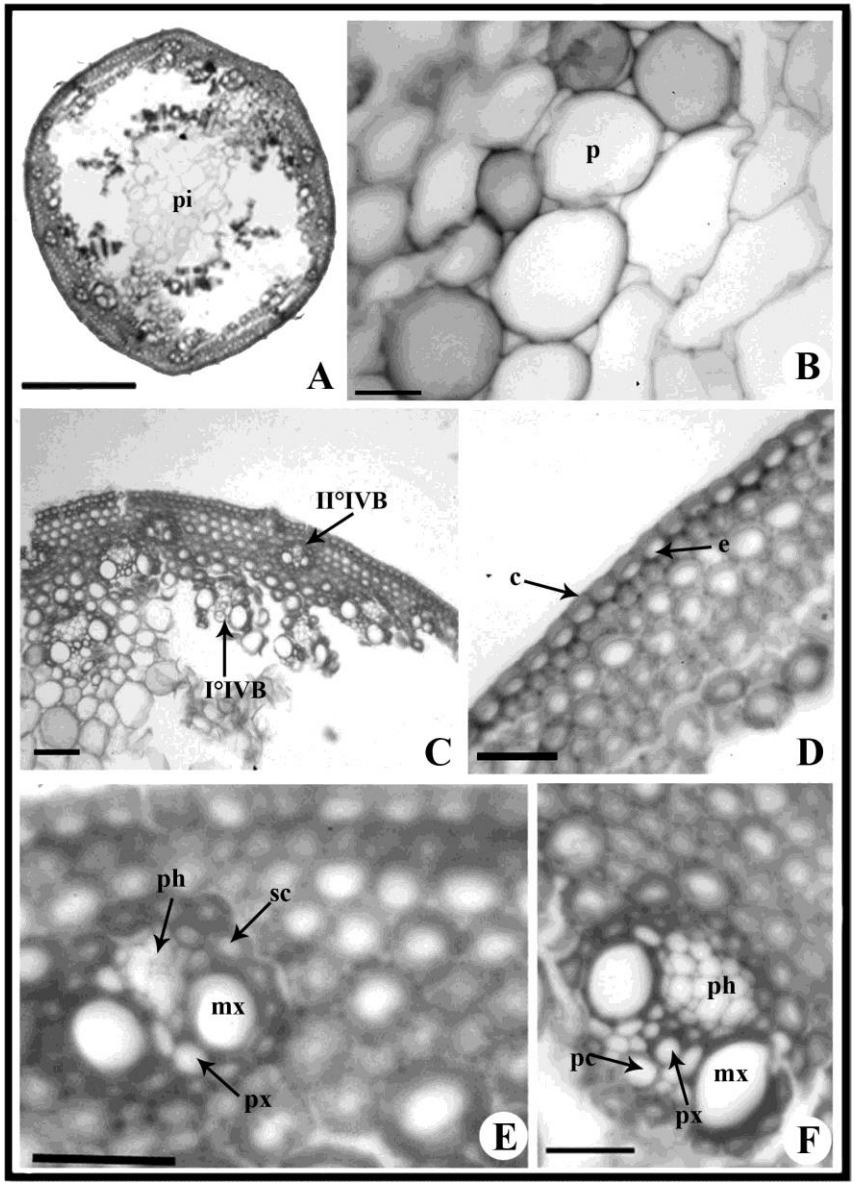
6. *Bothriochloa pertusa* (Fig. 61(5) A-F)

Round in transection with smooth surface (Fig. A)
Size: 155.6x138.9±3.78µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Barrel Shaped-V (Fig. D)
Hypodermis: 3-4 layered sclerenchymatous
With III^{o} PVB embedded protoxylem
Ground tissue: Round to oval shaped Parenchymatous (Fig. B, C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type I (Fig. F)
Lysigenous cavity equal to Type-B and E sclerenchyma present
Size: 11x12.67±3.29µm
II^{o} IVB: Type M (Fig. E)
Size: 7.5x9.32±2.85µm
III^{o} PVB: -
Size: -
Bar size: A = 50 µm, B-F = 5 µm



5. *Arthraxon lanceolatus*

Fig. 61



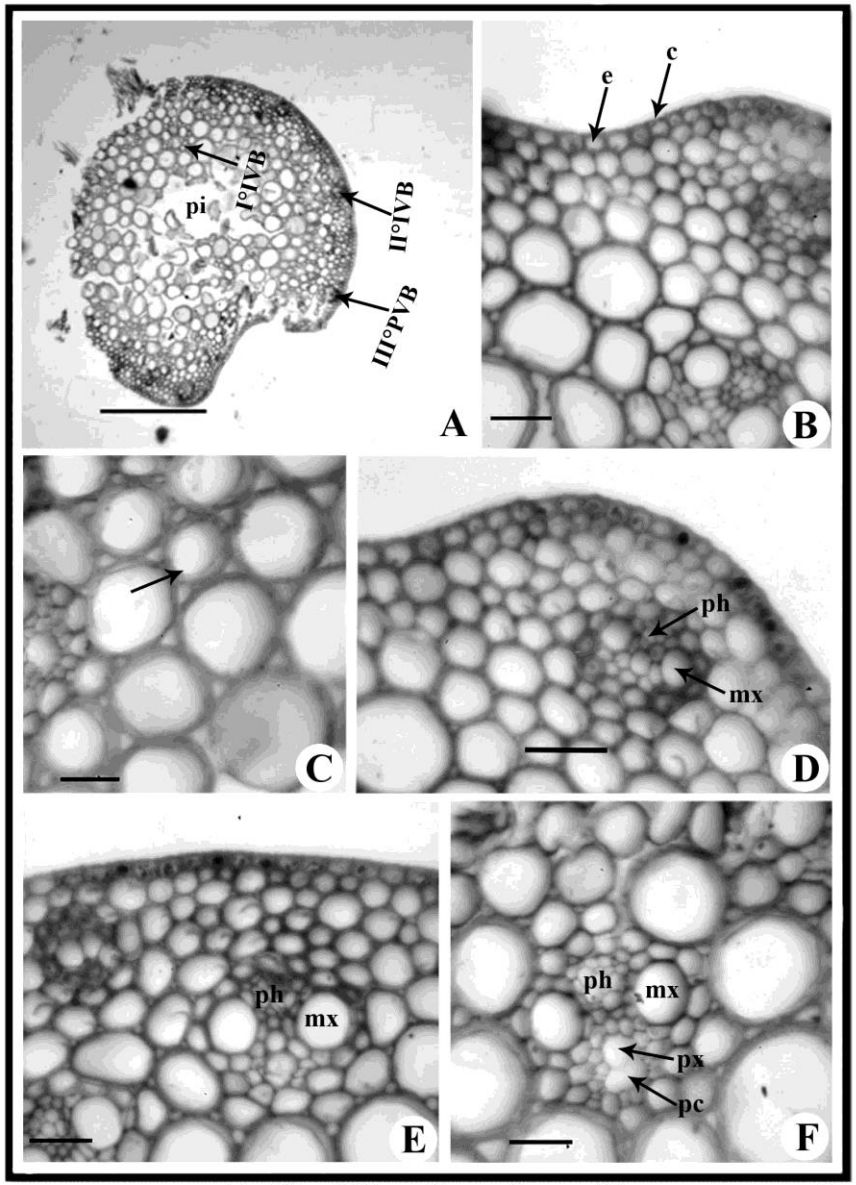
6. *Bothriochloa pertusa*

7. *Capillipedium huegelii* (Fig. 62(7) A-F)

Round in transection with concave distal end (Fig. A)
Size: 152.94x138.24±18.63 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Barrel Shaped-IV (Fig. B)
Hypodermis: 3-4 layered parenchymatous
Interrupted by sclerenchyma With III^{o} PVB embedded
Type-C sclerenchyma present
Ground tissue: Round to oval shaped Parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type I , Scatterly arranged (Fig. F)
Size: 16x17±6.37 µm
II^{o} IVB: Type P (Fig. E)
Size: 11.36x13.18±2.84 µm
III^{o} PVB: Type Q (Fig. D)
Size: 5.67x7.34±1.35 µm
Bar size: A = 50 µm, B-F = 5 µm

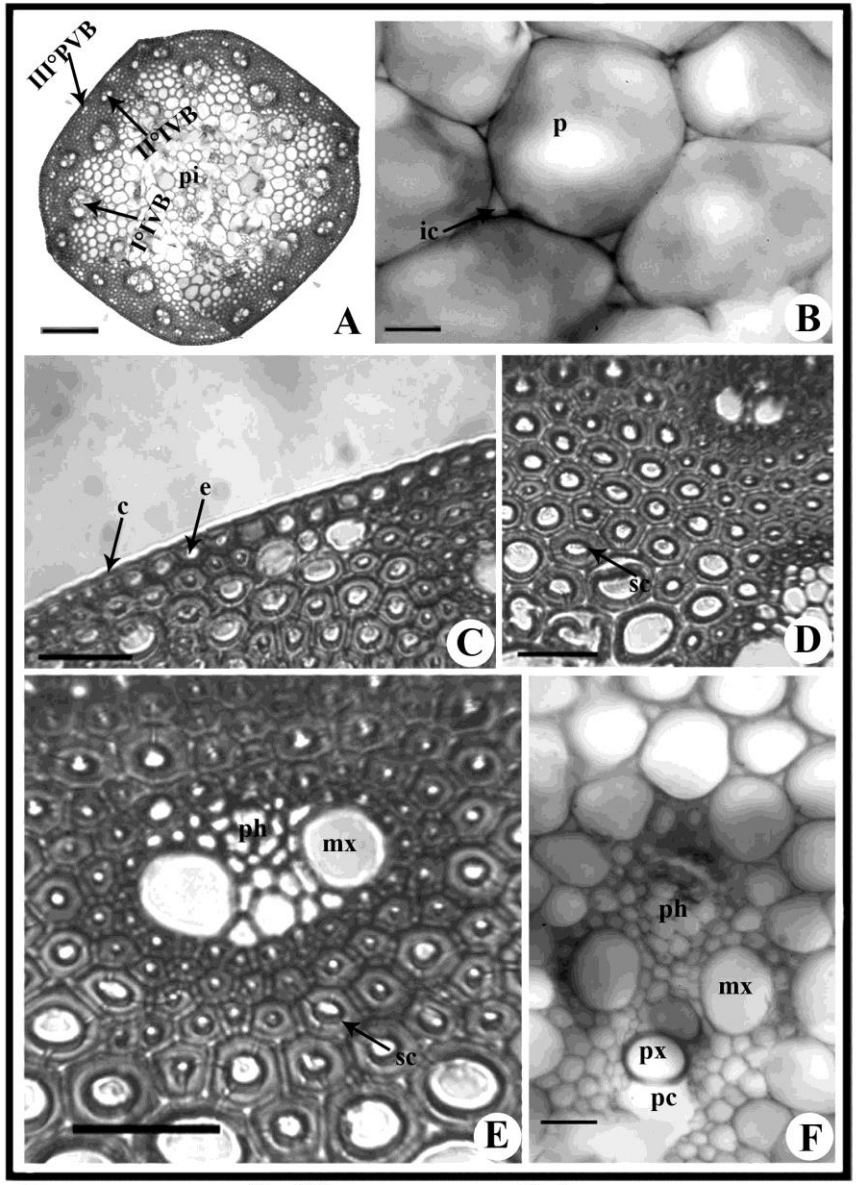
8. *Chrysopogon fulvus* (Fig. 62(8) A-F)

Squarish round in transaction (Fig. A)
Size: 277.78x283.34±35.22 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Square Shaped-III (Fig. C)
Hypodermis: 8-10 layered sclerenchymatous
With III^{o} PVB embedded
Type-A sclerenchyma present (Fig. D)
Ground tissue: Round to oval shaped Parenchymatous (Fig. B)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type C, partially covered by sclerenchymatous cells (Fig. F)
Size: 28.89x21.67±5.18µm
II^{o} IVB: Type K (Fig. E)
Size: 15.47x20.16±6.18 µm
III^{o} PVB: Type Q
Size: 6.30x10±2.73 µm
Bar size: A = 50 µm, B-F = 5 µm



7. *Capillipedium hugelii*

Fig. 62



8. *Chrysopogon fulvus*

9. *Cymbopogon martini* (Fig. 63(9) A-F)

Round to oval in transection with slightly undulating surface (Fig. A)
Size: 759x900±48.22 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Rectangular Shaped-II
Hypodermis: 10-12 layered sclerenchymatous
With III^{o} PVB embedded
Type-E, C sclerenchyma present (Fig. C)
Ground tissue: Round to oval shaped Parenchymatous (Fig. B)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B Scatterly arranged (Fig. F)
Size: 24.5x27.5±3.73µm
II^{o} IVB: Type P (Fig. D, E)
Size: 14.09x14.09±4.62 µm
III^{o} PVB: Type Q
Size: 3.86x7.95±1.37 µm
Bar size: A = 50 µm, B-F = 5 µm

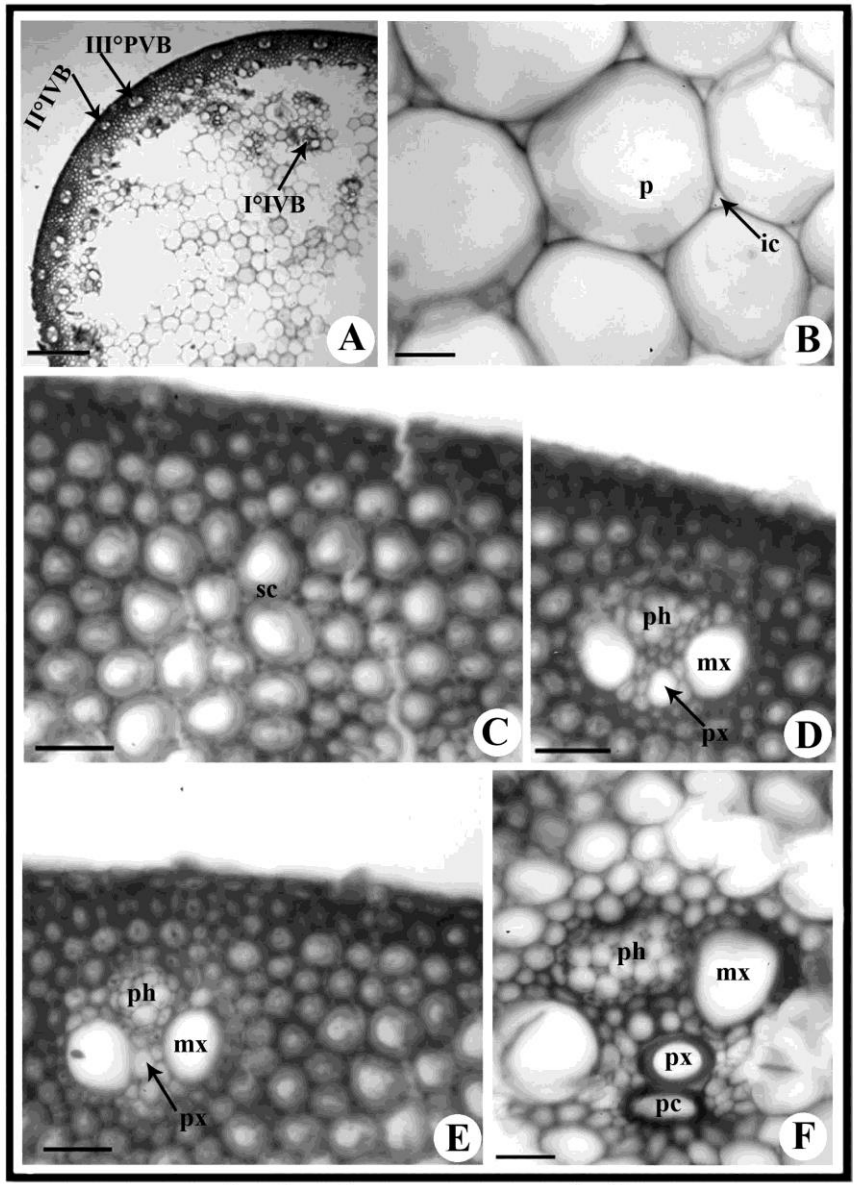
Dichanthium

10. *Dichanthium annulatum*

11. *Dichanthium caricosum*

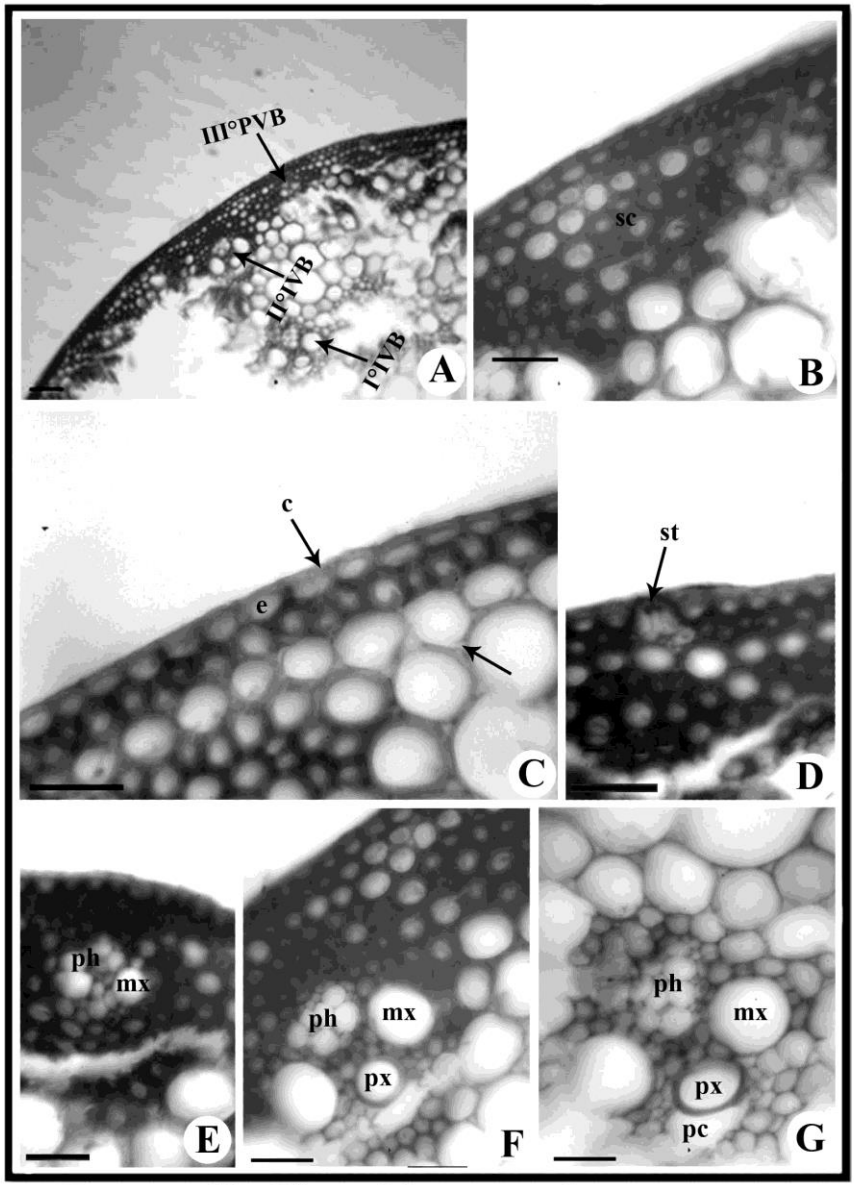
10. *Dichanthium annulatum* (Fig. 63(10) A-G)

Round in transection (Fig. A)
Size: 253.72x241.67±27.56 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Rectangular Shaped-III (Fig. C)
Hypodermis: 5-6 layered sclerenchymatous
With III^{o} PVB embedded
Type-E sclerenchyma present (Fig. B)
Ground tissue: Round to oval shaped Parenchymatous,
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B (Fig. G)
Lysigenous cavity is irregularly oblong shaped
Size: 21x24.5±7.29 µm
II^{o} IVB: Type P (Fig. F)
Size: 12x16.5±3.81 µm
III^{o} PVB: Diamond shaped (Fig. E)
Size: 7.5x11±1.38 µm
Bar size: A = 50 µm, B-G = 5 µm



9. *Cymbopogon martinii*

Fig. 63



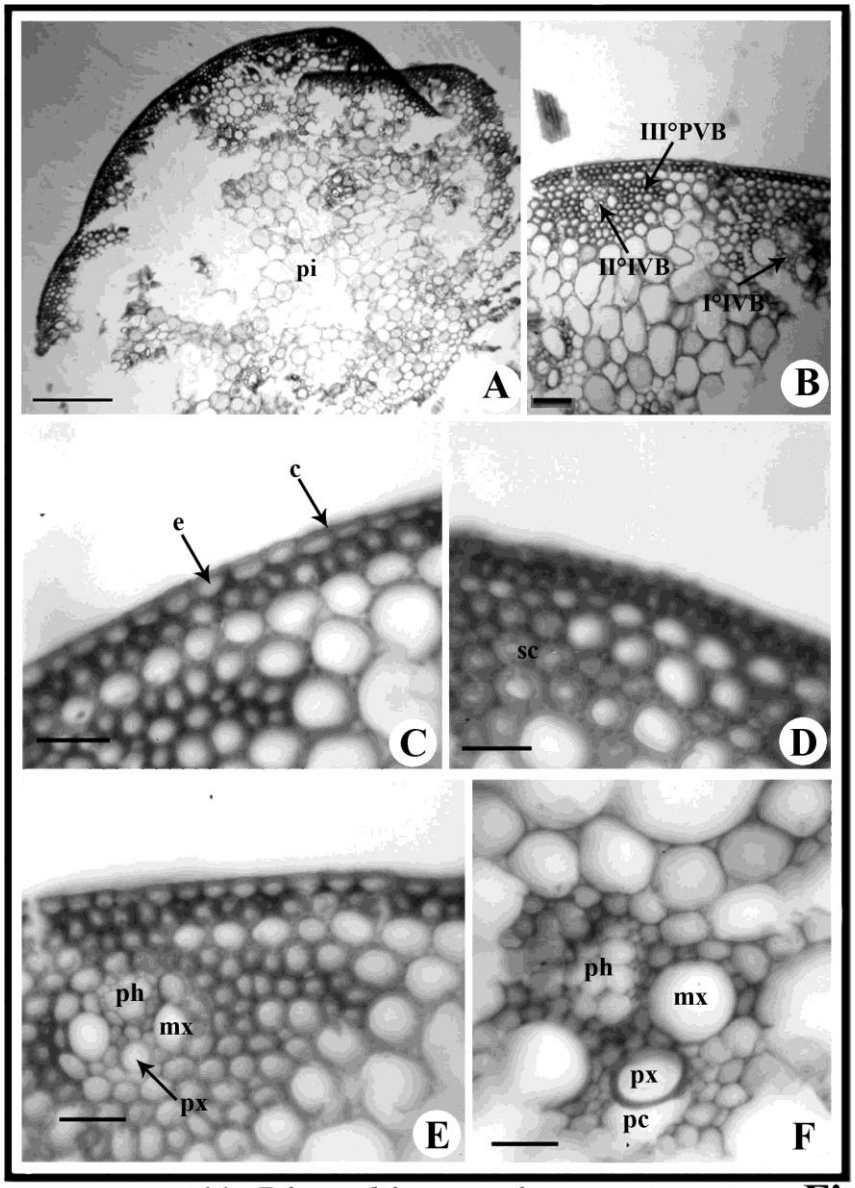
10. *Dicanthium annulatum*

11. *Dichanthium caricosum* (Fig. 64(11) A-F)

Round to oval in transection with smooth surface (Fig. A)
Size: 527.2x613.23±61.78 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Rectangular Shaped-III (Fig. C)
Hypodermis: 3-4 layered sclerenchymatous
With III^{o} PVB embedded
Type-E sclerenchyma present (Fig. D)
Ground tissue: Round to oval shaped Parenchymatous
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymatous cap present (Fig. F)
Scatterly arranged
Size: 22x23.5±4.83 µm
II^{o} IVB: Type M (Fig. E)
Size: 13.18x11.82±1.92 µm
III^{o} PVB: Type Q (Fig. B)
Size: 7.1x9.13±2.73 µm
Bar size: A = 50 µm, B = 10 µm, C-F = 5 µm
Differentiating features:
Diamond shaped II°IVB ……..……..*D. annulatum*
Round shaped II°IVB……...……..*D. caricosum*

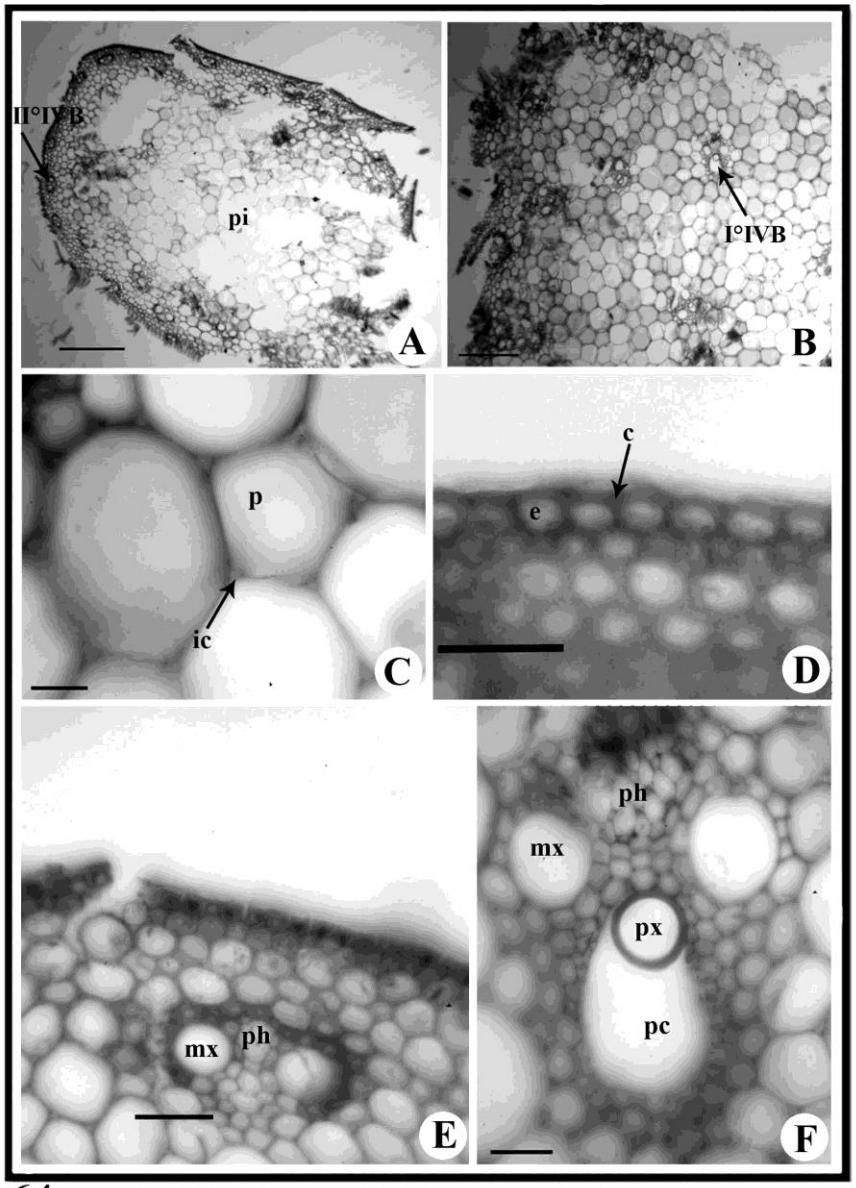
12. *Hackelochloa granularis* (Fig. 64(12) A-F)

Oval in transection with smooth surface (Fig. A)
Size: 218.18x254.54±31.37 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Barrel Shaped-I (Fig. D)
Hypodermis: Single layered sclerenchymatous
Type-B sclerenchyma present
Ground tissue: Angular shaped Parenchymatous (Fig. B, C)
Vascular bundles arranged in ring form
Vascular system: III^{o} PVB absent
I^{o} IVB: Type F, sclerenchymatous cap present (Fig. F)
Size: 16x23±4.73 µm
II^{o} IVB: Type N (Fig. E)
Size: 8.08x5.85±1.36 µm
III^{o} PVB: -
Size:-
Bar size: A = 50 µm, B = 10µm, C-F = 5 µm



11. *Dicanthium caricosum*

Fig. 64



12. *Hackelochloa granularis*

Heteropogon

13. *Heteropogon contortus var. genuinus sub var. typicus*

14. *Heteropogon contortus var. genuinus sub var. hispidissimus*

15. *Heteropogon ritcheii*

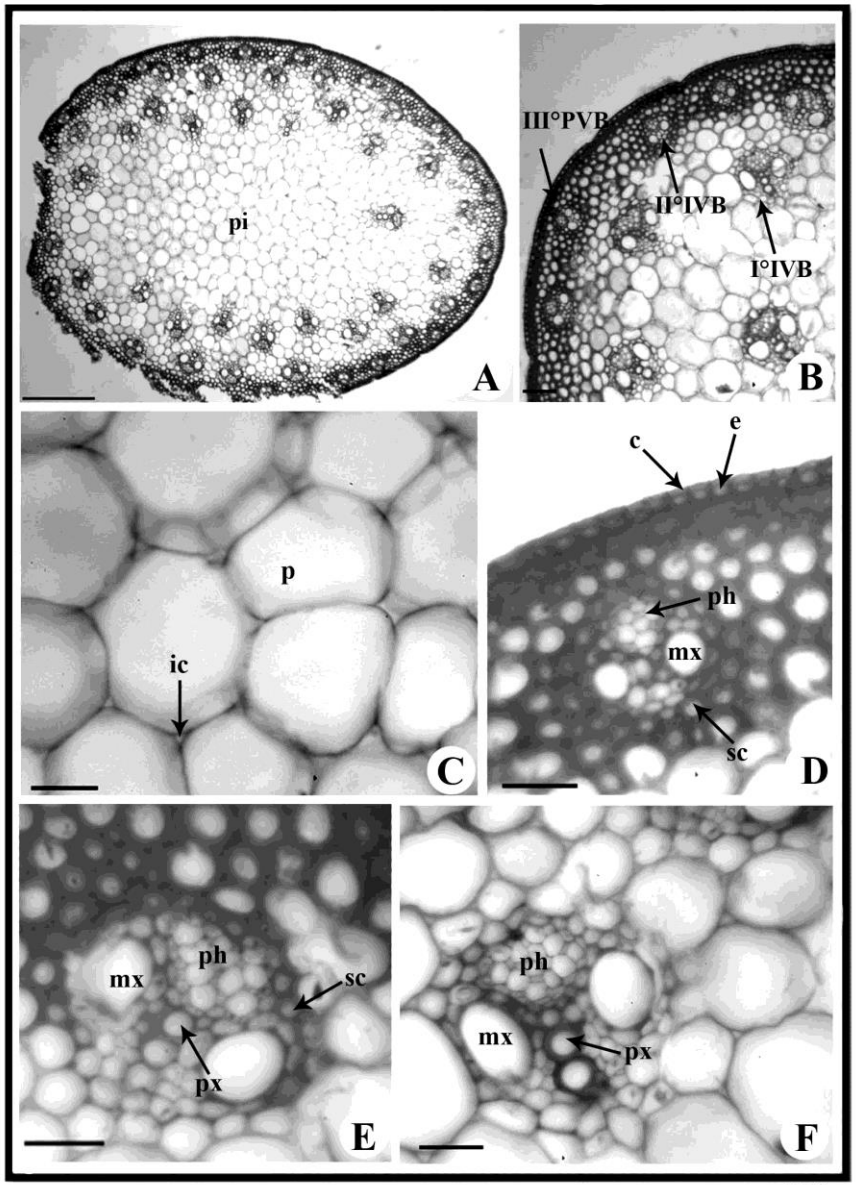
16. *Heteropogon triticeus*

13. *Heteropogon contortus var. genuinus sub var. typicus* (Fig. 65(13) A-F)

Oblong in transection with smooth surface (Fig. A)
Size: 241.67x316.67±28.82 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Barrel Shaped-V (Fig. D)
Hypodermis: 5-6 layered sclerenchymatous
With III^{o} PVB embedded
Type-B, E sclerenchyma present
Ground tissue: Round to oval shaped Parenchymatous (Fig. B, C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type I, sclerenchymatous cap present (Fig. F)
Size: 16.82x17.73±4.39µm
II^{o} IVB: Type M (Fig. E)
Size: 12.92x16.25±3.82 µm
III^{o} PVB: Type Q (Fig. D)
Size: 9.17x9.58±3.78 µm
Bar size: A = 50 µm, B = 10 µm, C-F = 5 µm

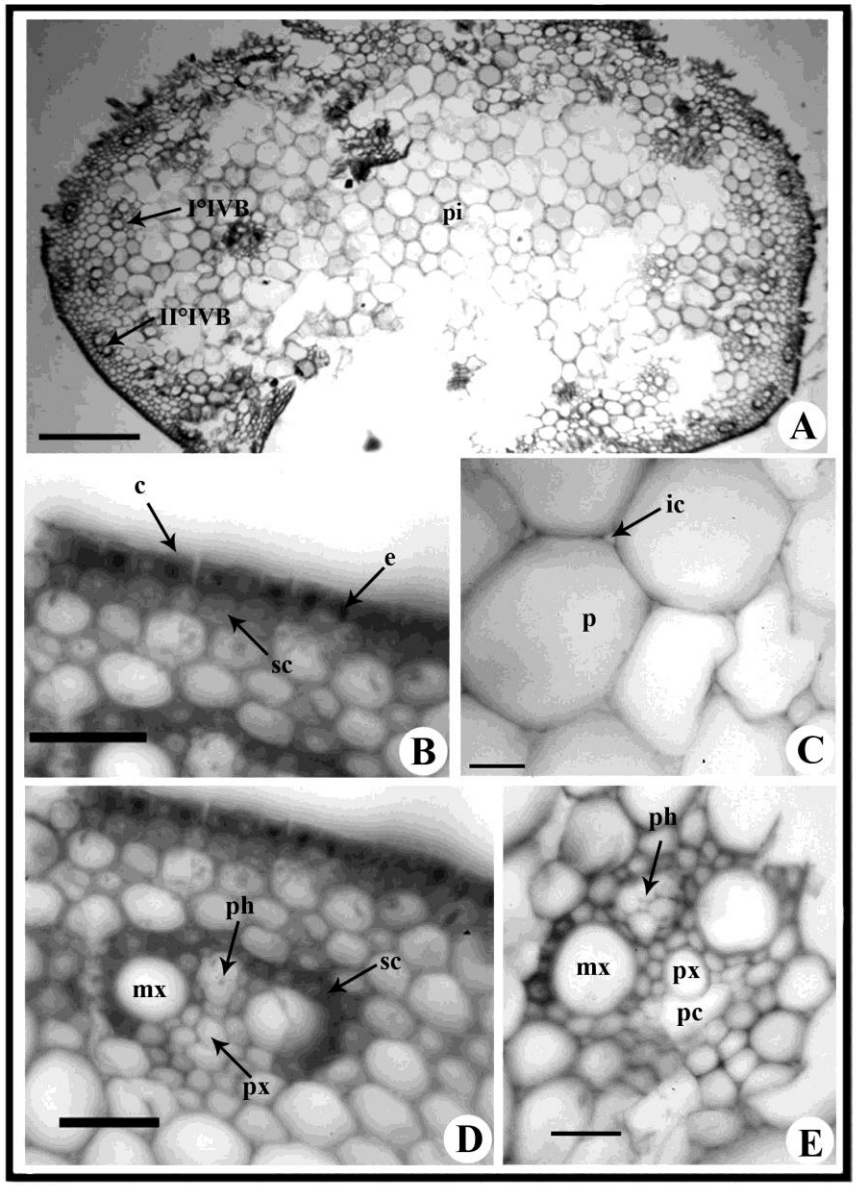
14. *Heteropogon contortus var. genuinus sub var. hispidissimus* (Fig. 65(14) A-E)

Oblong in transection with smooth surface (Fig. A)
Size: 256.25x384.37±28.84 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Square Shaped-I (Fig. B)
Hypodermis: Single layered sclerenchymatous
With III^{o} PVB embedded
Type-B sclerenchyma present
Ground tissue: Round to oval shaped Parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type E (Fig. E)
Size: 15x18.75±4.25 µm
II^{o} IVB: Type N (Fig. D)
Size: 10.36x14.93±4.72 µm
III^{o} PVB: Type Q
Size: 7.5x9.87±4.83 µm
Bar size: A = 50 µm, B-E = 5 µm



13. *Heteropogon contortus var. contortus sub var. typicus*

Fig. 65



14. *Heteropogon contortus var. contortus sub var. genuinus*

15. *Heteropogon ritchiei* (Fig. 66(15) A-F)

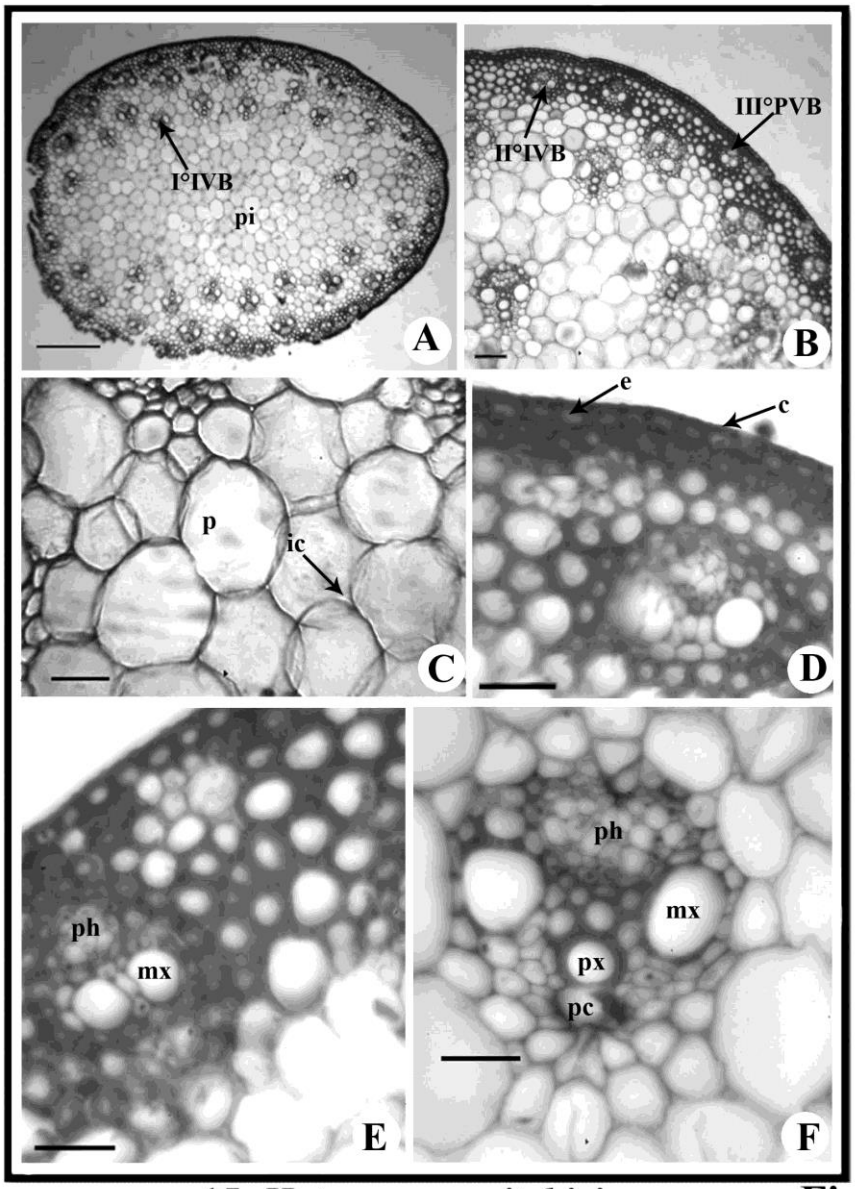
Oblong in transection with slightly undulating surface (Fig. A)
Size: 260x335±35.59 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Rectangular Shaped-III (Fig. D)
Hypodermis: 5-6 layered sclerenchymatous (Fig. B)
With III^{o} PVB embedded
Type-B, E sclerenchyma present
Bicylindrical pattern
Ground tissue: Round to oval shaped Parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type I (Fig. F)
Size: 19.61x18.07±3.28 µm
II^{o} IVB: Type M (Fig. E)
Size: 10.84x13.34±4.18 µm
III^{o} PVB: Type Q
Size: 9.23x10±3.75 µm
Bar size: A = 50 µm, B = 10µm, C-F = 5 µm

16. *Heteropogon triticeus* (Fig. 66(16) A-F)

Oval to round in transection with smooth surface (Fig. A)
Size: 1155.56x1444.45±47.28 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Barrel Shaped-IV (Fig. C)
Hypodermis: 3-4 layered sclerenchymatous
With III^{o} PVB embedded
Type-B sclerenchyma present
Ground tissue: Round to oval shaped Parenchymatous (Fig. B)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymatous cap present (Fig. F)
Size: 25x27.27±5.18 µm
II^{o} IVB: Type N (Fig. E)
Size: 16.67x16.78±5.38 µm
III^{o} PVB: Type Q (Fig. D)
Size: 10.5x14±3.28 µm
Bar size: A = 50 µm, B-F = 5 µm

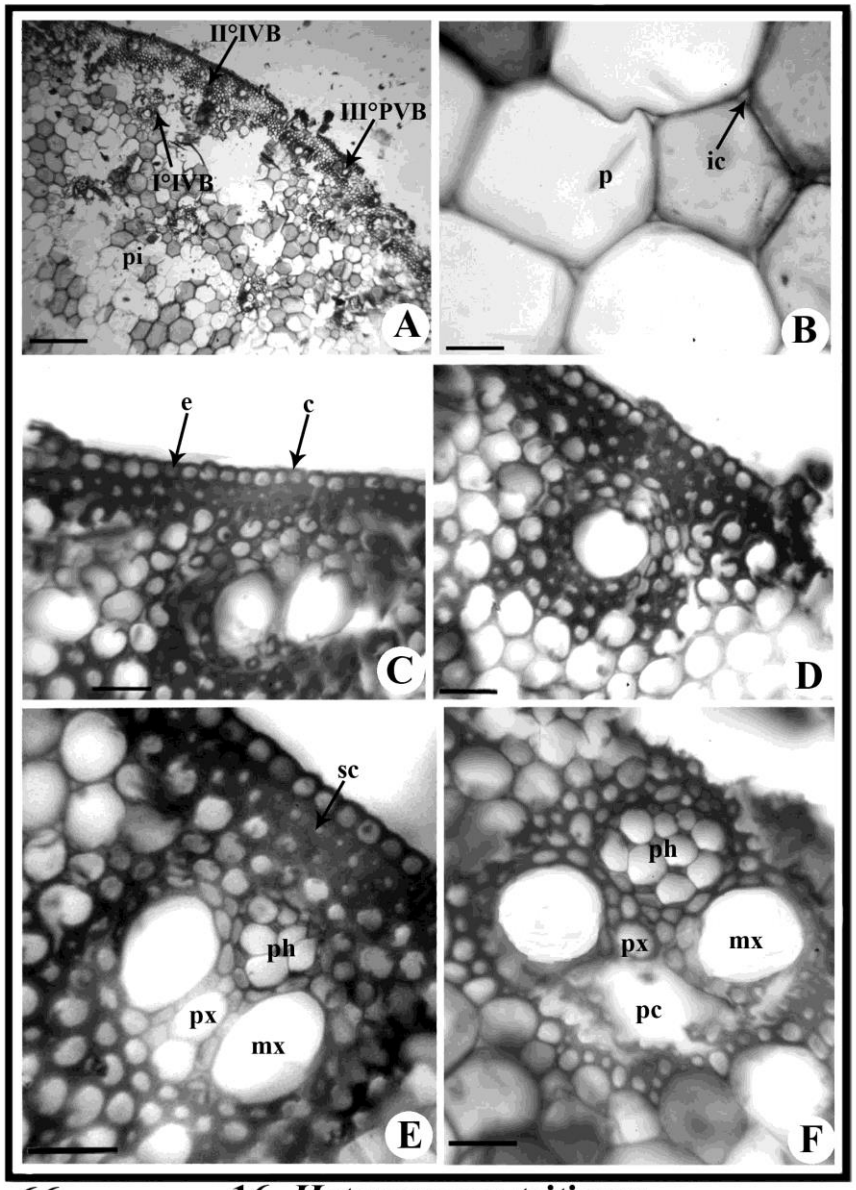
Differentiating features:

Sclerenchyma in form of bicylinder…….. *H. ritchiei*
Sclerenchyma in form of unicylinder
Square shaped epidermal cell....*H. contortus var. genuinus sub var. hispidissimus*
Barrel shaped epidermal cell
Sclerenchyma type E present ...….. *H. contortus* var. *genuinus* sub var. *typicus*
Sclerenchyma type B present……...……*H. triticeous*



15. *Heteropogon ritchiei*

Fig. 66



16. *Heteropogon triticeus*

17. *Imperata cylindrica* (Fig. 67(17) A-F)

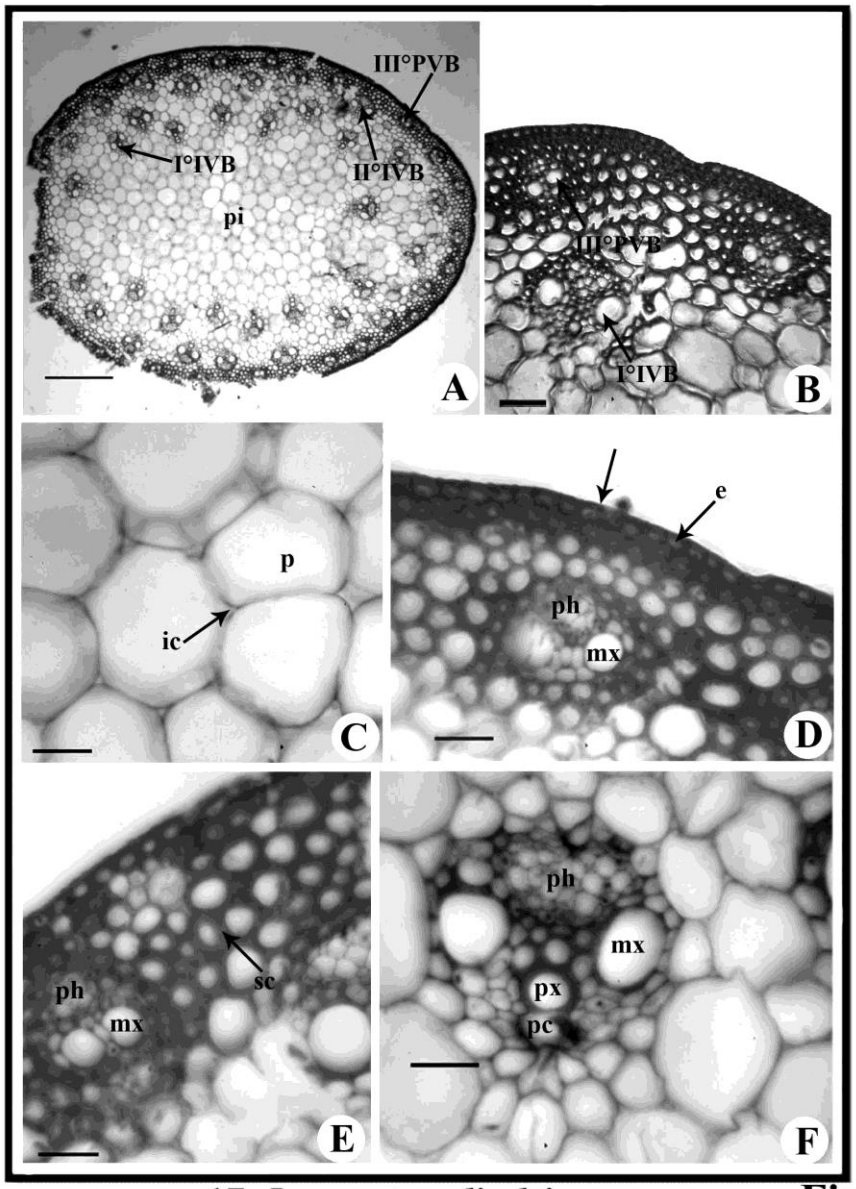
Oblong in transection with slightly undulating surface (Fig. A)
Size: 183x118.27±34.25 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Barrel Shaped-V (Fig.)D
Hypodermis: 5-6 layered sclerenchymatous (Fig. B)
With III^{o} PVB embedded
Type-B, E sclerenchyma present (Fig. E)
Ground tissue: Round to oval shaped Parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type H, sclerenchymatous cap present (Fig. F)
Size: 22.5x20±4.27 µm
II^{o} IVB: Type O (Fig. E)
Size: 11.12x13.89±2.78 µm
III^{o} PVB: Type Q
Size: 6x5.71±1.39 µm
Bar size: A = 50 µm, B = 10 µm, C-F = 5 µm

Ischaemum

18. *Ischaemum indicus*
19. *Ischaemum molle*
20. *Ischaemum pilosum*
21. *Ischaemum rugosum*

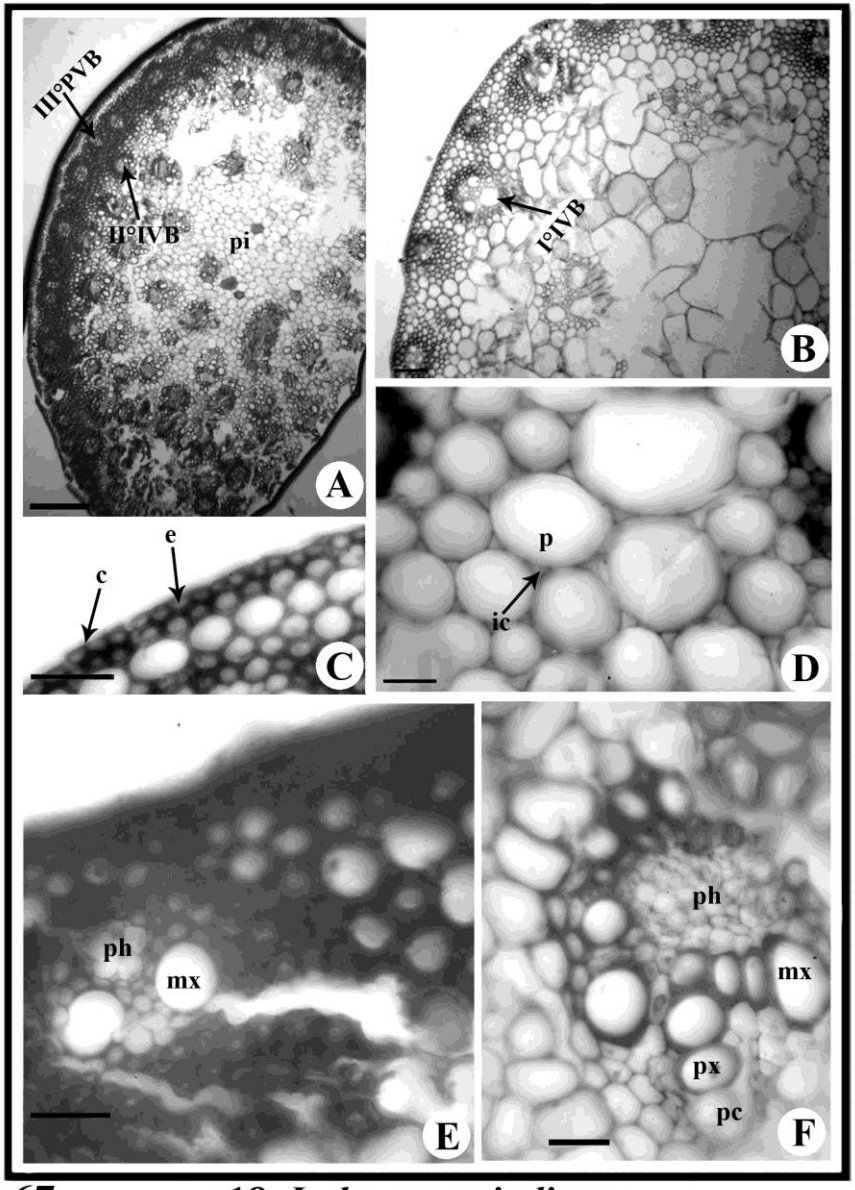
18. *Ischaemum indicus* (Fig. 67(18) A-F)

Elliptical in transection with smooth surface (Fig. A)
Size: 280x420±21.38 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Barrel Shaped-IV (Fig. C)
Hypodermis: 3-4 layered sclerenchymatous (Fig. B)
With III^{o} PVB embedded
Type-E sclerenchyma present
Ground tissue: Round to oval shaped Parenchymatous (Fig. D)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type D (Fig. F)
Size: 27.5x23±6.28 µm
II^{o} IVB: Type P (Fig. E)
Size: 9.6x11.6±2.74 µm
III^{o} PVB: Type Q
Size: 6.26x7.93±1.83 µm
Bar size: A = 50 µm, B = 10 µm, C-F = 5 µm



17. *Imperata cylindrica*

Fig. 67



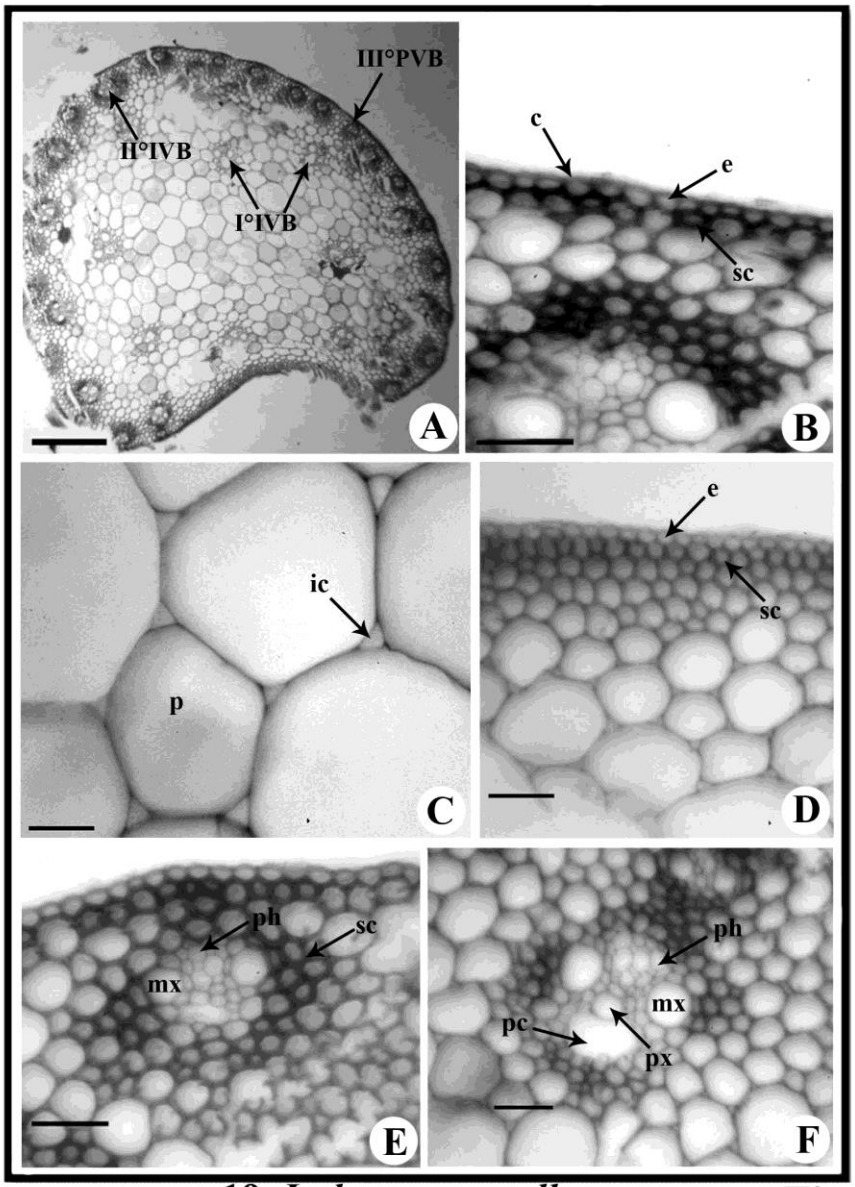
18. *Ischaemum indicum*

19. *Ischaemum molle* (Fig. 68(19) A-F)

Heart in transection with smooth surface (Fig. A)
Size: 216x224±34.87 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Barrel Shaped-IV (Fig. B, D)
Hypodermis: 2-3 layered sclerenchymatous
With III^{o} PVB embedded
Type-D sclerenchyma present (Fig. B)
Ground tissue: Round to oval shaped Parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymatous cells present (Fig. F)
Size: 15.5x16±3.8 µm
II^{o} IVB: Type K (Fig. E)
Size: 8.6x12.4±3.19 µm
III^{o} PVB: Type Q
Size: 4.38x6.15±1.83 µm
Bar size: A = 50 µm, B-F = 5 µm

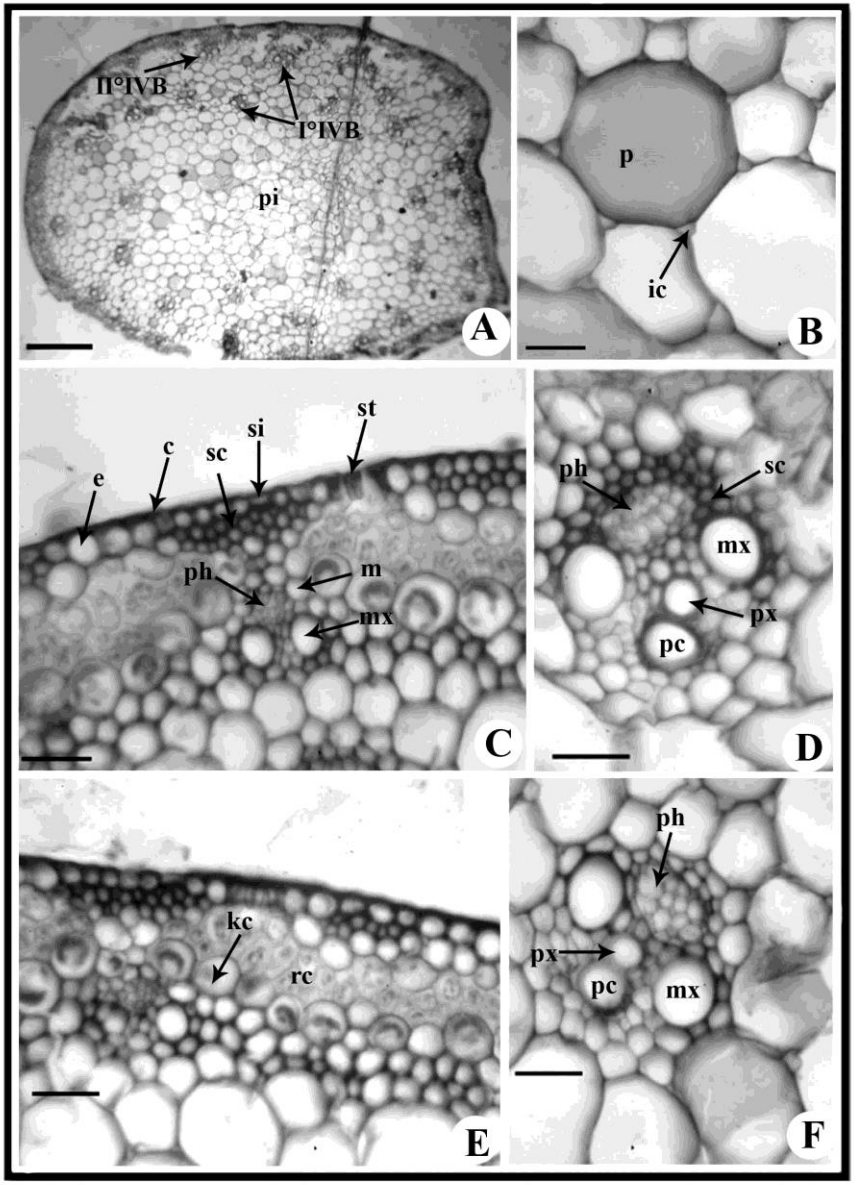
20. *Ischaemum pilosum* (Fig. 68(20) A-F)

Oblong in transection with smooth surface (Fig. A)
Size: 250±331.82±41.73 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith. Kranz anatomy present.
Epidermis: Elongated Shaped-II (Fig. C)
Hypodermis: 3-4 layered chlorenchymatous
Interrupted by sclerenchymatous cells
Type-B sclerenchyma present
Ground tissue: Round to oval shaped Parenchymatous (Fig. B)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type I (Fig. F, D)
Size: 250±331.82±41.73 µm
II^{o} IVB: Type M
Size: 12.73x13.82±3.28 µm
III^{o} PVB: Type Q (Fig. C)
Size: 7.27x6.36±2.73 µm
Kranz arc: Half circle (Fig. E)
Chloroplast type: Centrifugal
Shape of kranz cell: Round to oval (Fig. E) **Mestome:** Single layered
Bar size: A = 50 µm, B-F = 5 µm



19. *Ischaemum molle*

Fig. 68



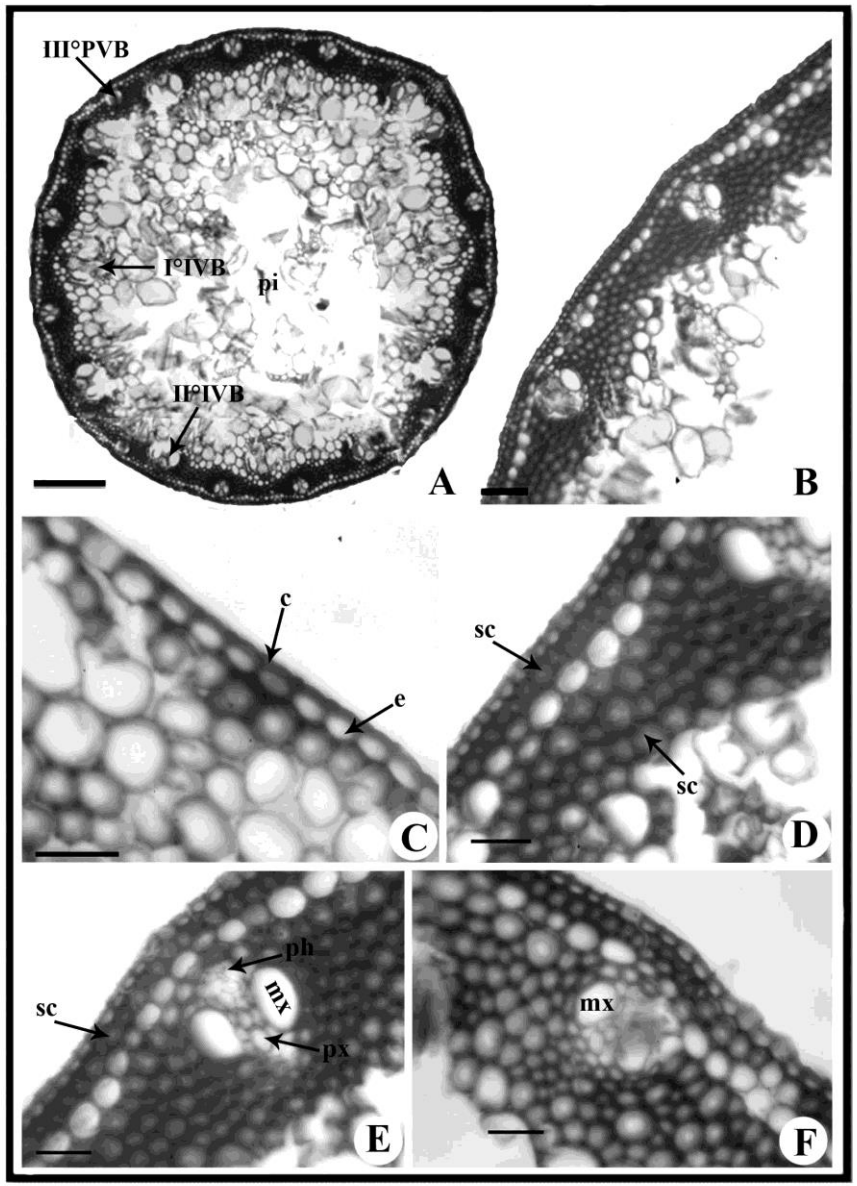
20. *Ischaemum pilosum*

21. *Ischaemum rugosum* (Fig. 69(21) A-F)

Round in transection with smooth surface (Fig. A)
Size: 330.43x321.74±15.12 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Barrel Shaped-V (Fig. C)
Hypodermis: Single layered parenchymatous
Than 4-5 layered sclerenchymatous (Fig. B)
With III^{o} PVB embedded
Type-B sclerenchyma present (Fig. D)
Ground tissue: Round to oval shaped Parenchymatous
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymatous cap present
Scatterly arranged
Size: 24.63x22.37±4.62 µm
II^{o} IVB: Type P (Fig. E)
Size: 9.55x8.64±2.16 µm
III^{o} PVB: Type Q (Fig. F)
Size: 8.89x10±1.63 µm
Bar size: A = 50 µm, B = 10 µm, C-F = 5 µm
Differentiating features:
Presence of kranz arc……..…… *I. pilosum*
Absence of kranz arc
Sclerenchyma type B present…….…… *I. rugosum*
Sclerenchyma type D present
Elliptical shaped in transection……..……. *I. indicus*
Heart shaped in transection…….…… *I. molle*

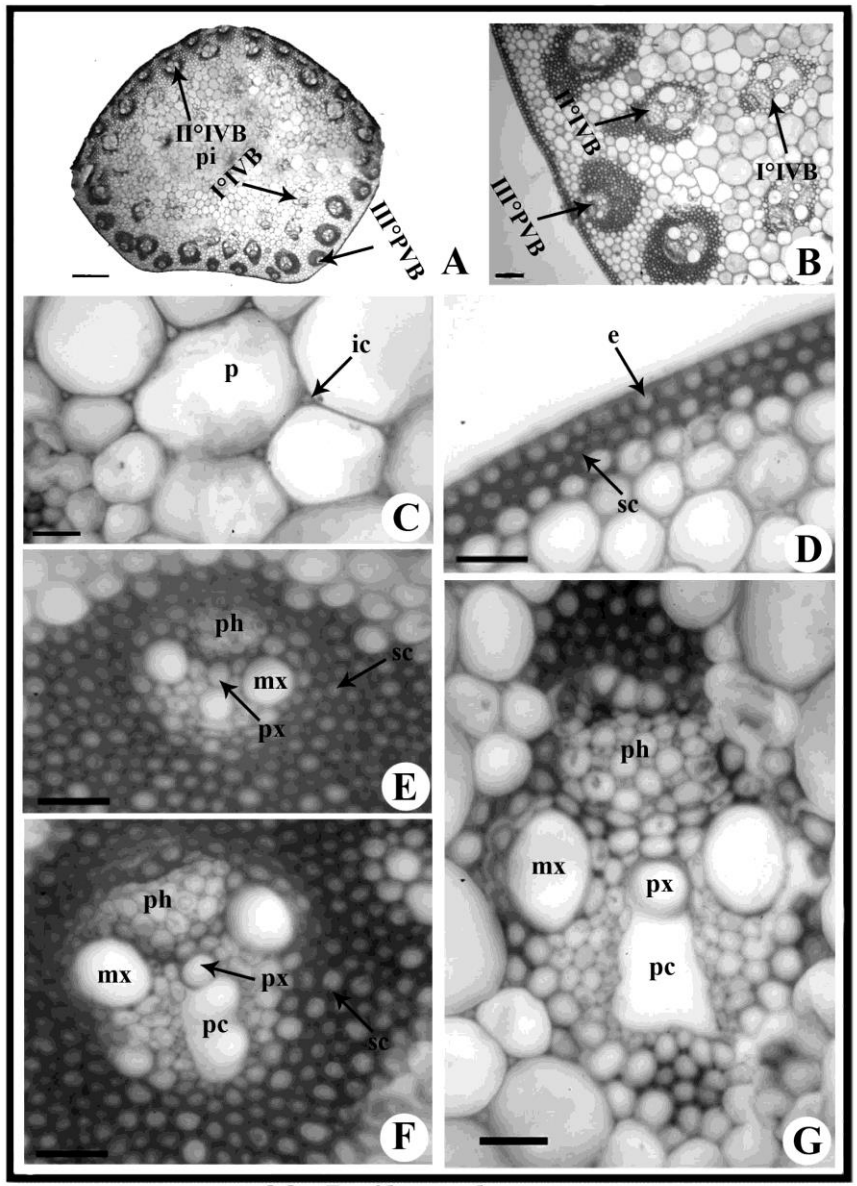
22. *Iseilema laxum* (Fig. 69(22) A-G)

Oval in transection with distal concave end, smooth surface (Fig. A)
Size: 333.34x416.67±24.38 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Square Shaped-I (Fig. D)
Hypodermis: 2 layered sclerenchymatous (Fig. B)
With III^{o} PVB embedded
Type-D sclerenchyma present
Ground tissue: Round to oval shaped Parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type C, sclerenchymatous cap present (Fig. F, G)
Size: 35.45x24.54±7.19 µm
II^{o} IVB: Type M (Fig. E)
Size: 16.25x18.18±4.17 µm
III^{o} PVB: Type Q
Size: 10.91x13.18±2.74 µm
Bar size: A = 50 µm, B = 10 µm, C-G = 5 µm



21. *Ischaemum rugosum*

Fig. 69



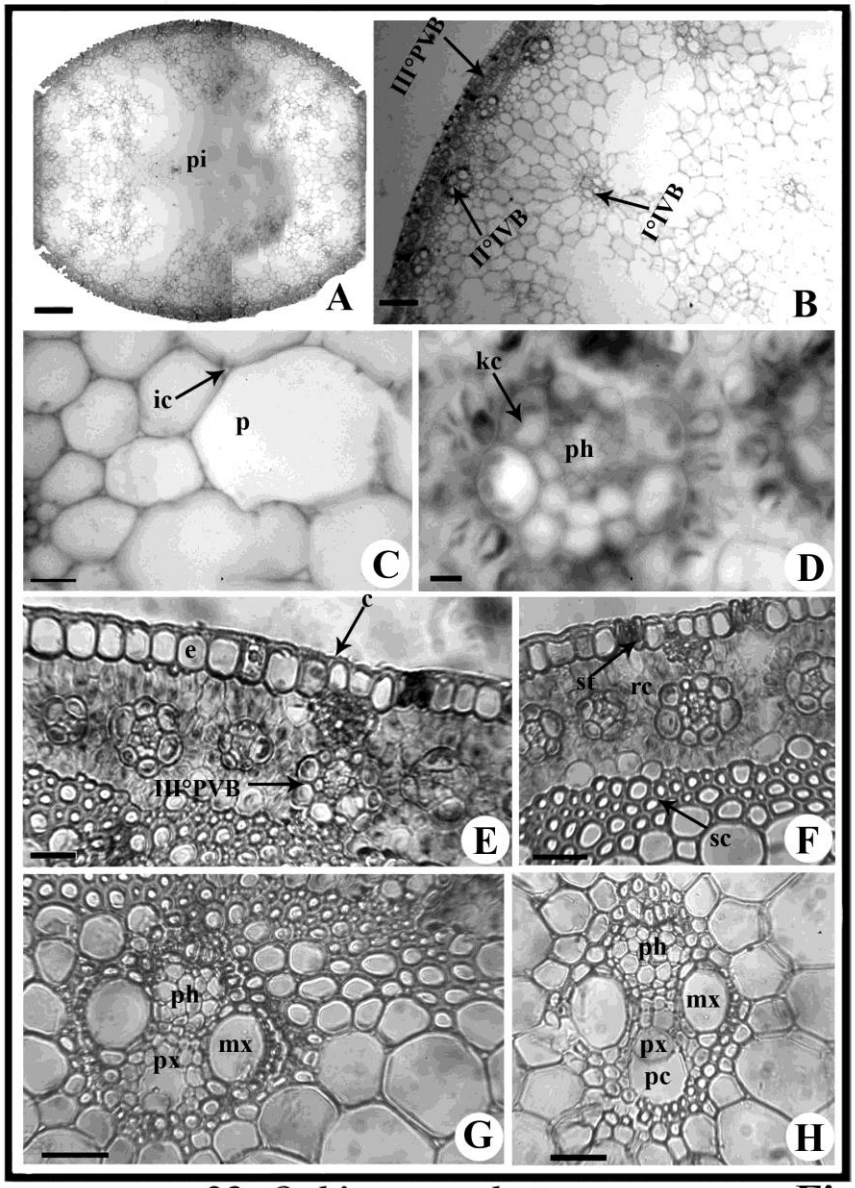
22. *Iseilema laxum*

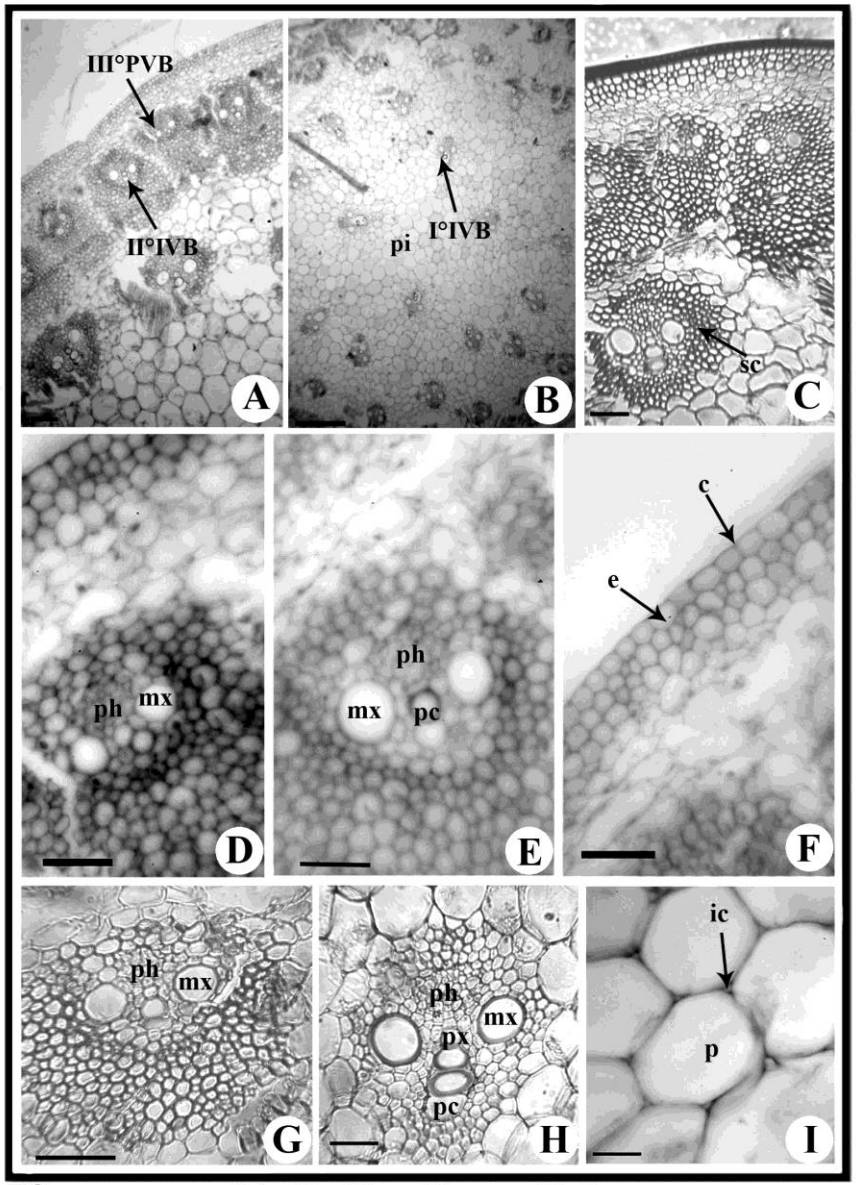
23. *Ophiuros exaltatu* (Fig. 70(23) A-H)

Oval in transection with slightly undulating surface (Fig. A)
Size: 480x545±38.17 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith. Kranz anatomy is present.
Epidermis: Elonagated Shaped-I (Fig. E)
Hypodermis: 5-6 layered chlorenchymatous (Fig. B)
Interrupted by sclerenchymatous girder
With III^{o} PVB embedded
Type-E sclerenchyma present
Ground tissue: Round to oval shaped Parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B (Fig. H, G)
Scaterlly arranged
Size: 22.78x18.34±5.28 µm
II^{o} IVB: Type P
Size: 17.5x17±3.97 µm
III^{o} PVB: Type Q (Fig. E)
Size: 3.82x4.12±1.82 µm
Kranz arc: Circle (Fig. E)
Chloroplast type: Centrifugal
Shape of kranz cell: Round to oval (Fig. D) **Mestome:** Single layered
Bar size: A = 50 µm, B = 10 µm, C-H = 5 µm

24. *Rottboellia exaltata* (Fig. 70(24) A-I)

Oval in transaction (Fig. A)
Size: 367.28x227.18±24.37 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Barrel Shaped-III (Fig. F)
Hypodermis: 2-3 layered sclerenchymatous
With III^{o} PVB embedded
Type-D sclerenchyma present (Fig. C)
Ground tissue: Angular shaped Parenchymatous (Fig. B, I)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type G (Fig. H)
Scatterly arranged
Size: 24.37x21.25±3.17 µm
II^{o} IVB: Type M (Fig. G)
Size: 8.27x10.17±3.19 µm
III^{o} PVB: Type Q (Fig. D)
Size: 7.83x8.69±3.71 µm
Bar size: A-C = 50 µm, D-I = 5 µm





23. *Ophiuros exaltatus* **Fig. 70** **24. *Rottboellia exaltata***

25. *Saccharum spontanum* (Fig. 71(25) A-F)

Round in transection with slightly undulating surface (Fig. A)
Size: 305x355±21.79 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Rectangular Shaped-III (Fig. E)
Hypodermis: 1-2 layered sclerenchymatous
And parenchyma cells with III^{o} PVB embedded
Type-D sclerenchyma present
Ground tissue: Round to oval shaped Parenchymatous (Fig. B, C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type C sclerenchymatous cap present (Fig. F)
Size: 17.5x25±5.72 µm
II^{o} IVB: Type M
Size: 15.03x15.04±3.16 µm
III^{o} PVB: Type Q (Fig. D)
Size: 7.69x4.62±1.92 µm
Bar size: A = 50 µm, B = 10 µm, C-F = 5 µm

Sehima

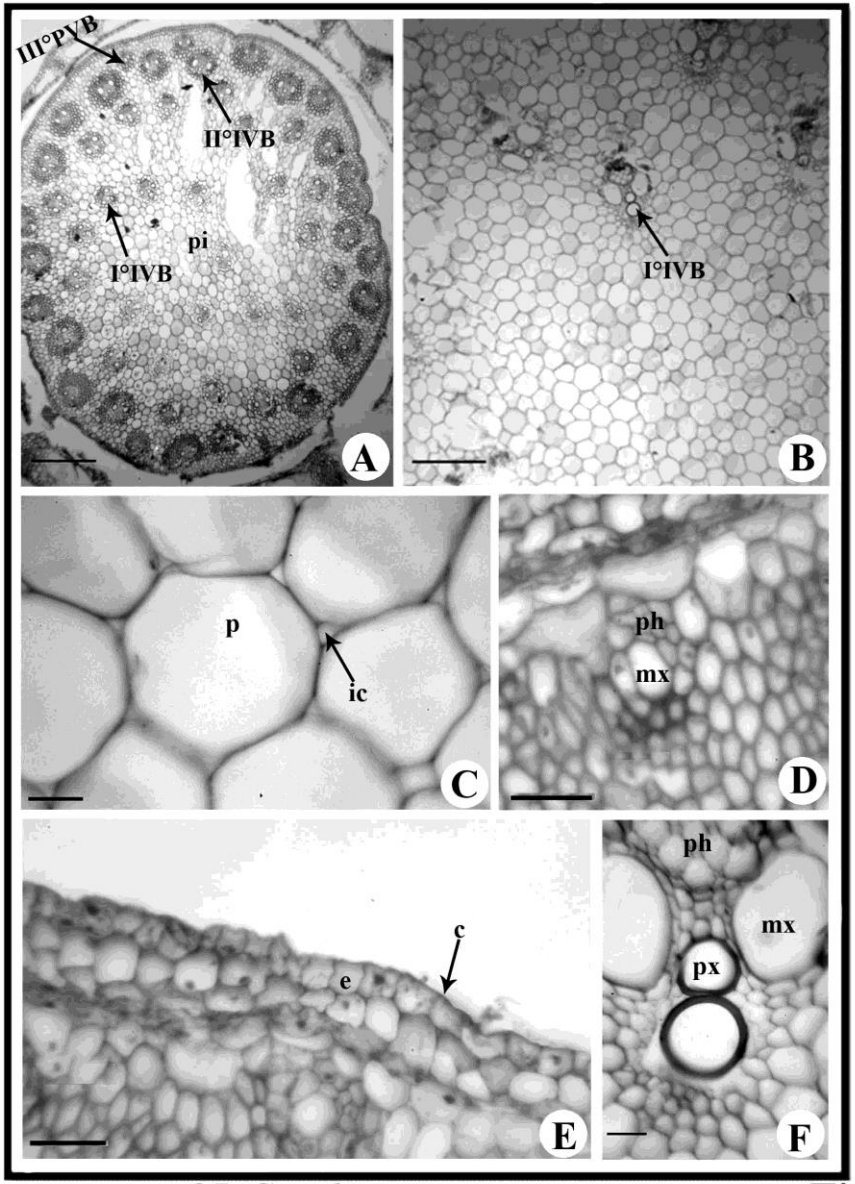
26. *Sehima ischaemoides*

27. *Sehima nervosum*

28. *Sehima sulcatum*

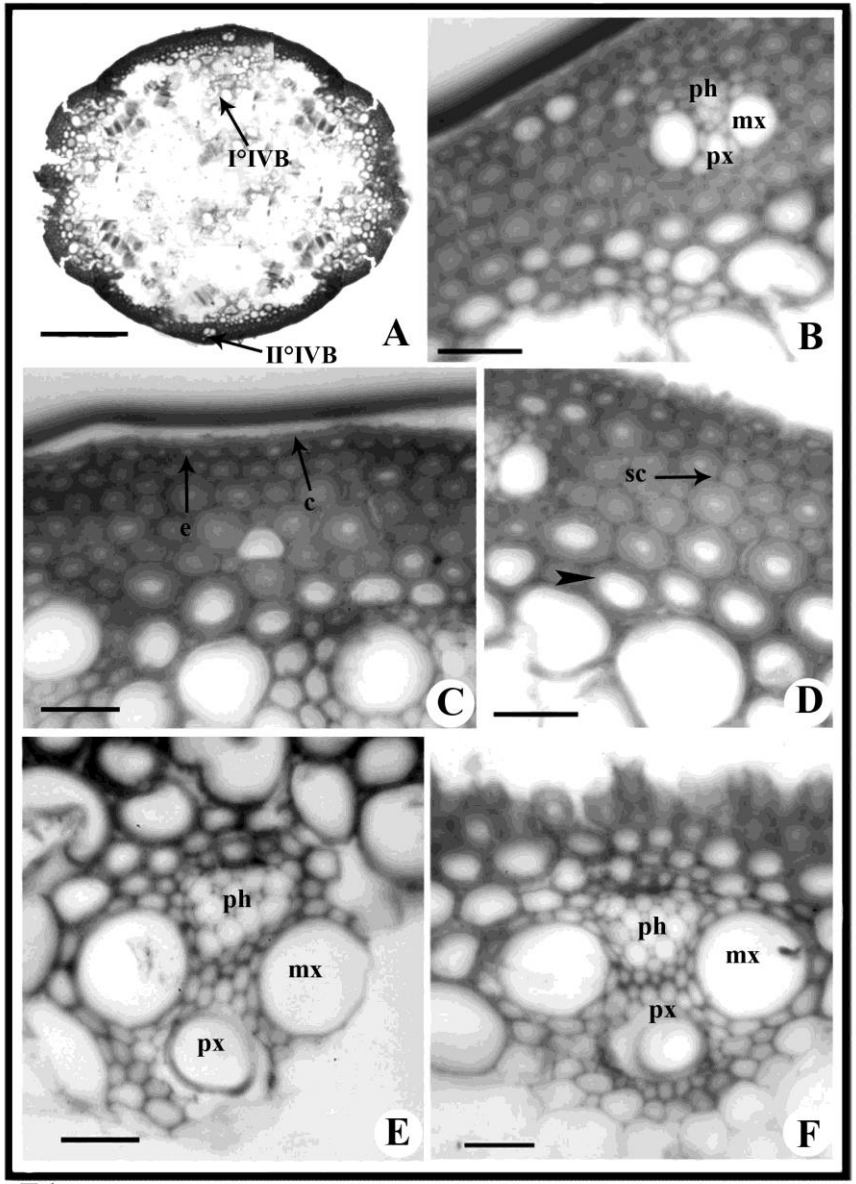
26. *Sehima ischaemoides* (Fig. 71(26) A-F)

Round to oval in transection with slightly undulating surface (Fig. A)
Size: 203.57x214.28±18.36 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Barrel Shaped-V (Fig. C)
Hypodermis: 5-6 layered sclerenchymatous
With III^{o} PVB embedded
Type-B sclerenchyma present (Fig. D)
Ground tissue: Round to oval shaped
Parenchymatous,
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type E (Fig. E, F)
Size: 17.39x25.22±4.28 µm
II^{o} IVB: Type P (Fig. B)
Size: 8.26x7.93±2.71 µm
III^{o} PVB: Type Q
Size: 5.19x7.41±2.71 µm
Bar size: A = 50 µm, B-F = 5 µm



25. *Saccharum spontaneum*

Fig. 71



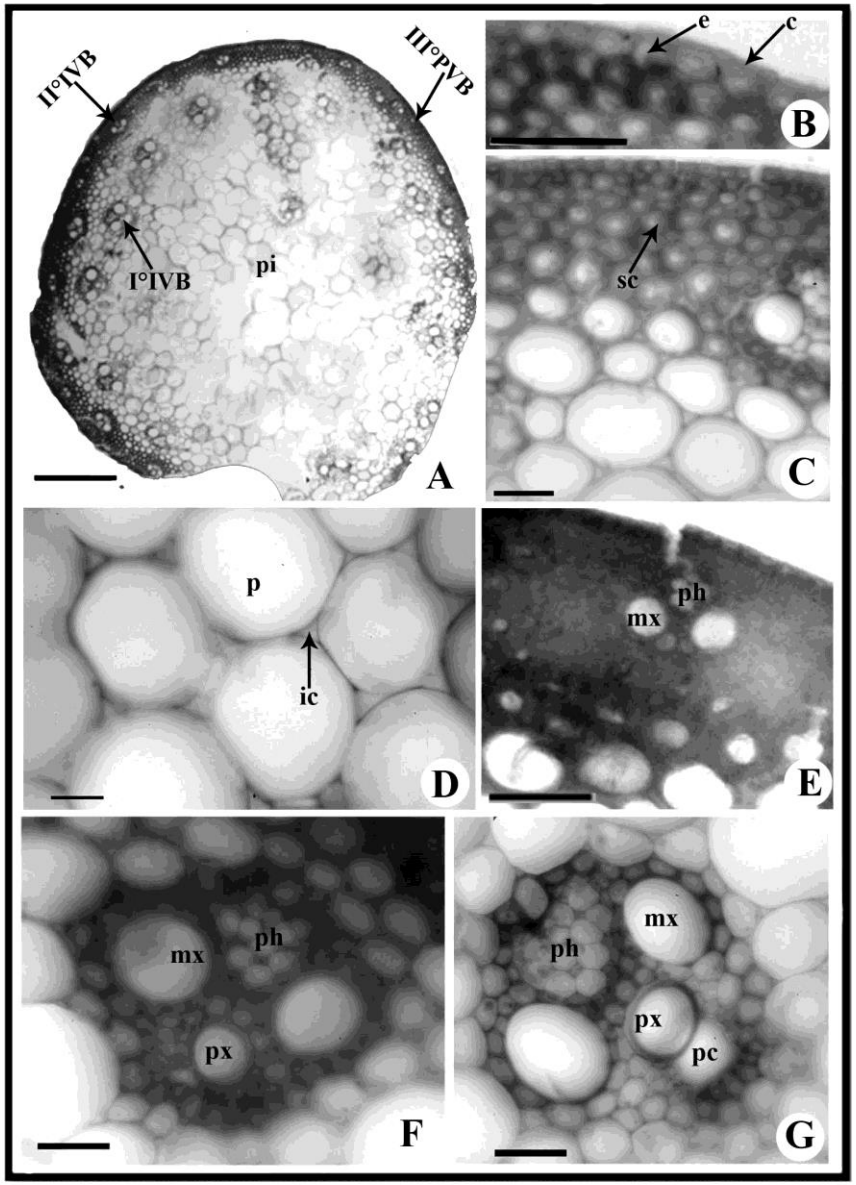
26. *Sehima ischaemoides*

27. *Sehima nervosum* (Fig. 72 (27) A-G)

Round in transection with smooth surface (Fig. A)
Size: 257.41x259.26±24.63 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Barrel Shaped-V (Fig. B)
Hypodermis: 5-6 layered sclerenchymatous
With III^{o} PVB embedded
Type-B sclerenchyma present (Fig. C)
Ground tissue: Round to oval shaped Parenchymatous (Fig. D)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type C, sclerenchymatous cap present (Fig. G)
Size: 21.74x20.22±6.26 µm
II^{o} IVB: Type P (Fig. F)
Size: 17.08x21.25±3.71 µm
III^{o} PVB: Type Q (Fig. E)
Size: 3.94x5.76±1.52 µm
Bar size: A = 50 µm, B-G = 5 µm

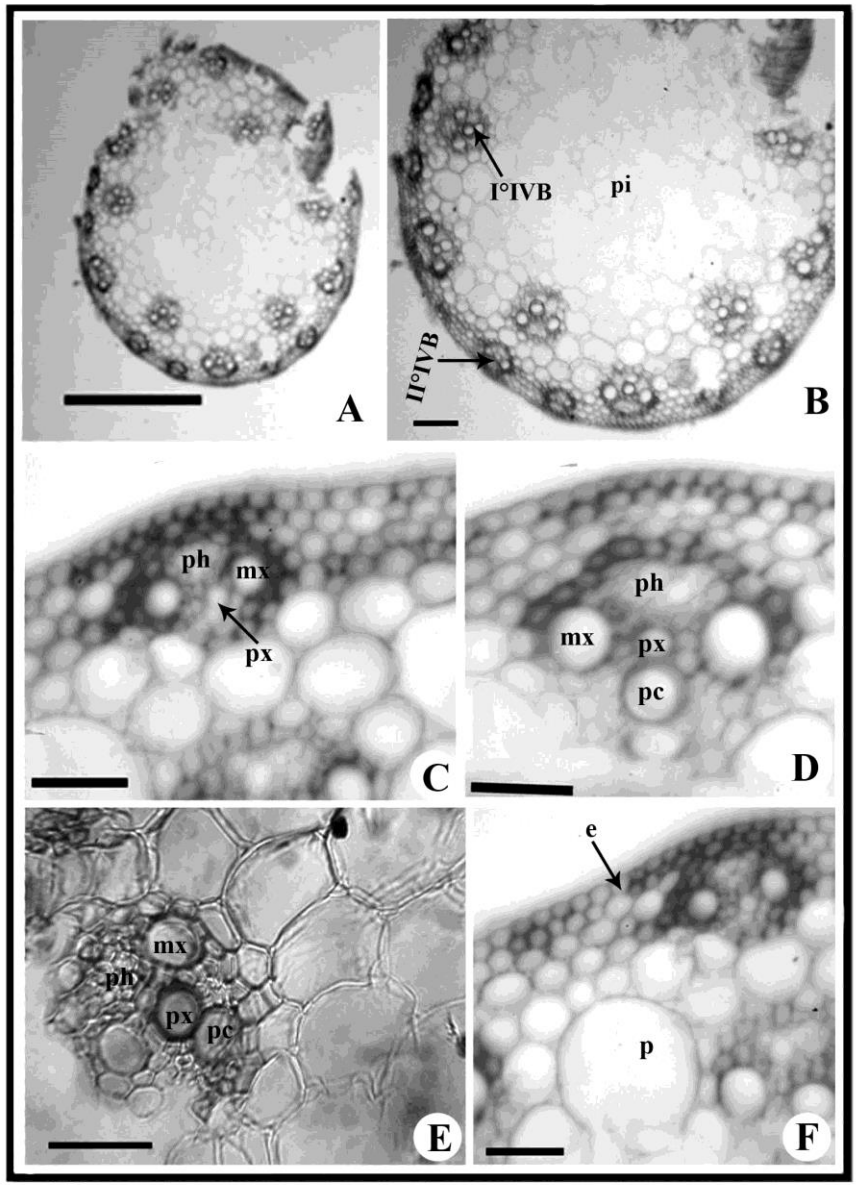
28. *Sehima sulcatum* (Fig. 72(28) A-F)

Round in transection with slightly undulating surface (Fig. A)
Size: 127.27x102.27±11.72 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Barrel Shaped-III
Hypodermis: 2-3 layered sclerenchymatous in form of girder (Fig. B)
Type-D sclerenchyma present
Ground tissue: Round to oval shaped Parenchymatous (Fig. F)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type C, sclerenchymatous cells present (Fig. D, E)
Size: 11.67x13.94±2.78 µm
II^{o} IVB: Type P (Fig. C)
Size: 6.34x8.34±2.19 µm
III^{o} PVB: Type Q
Size: 4.27x4.07±1.18 µm
Bar size: A = 50 µm, B = 10 µm, C-F = 5 µm
Differentiating features:
Sclerenchyma in form of girder…..……. *S. sulcatum*
Sclerenchyma in form of unicylinder
Inverted triangular shaped I°IVB……..…… *S. ischaemoides*
Triangular diamond shaped I°IVB……..…… *S. nervosum*



27. *Sehima nervosum*

Fig. 72



28. *Sehima sulcatum*

29. *Sorghum halepense* (Fig. 73(29) A-F)

Round in transection with slightly undulating surface (Fig. A)

Size: 1765x1877.5±32.78 µm, Hairs/Prickles absent.

Solid internode with parechymatous pith.

Epidermis: Rectangular Shaped-I (Fig. B)

Hypodermis: 1-2 layered sclerenchymatous in form of girder

Type-D sclerenchyma present

Ground tissue: Round to oval shaped parenchymatous (Fig. C)

Vascular bundles arranged in ring form

Vascular system: all present

Iº IVB: Type I, sclerenchymatous cells present (Fig. E, F)

Size: 19.13x25.22±5.27 µm

IIº IVB: Type K (Fig. D)

Size: 17.27x21.82±4.87 µm

IIIº PVB: Type Q

Size: 4.55x4.31±1.64 µm

Bar size: A = 50 µm, B-F = 5 µm

30. *Thelepogn elegans* (Fig. 73(30) A-F)

Round in transection with slightly undulating surface (Fig. A)

Size: 500x550±16.62 µm, Hairs/Prickles absent.

Solid internode with parechymatous pith.

Epidermis: Elongated Shaped-I (Fig. C)

Hypodermis: 2-3 layered sclerenchymatous interrupted by parenchyma cells

Type-D sclerenchyma present

Ground tissue: Angular parenchymatous (Fig. B)

Vascular bundles arranged in ring form

Vascular system: all present

Iº IVB: Type B, sclerenchymatous cells present (Fig. F)

Size: 16.67x21.43±3.17 µm

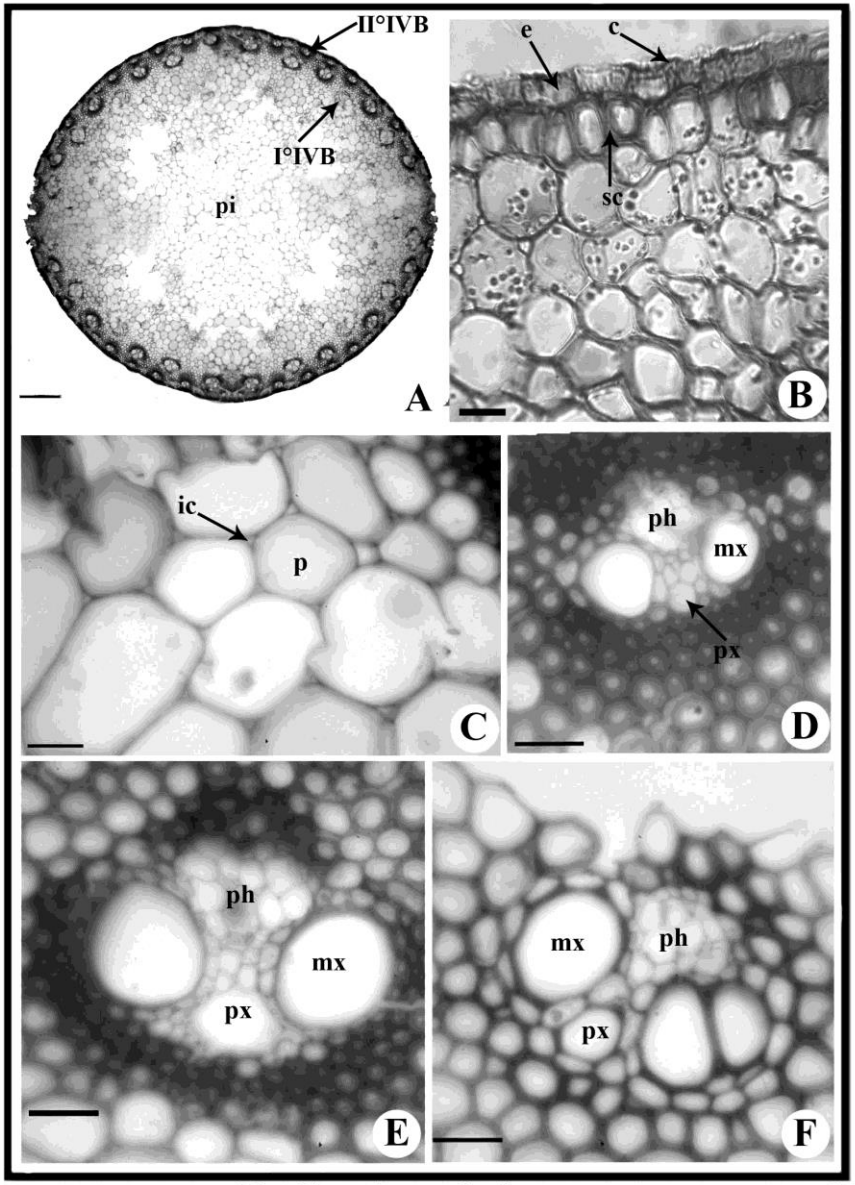
IIº IVB: Type P (Fig. E)

Size: 7.67x10±2.73 µm

IIIº PVB: Type Q

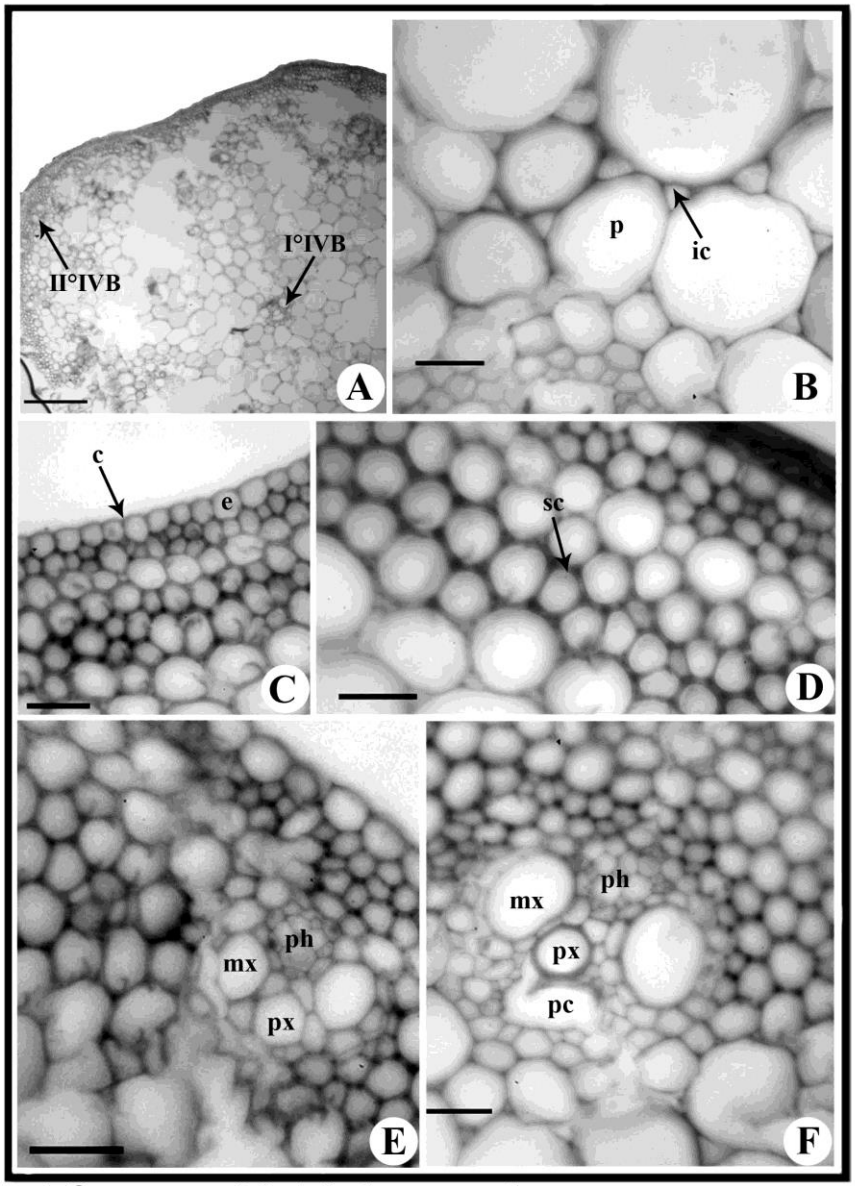
Size: 6.82x5.93±2.23 µm

Bar size: A = 50 µm, B-F = 5 µm



29. *Sorghum halepense*

Fig. 73



30. *Thelepogn elegans*

Themeda

31. *Themeda cymbaria*

32. *Themeda laxa*

33. *Themeda triandra*

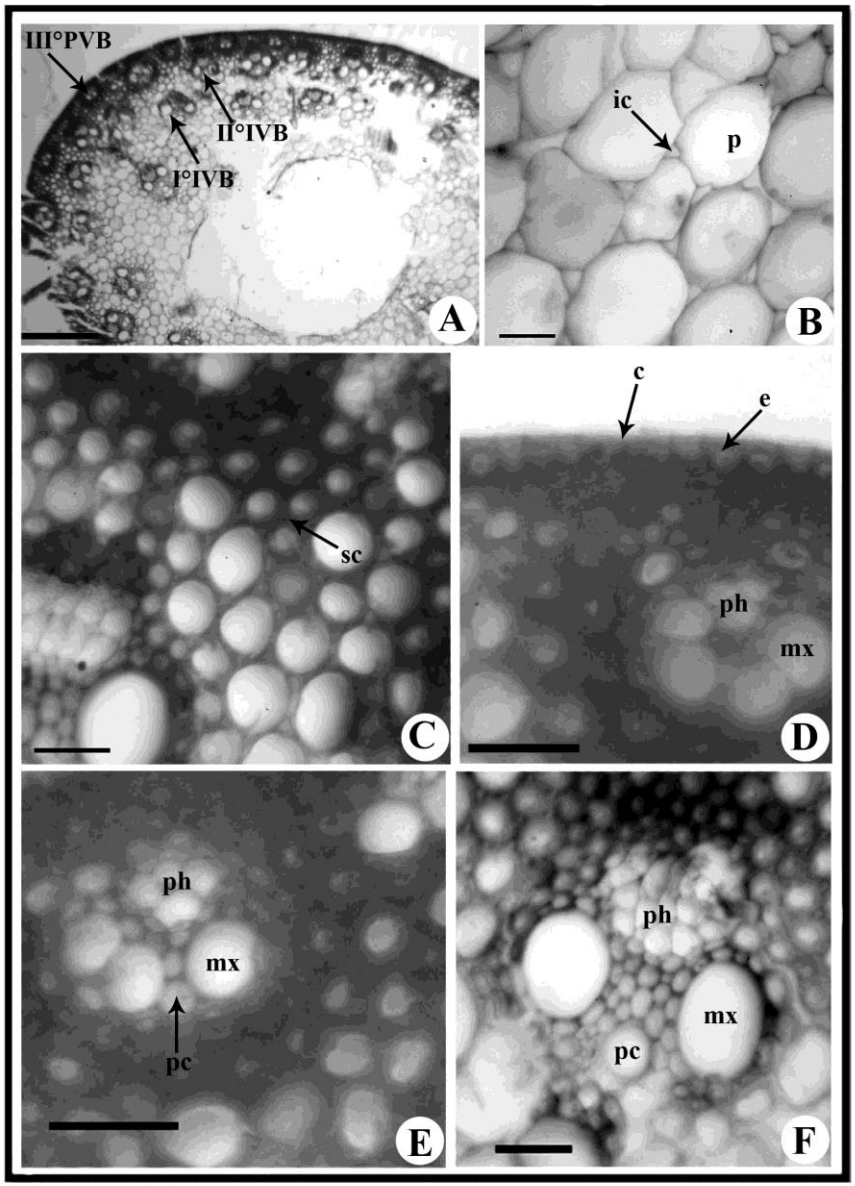
34. *Themeda quadrivalvis*

31. *Themeda cymbaria* (Fig. 74(31) A-F)

Round in transection with slightly undulating surface (Fig. A)
Size: 269.23x369.23±31.73 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Square Shaped-I (Fig. D)
Hypodermis: 6-7 layered sclerenchymatous
With III^{o} PVB embedded
Type-E sclerenchyma present (Fig. C)
Ground tissue: Round to oval shaped parenchymatous (Fig. B)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymatous cap present (Fig. F)
Size: 20x19.58±2.73 µm
II^{o} IVB: Type K (Fig. E)
Size: 8.28x5.84±2.74 µm
III^{o} PVB: Type Q
Size: 6.86x10.29±1.37 µm
Bar size: A = 50 µm, B-F = 5 µm

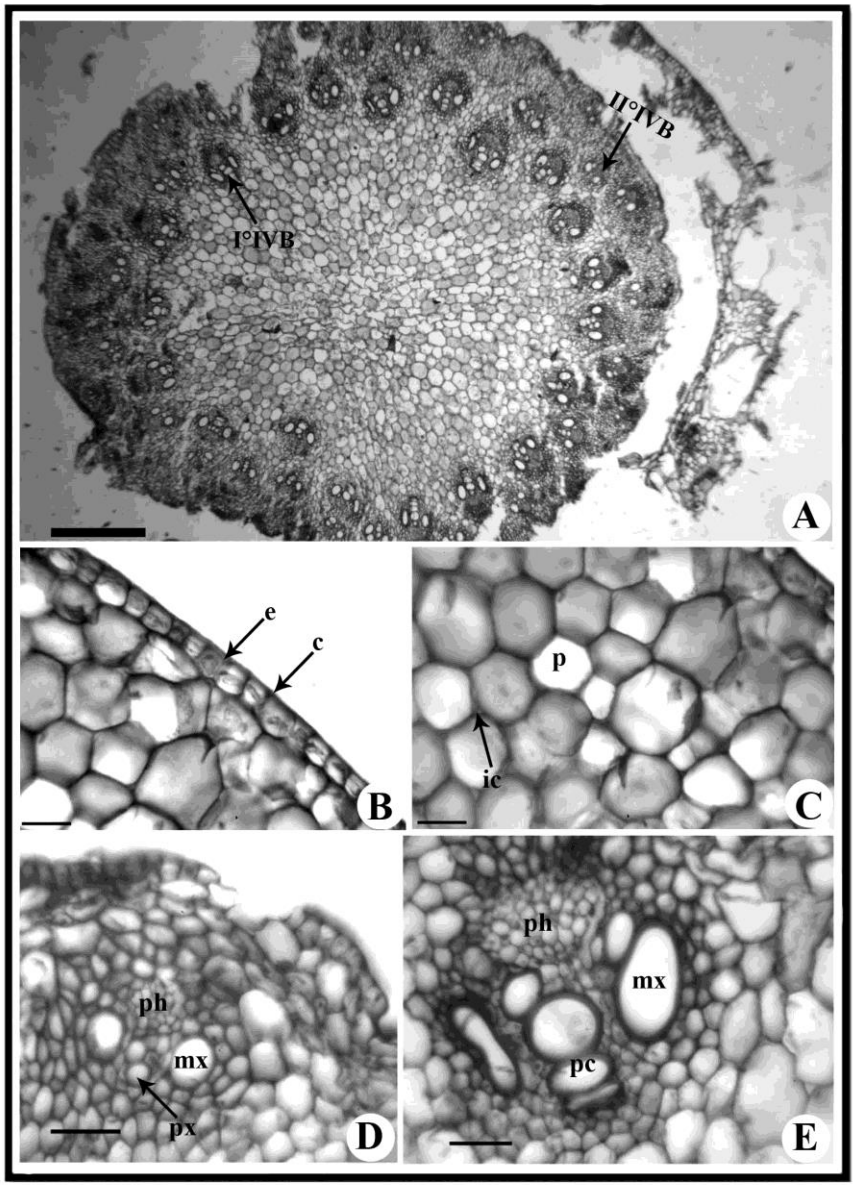
32. *Themeda laxa* (Fig. 74(32) A-E)

Round in transection with slightly undulating surface (Fig. A)
Size: 275x318.75±25.38 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Square Shaped-II (Fig. B)
Hypodermis: 1-2 layered sclerenchymatous
Than angular parenchyma present
Type-D sclerenchyma present
Ground tissue: Angular parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: III^{o} PVB absent
I^{o} IVB: Type I, sclerenchymatous cap present (Fig. E)
Size: 25x24.17±8.78 µm
II^{o} IVB: Type P (Fig. D)
Size: 9.63x11.36±3.18 µm
III^{o} PVB: -
Size: -
Bar size: A = 50 µm, B-E = 5 µm



31. *Themeda cymbaria*

Fig. 74



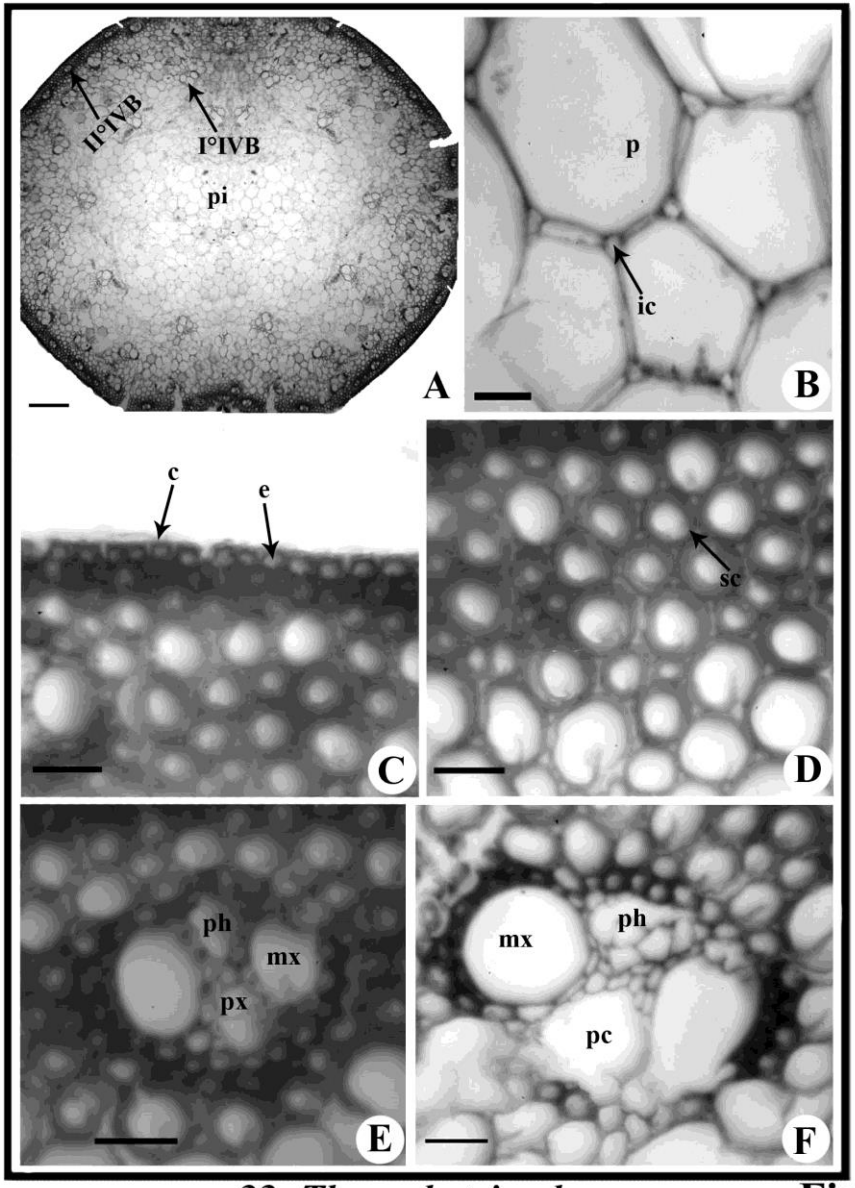
32. *Themeda laxa*

33. *Themeda triandra* (Fig. 75(33) A-F)

Round in transection with smooth surface (Fig. A)
Size: 305x362±11.28 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Rectangular Shaped-III (Fig. C)
Hypodermis: 7-8 layered sclerenchymatous
With III^{o} PVB embedded
Type-B, E sclerenchyma present (Fig. D)
Ground tissue: Angular parenchymatous (Fig. B)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type E, sclerenchymatous cells present (Fig. F)
Size: 19.77x27.5±7.21 µm
II^{o} IVB: Type P (Fig. E)
Size: 13.46x16.15±4.26 µm
III^{o} PVB: Type Q
Size: 8.27x8.92±2.81 µm
Bar size: A = 50 µm, B-F = 5 µm

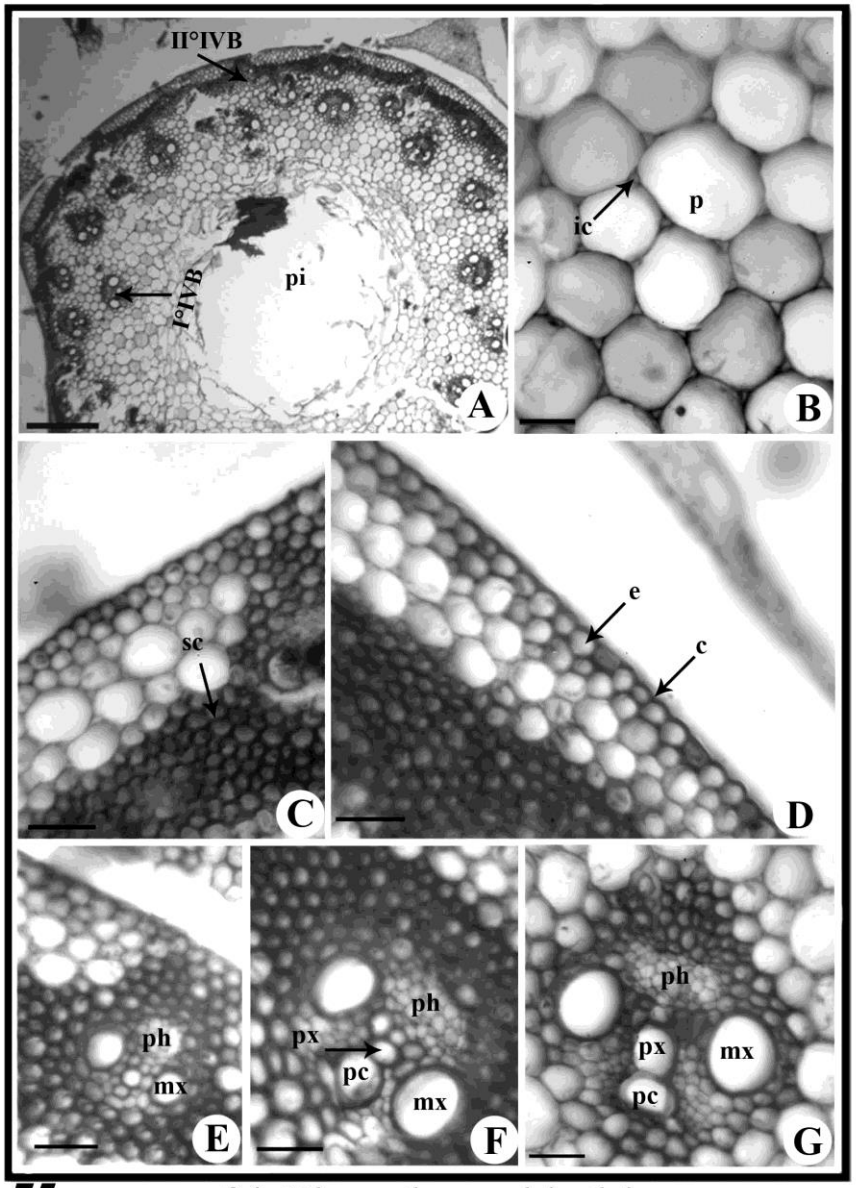
34. *Themeda quadrivalvis* (Fig. 75(34) A-G)

Round in transection with slightly undulating surface (Fig. A)
Size: 390.91x363.64±25.81 µm, Hairs/Prickles absent.
Hollow internode.
Epidermis: Elongated Shaped-II (Fig. D)
Hypodermis: 3-4 layered parenchymatous
7-8 layered sclerenchyma
With III^{o} PVB embedded
Type-B sclerenchyma present (Fig. C)
Ground tissue: Round to oval shaped parenchymatous (Fig. B)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type A, sclerenchymatous cap present (Fig. G)
Surrounded by sclerenchyma
Size: 24.71x24.71±6.17 µm
II^{o} IVB: Type P (Fig. F)
Surrounded by sclerenchyma
Size: 12.95x16.36±3.19 µm
III^{o} PVB: Type Q (Fig. E)
Size: 9.5x10.5±3.47 µm
Bar size: A = 50 µm, B-G = 5 µm
Differentiating features:
Sclerenchyma type D present
Rectangular shaped epidermal cell…….…….. *T. laxa*
Elongated shaped epidermal cell…..……. *T. qurqdrivalvis*
Sclerenchyma type E present
Square shaped epidermal cell……*T. cymbaria*
Rectangular shaped epidermal cell…….…….. *T. triandra*



33. *Themeda triandra*

Fig. 75



34. *Themeda quadrivalvis*

35. *Triplopogon ramosissimus* (Fig. 76(35) A-D)

Squarish round in transection with smooth surface (Fig. A)

Size: 1050.14x1108.16±5.28 µm, Hairs/Prickles absent.

Solid internode with parechymatous pith.

Epidermis: Square Shaped-III (Fig. B)

Hypodermis: Parenchymatous interrupted by sclerenchyma cells (Fig. A)

Type-E sclerenchyma present

Ground tissue: Round to oval shaped parenchymatous (Fig. C)

Vascular bundles arranged in ring form

Vascular system: all present

Iº IVB: Type C (Fig. D)

Size: 58.34x91.08±2.73 µm

IIº IVB: Type L (Fig. B)

Size: 50.34x51.63±0.83 µm

IIIº PVB: Type Q (Fig. A)

Size: 33.45x29.35±0.21 µm

Bar size: A = 50 µm, B-D = 5 µm

36. *Vetivaria zinzanoides* (Fig. 76(36) A-F)

Oval in transection with smooth surface (Fig. A)

Size: 1133.34x1483.34±34.16 µm, Hairs/Prickles absent.

Solid internode with parechymatous pith.

Epidermis: Square Shaped-III (Fig. D)

Hypodermis: 2-3 layered sclerenchymatous

Than parenchyma cells present

Air spaces present (Fig. C)

Type-D sclerenchyma present

Ground tissue: Round to oval shaped parenchymatous (Fig. F)

Vascular bundles arranged in ring form

Vascular system: all present

Iº IVB: Type B, sclerenchymatous cap present (Fig. F)

Size: 36.12x27.78±8.15 µm

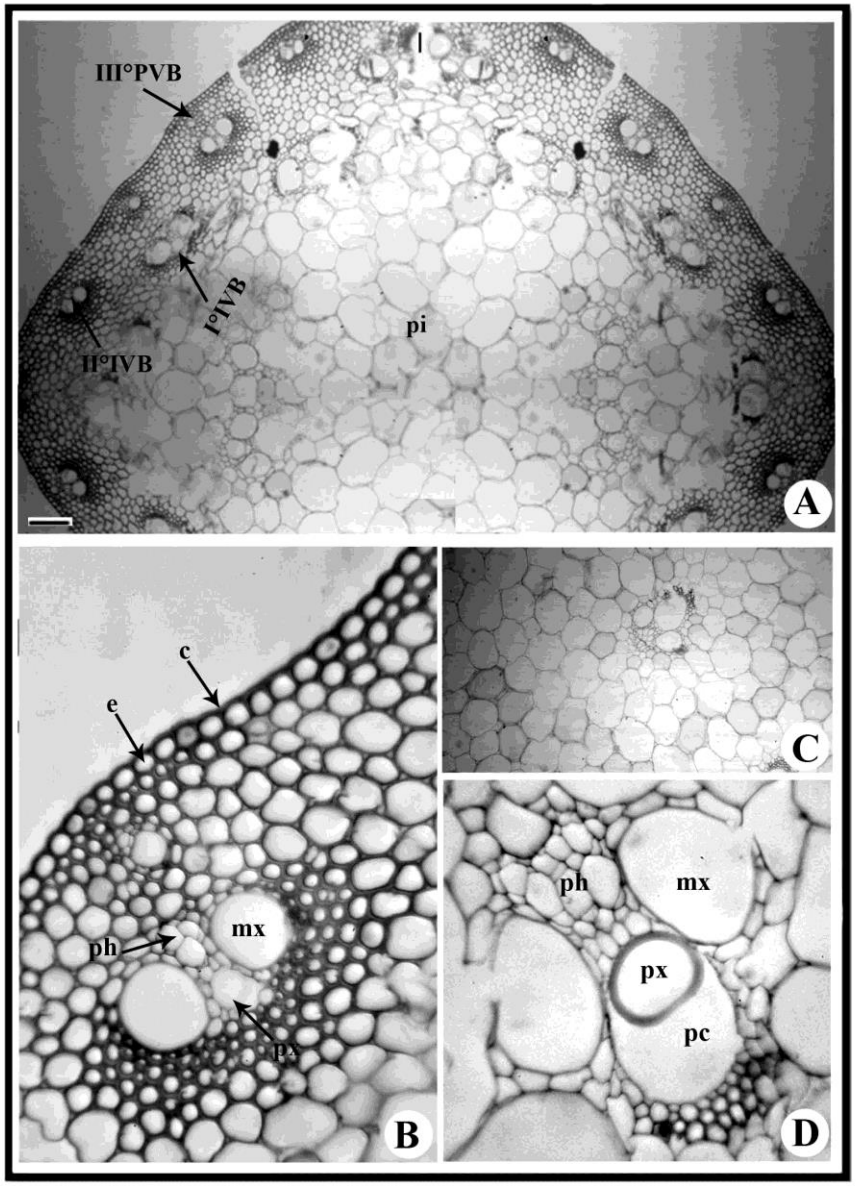
IIº IVB: Type L, Surrounded by sclerenchyma (Fig. E)

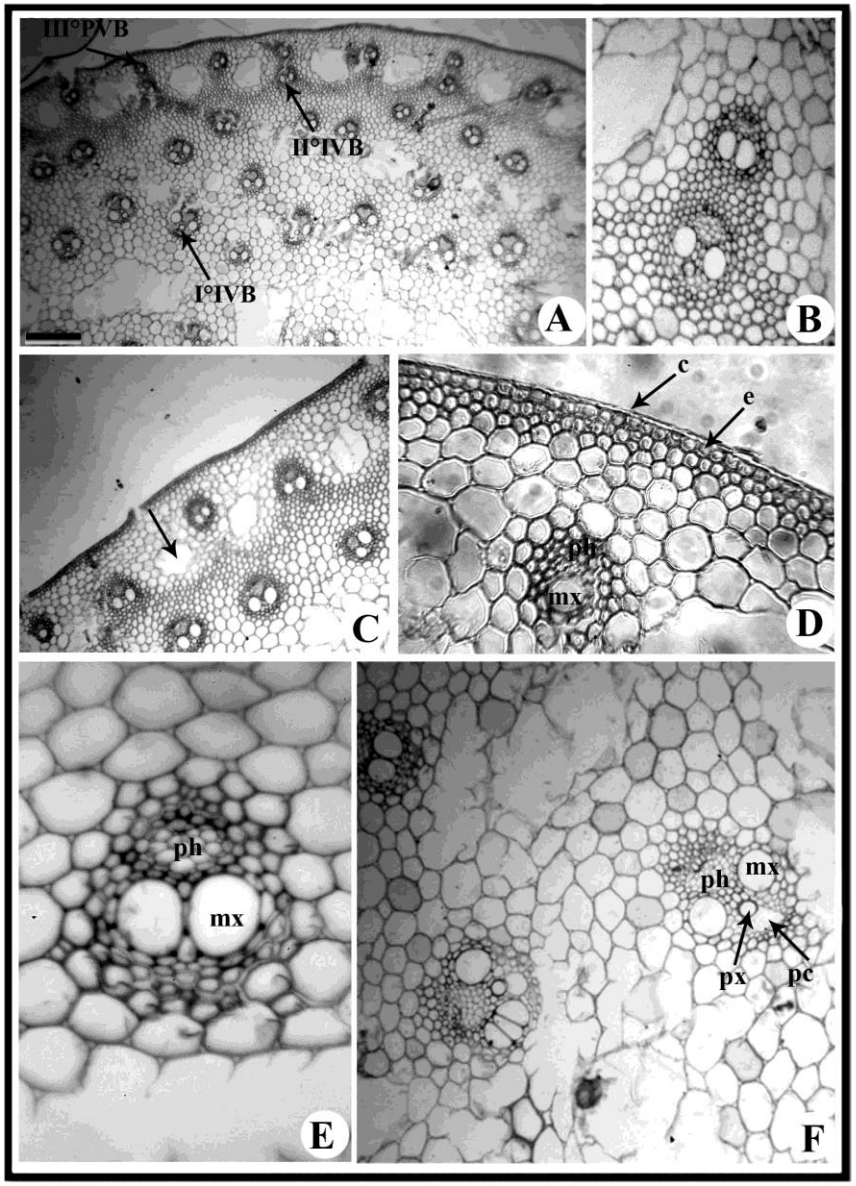
Size: 13.89x16.67±4.18 µm

IIIº PVB: Type Q (Fig. A)

Size: 8.34x8.34±4.28 µm

Bar size: A = 50 µm, B, D-F= 5 µm, C = 10 µm





35. *Triplopogon ramosissimus* **Fig. 76** 36. *Vetivaria zinzanoides*

37. *Alloteropsis cimicina* (Fig. 77(37) A-E)

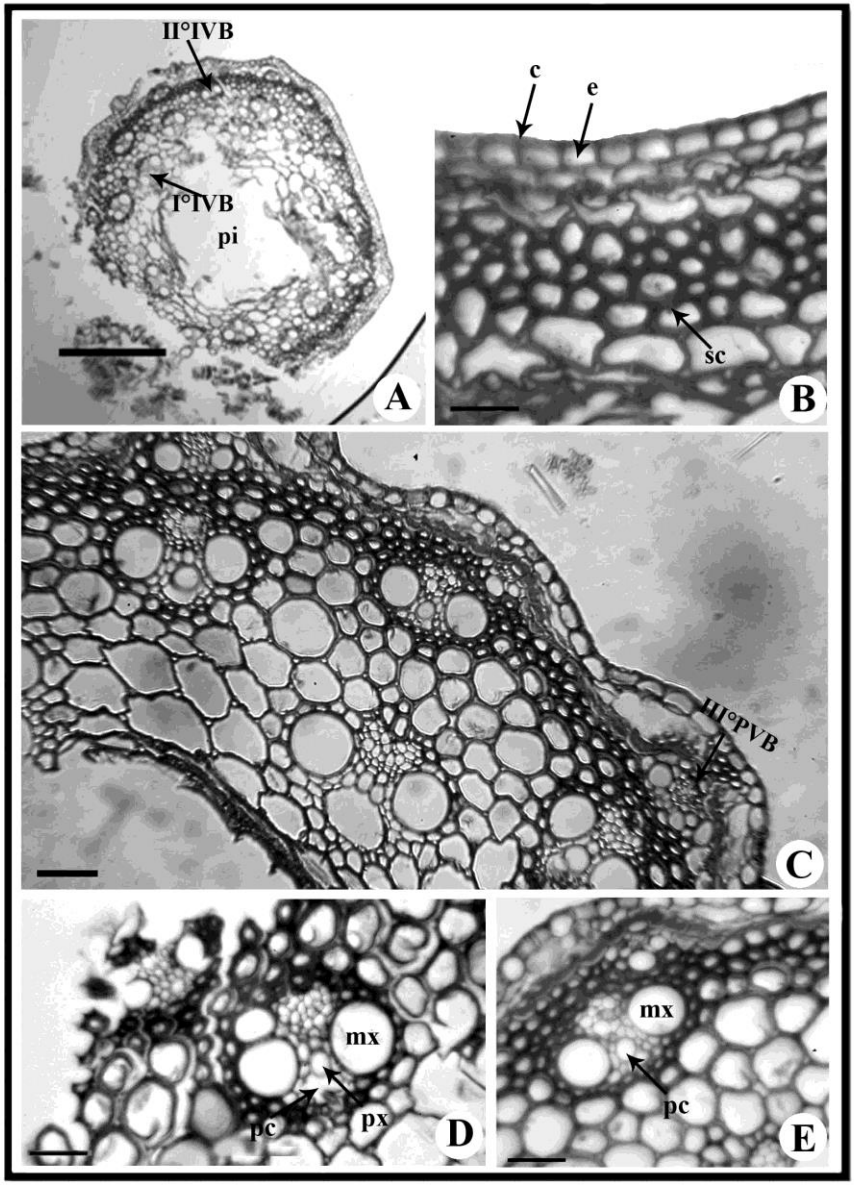
Oval in transection with undulating surface (Fig. A)
Size: 159.13x153.13±16.28 µm, Hairs/Prickles absent.
Hollow internode.
Epidermis: Rectangular Shaped-III (Fig. B)
Hypodermis: 2-3 layered parenchyma cells
3-4 layered sclerenchymatous (Fig. B)
With III^{o} PVB embedded
Type-D sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymatous cells present (Fig. E)
Size: 10.56x15±2.91 µm
II^{o} IVB: Type P (Fig. D)
Size: 13.34x16.67±3.18µm
III^{o} PVB: Type Q (Fig. C)
Size: 4.5x6.5±1.24µm
Bar size: A = 50 µm, B, D-E = 5 µm, C = 10 µm

Brachiaria

38. *Brachiaria distachya*
39. *Brachiaria eruciformis*
40. *Brachiaria ramosa*
41. *Brachiaria reptans*

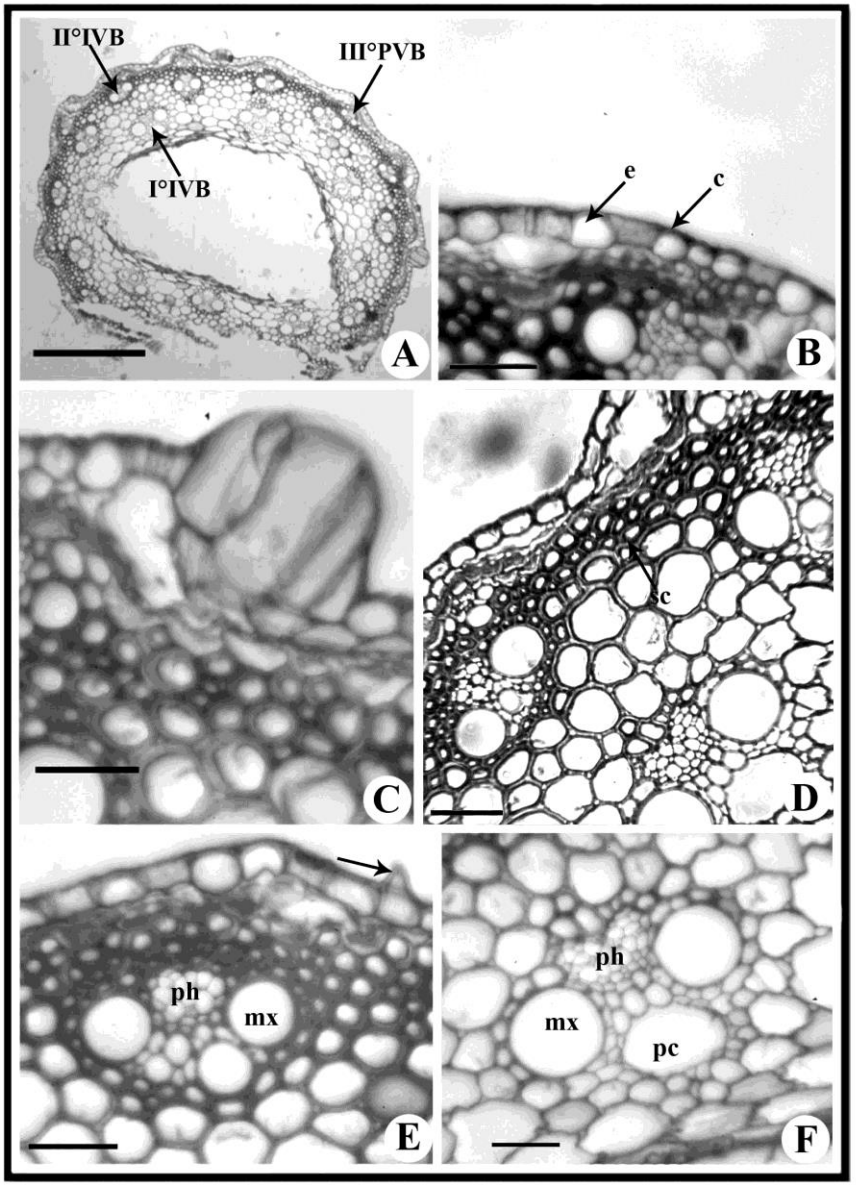
38. *Brachiaria distachya* (Fig. 77(38) A-F)

Oval in transection with undulating surface (Fig. A)
Size: 141.17x170.59±32.34 µm, Hairs/Prickles present (Fig. E, arrow).
Hollow internode.
Epidermis: Rectangular Shaped-III (Fig. B)
Bulliform cells present (Fig. C)
Hypodermis: 2-3 layered parenchyma cells (Fig. D)
3-4 layered sclerenchymatous
With III^{o} PVB embedded
Type-E sclerenchyma present (Fig. D)
Ground tissue: Round to oval shaped parenchymatous (Fig. D)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type C (Fig. F)
Size: 15.45x21.36±2.15 µm
II^{o} IVB: Type P (Fig. A)
Size: 8.57x13.39±3.71 µm
III^{o} PVB: Type Q (Fig. A)
Size: 5.88x7.35±1.62 µm
Bar size: A = 50 µm, B-F = 5 µm



37. *Alloteropsis cimicina*

Fig. 77



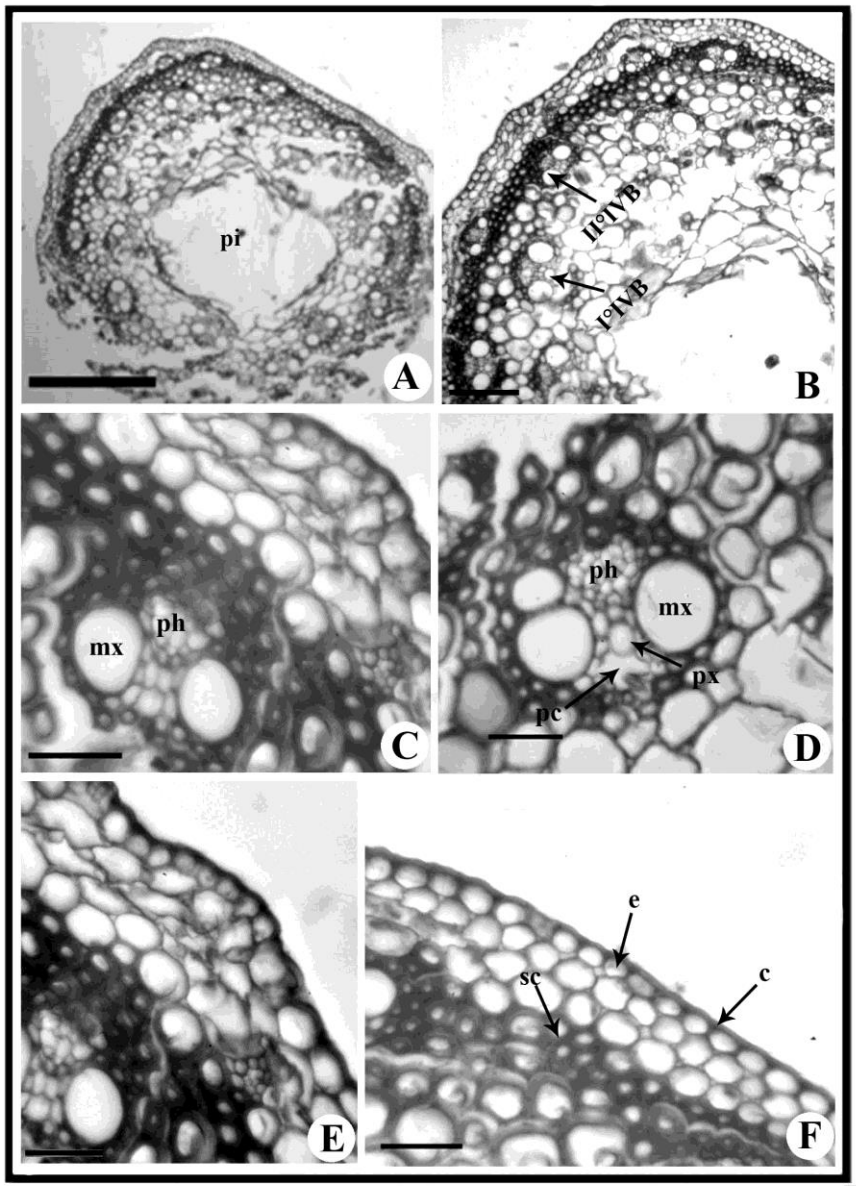
38. *Brachiaria distachya*

39. *Brachiaria eruciformis* (Fig. 78(39) A-F)

Square to oval in transection with slightly undulating surface (Fig. A)
Size: 112.5x137.5±22.08 µm, Hairs/Prickles absent.
Hollow internode.
Epidermis: Barrel Shaped-III (Fig. F)
Hypodermis: 2-3 layered parenchyma cells (Fig. E)
3-4 layered sclerenchymatous
With III^{o} PVB embedded
Type-E sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. B)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type A, sclerenchymatous cells present (Fig. D)
Size: 14.09x17.27±2.17 µm
II^{o} IVB: Type L (Fig. C)
Size: 8x10±1.27 µm
III^{o} PVB: Type Q
Size: 3.34x4.17±1.34 µm
Bar size: A = 50 µm, B = 10 µm, C-F = 5 µm

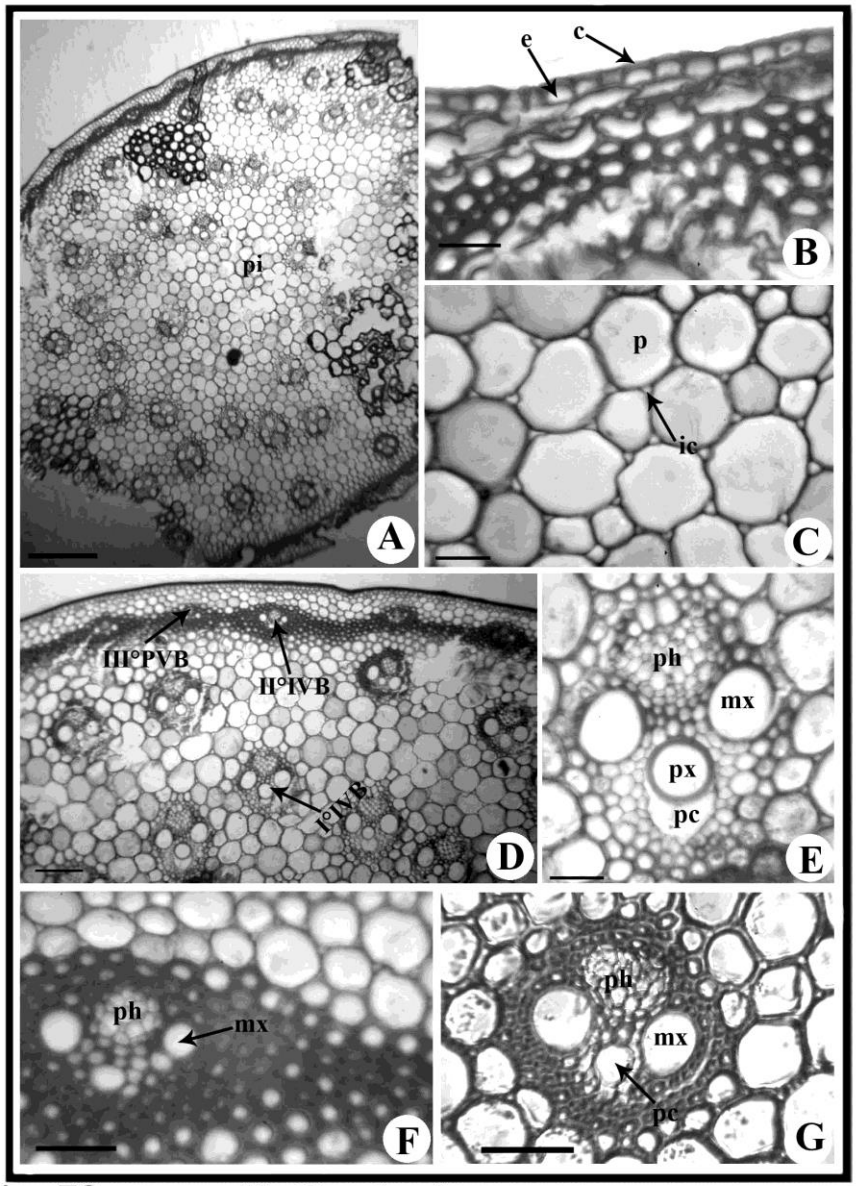
40. *Brachiaria ramosa* (Fig. 78(40) A-G)

Oblong in transection with smooth surface (Fig. A)
Size: 340.91x572.73±32.72 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Rectangular shaped-I (Fig. B)
Hypodermis: 3-4 layered parenchyma cells
5-6 layered sclerenchymatous (Fig. D)
With III^{o} PVB embedded
Type-E sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymatous cells covered VB (Fig. E)
Size: 26.67x22.78±5.16 µm
II^{o} IVB: Type P (Fig. G)
Size: 11.25x11.56±2.18 µm
III^{o} PVB: Type Q (Fig. F)
Size: 7.69x11.54±3.18 µm
Bar size: A = 50 µm, B, C, E-G = 5 µm, D = 10 µm



39. *Bracharia eruciformis*

Fig. 78



40. *Bracharia ramosa*

41. *Brachiaria reptans* (Fig. 79(41) A-F)

Horseshoe in transection with slightly undulating surface (Fig. A)

Size: 167.86x164.28±21.91 µm, Hairs/Prickles absent.

Hollow internode. Kranz anatomy present (Fig. D).

Epidermis: Barrel Shaped-III (Fig. F)

Hypodermis: 3-4 layered chlorenchymatous

Than 2-3 layered sclerenchymatous

With III^{o} PVB embedded

Type-D sclerenchyma present (Fig. E)

Ground tissue: Round to oval shaped parenchymatous

Vascular bundles arranged in ring form

Vascular system: all present

I^{o} IVB: Type H (Fig. B)

Size: 15.24x17.14±3.16 µm

II^{o} IVB: Type M, Sclerenchyma surrounded (Fig. C)

Size: 10.68x9.88±3.16 µm

III^{o} PVB: Type Q (Fig. D)

Size: 7.69x5±1.26 µm

Kranz arc: Half circle (Fig. F)

Chloroplast type: Centripetal

Shape of kranz cell: Round to oval (Fig. F)

Mestome: absent

Bar size: A = 50 µm, B -F = 5 µm

Differentiating features:

Presence of kranz arc…….…… *B. reptans*

Absence of kranz arc

Barrel shaped epidermal cell...…… *B. eruciformis*

Rectangular shaped epidermal cell

Triangular diamond shaped I°IVB, oval shaped in transection....……

……..*B. distachya*

Diamond shaped I°IVB, oblong shaped in transection...…… *B. ramosa*

Cenchrus

42. *Cenchrus biflorus*

43. *Cenchrus ciliaris*

44. *Cenchrus setigerus*

42. *Cenchrus biflorus* (Fig. 79(42) A-F)

Oblong in transection with smooth surface (Fig. A)

Size: 165x480±14.86 µm, Hairs/Prickles absent.

Solid internode with parechymatous pith.

Epidermis: Barrel Shaped-IV (Fig. C)

Hypodermis: 3-4 layered parenchymatous cell

Than 2-3 layered sclerenchymatous cells

With III^{o} PVB embedded

Type-B sclerenchyma present

Ground tissue: Round to oval shaped parenchymatous (Fig. D)

Vascular bundles arranged in ring form

Vascular system: all present

I^{o} IVB: Type I, phloem surrounded by sclerenchymatous cells (Fig. F)

Size: 23.18x18.18±7.16 µm

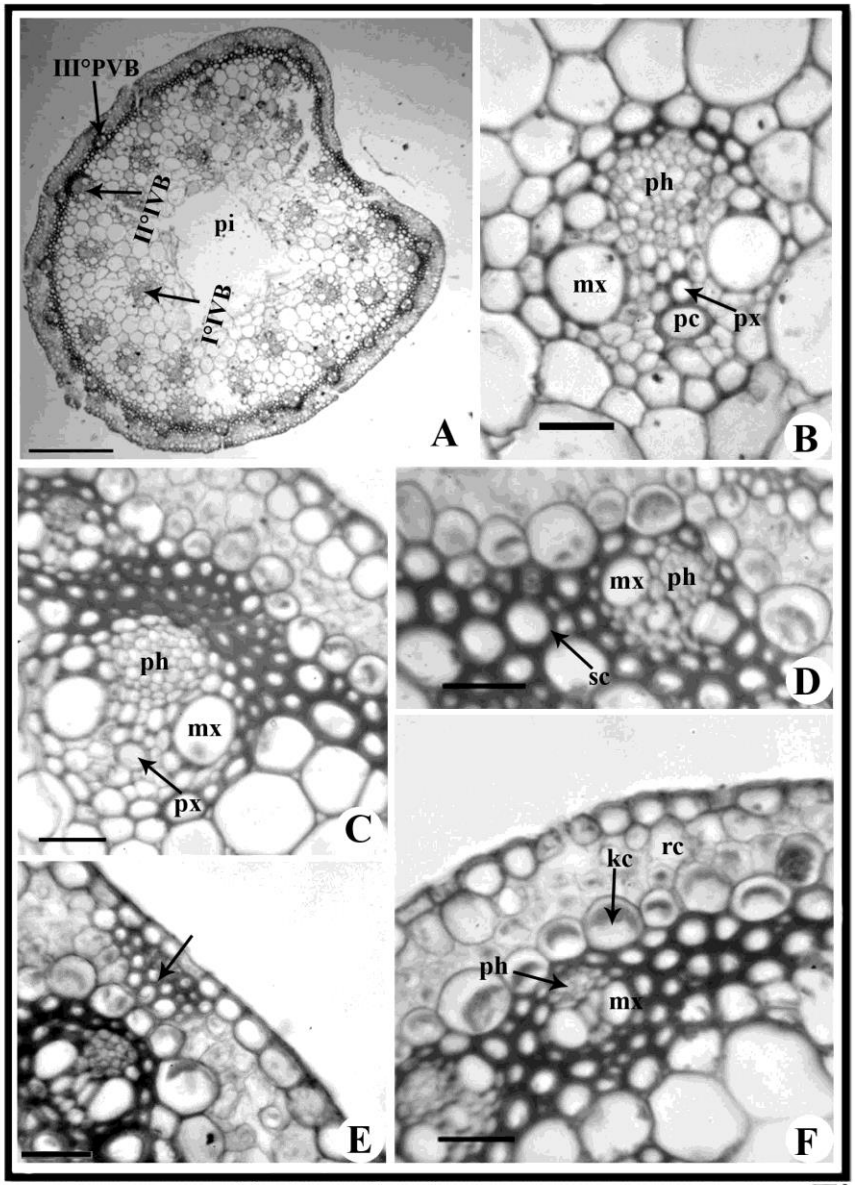
II^{o} IVB: Type P (Fig. B)

Size: 11.5x14.5±2.18µm

III^{o} PVB: Type Q (Fig. E)

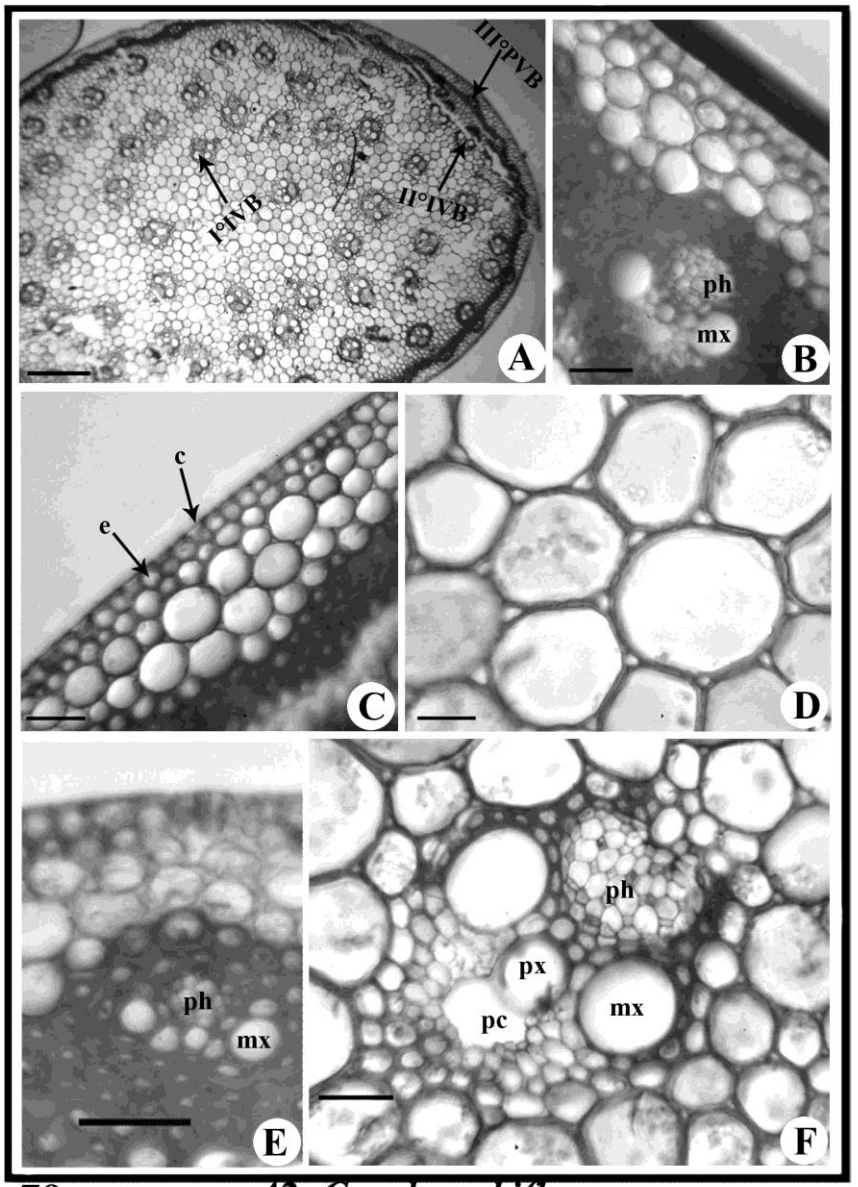
Size: 5.56x7.78±1.72 µm

Bar size: A = 50 µm, B-F = 5 µm



41. *Bracharia reptans*

Fig. 79



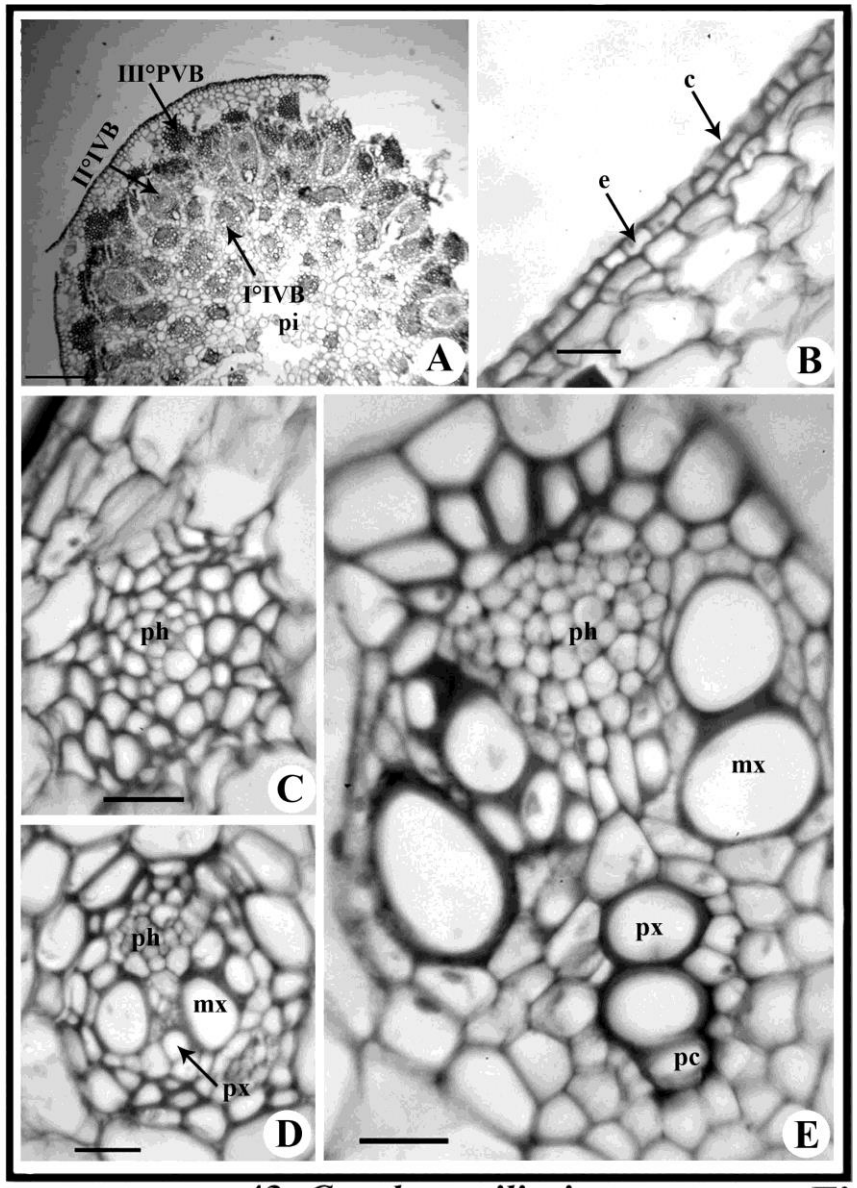
42. *Cenchrus biflorus*

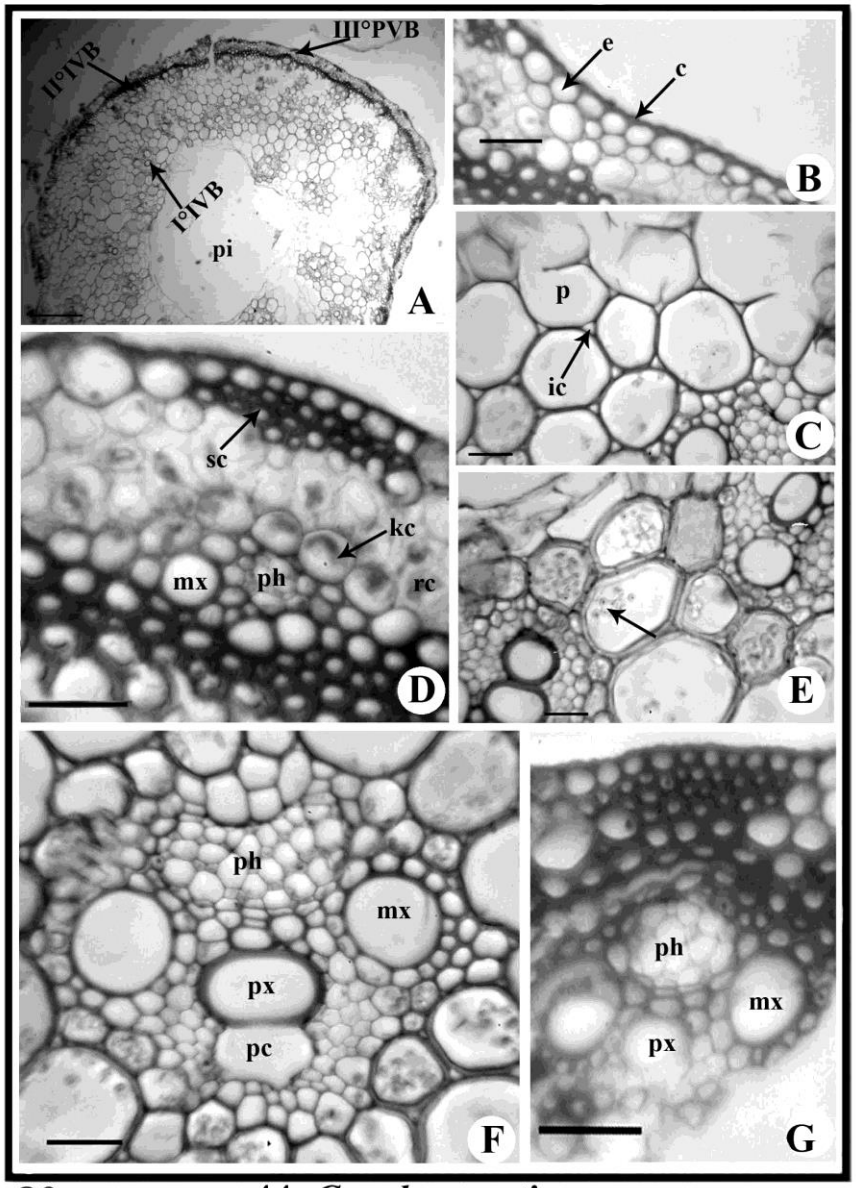
43. *Cenchrus ciliaris* (Fig. 80(43) A-E)

Round in transection with smooth surface (Fig. A)
Size: 600x591.67±47.61 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Rectangular Shaped-I (Fig. B)
Hypodermis: 3-4 layered parenchymatous (Fig. A)
With III^{o} PVB embedded
Sclerenchyma present in form of girder
Type-D sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. A)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymatous cap absent (Fig. E)
Size: 36.67x28±6.17 µm
II^{o} IVB: Type M (Fig. D)
Size: 18.63x15.91±4.76 µm
III^{o} PVB: Type Q (Fig. C)
Size: 15.2x13.6±5.15 µm
Bar size: A = 50 µm, B-E = 5 µm

44. *Cenchrus setigerus* (Fig. 80(44) A-G)

Horseshoe in transection with slightly undulating surface (Fig. A)
Size: 333.34x311.12±16.24 µm, Hairs/Prickles absent.
Hollow internode. Kranz anatomy present (Fig. D).
Epidermis: Round shaped (Fig. B)
Hypodermis: 6-7 layered chlorenchymatous interrupted by sclerenchymatous girder After ring of sclerenchyma present (Fig. D)
With III^{o} PVB embedded
Type-B sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous, starch grains present (Fig. E)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type H (Fig. F)
Size: 28.18x32.73±4.16 µm
II^{o} IVB: Type P (Fig. G)
Size: 10.88x13.82±3.28 µm
III^{o} PVB: Type Q
Size: 4.68x4.37±1.62 µm
Kranz arc: Half circle (Fig. D)
Chloroplast type: Centrifugal
Shape of kranz cell: Round to oval (Fig. D) **Mestome:** single layered
Bar size: A = 50 µm, B-G = 5 µm
Differentiating features:
Sclerenchyma in form of girder……..……. *C. ciliaris*
Sclerenchyma in form of unicylinder
Sclerenchyma type B present…….……*C. biflorus*
Sclerenchyma type E present..……. *C. setigerus*





43. *Cenchrus ciliaris* **Fig. 80** 44. *Cenchrus setigerus*

Digitaria

45. *Digitaria ciliaris*

46. *Digitaria granularis*

47. *Digitaria longiflora*

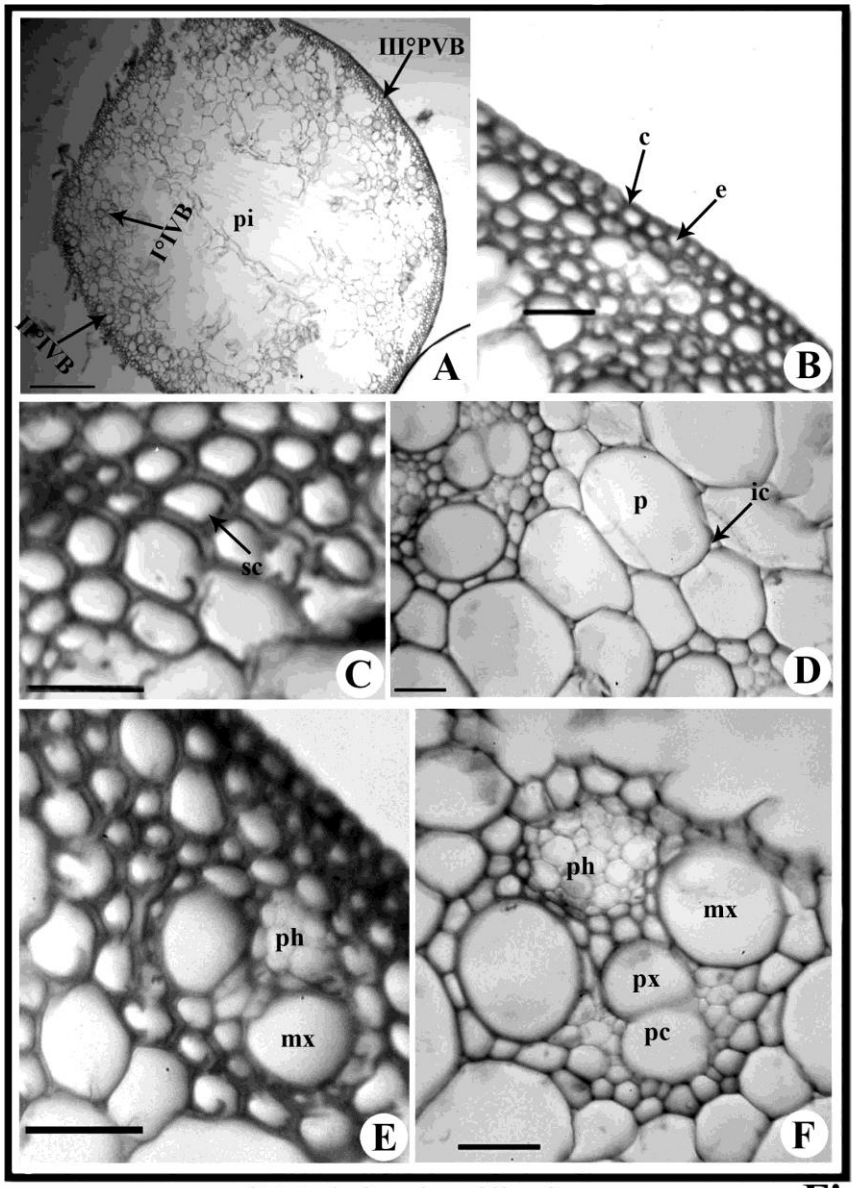
48. *Digitaria stircta*

45. *Digitaria ciliaris* (Fig. 81(45) A-F)

Round in transection with smooth surface (Fig. A)
Size: 320x305±21.63 µm, Hairs/Prickles absent.
Hollow internode.
Epidermis: Barrel Shaped-III (Fig. B)
Hypodermis: 5-6 layered sclerenchymatous
With III^{o} PVB embedded
Type-D sclerenchyma present (Fig. C)
Ground tissue: Round to oval shaped parenchymatous (Fig. D)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymatous cap absent (Fig. F)
Size: 21.54x23.85±6.18 µm
II^{o} IVB: Type L (Fig. E)
Size: 9.47x11.58±3.71 µm
III^{o} PVB: Type Q
Size: 6.15x5.72±2.16 µm
Bar size: A = 50 µm, B-F = 5 µm

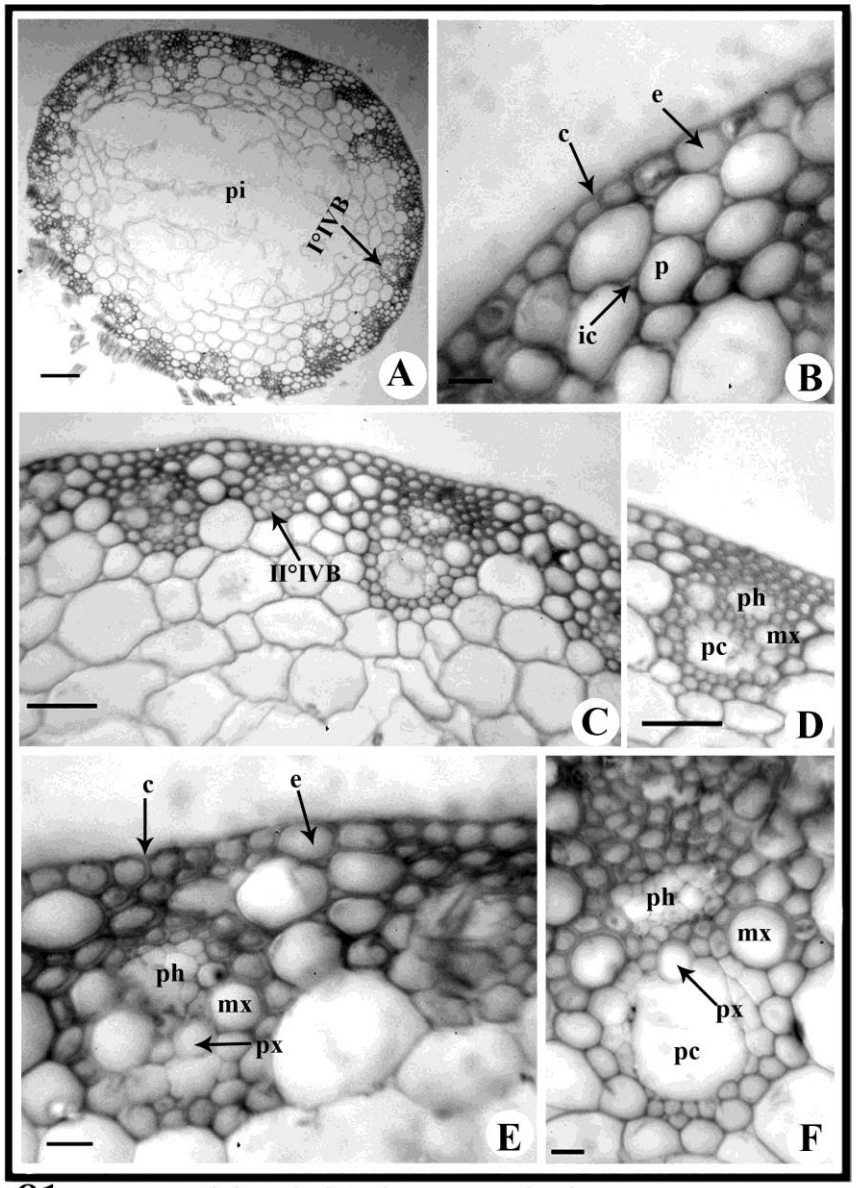
46. *Digitaria granularis* (Fig. 81(46) A-F)

Round to oval in transection with smooth surface (Fig. A)
Size: 258.34x294.26±13.24 µm, Hairs/Prickles absent.
Hollow internode.
Epidermis: Barrel Shaped-II (Fig. B, E)
Hypodermis: 3-4 layered parenchymatous interrupted by sclerenchymatous girder
With III^{o} PVB embedded (Fig. C)
Type-D sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: III^{o} PVB absent
I^{o} IVB: Type D, sclerenchymatous cap present (Fig. F)
Big square lysigenous cavity
Size: 43.75x40±6.16 µm
II^{o} IVB: Type O (Fig. D, E)
Size: 16.67x25.34±4.14µm
III^{o} PVB: -
Size: -
Bar size: A = 50 µm, C & D = 10 µm, B, E-F = 5 µm



45. *Digitaria ciliaris*

Fig. 81



46. *Digitaria granularis*

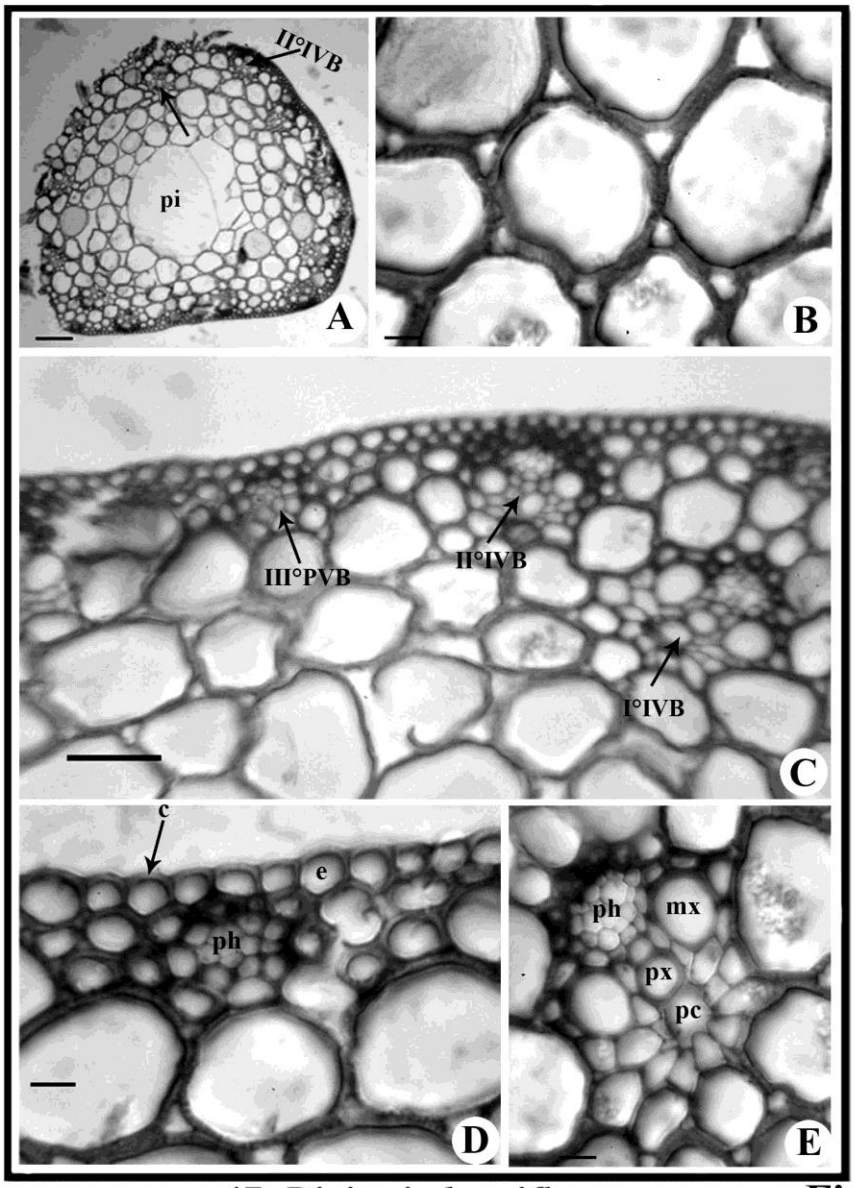
47. *Digitaria longiflora* (Fig. 82(47) A-E)

Round to triangular with blunt angle in transection (Fig. A)
Size: 409.09x463.64±72.22 µm, Hairs/Prickles absent.
Hollow internode.
Epidermis: Barrel Shaped-I (Fig. D)
Hypodermis: 3-4 layered sclerenchymatous, with III^{o} PVB embedded
Type-D sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. B)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type F, sclerenchymatous cells surrounded VB (Fig. E)
Size: 36x30±9.26 µm
II^{o} IVB: Type J (Fig. C)
Size: 16.24x21.29±3.28 µm
III^{o} PVB: Type Q (Fig. C, D)
Size: 3x3.67±1.62 µm
Bar size: A = 50 µm, C = 10 µm, B, D- E = 5 µm

48. *Digitaria stricta* (Fig. 82(48) A-E)

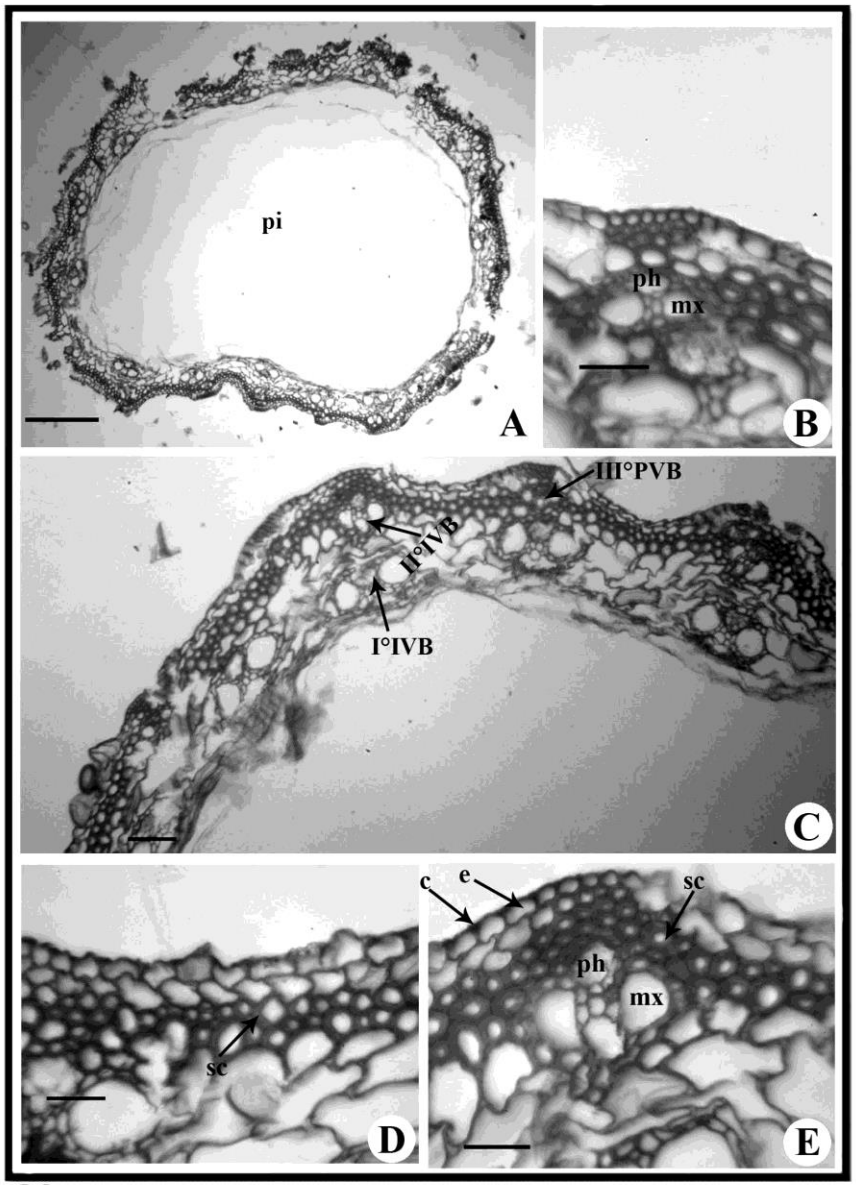
Oval to oblong in transection with undulating surface (Fig. A)
Size: 250x308.34±24.25 µm, Hairs/Prickles absent.
Hollow internode.
Epidermis: Barrel Shaped-II (Fig. E)
Hypodermis: 1-2 layered parenchyma
Than 3-4 layered sclerenchymatous
With III^{o} PVB embedded
Type-E sclerenchyma present (Fig. D)
Ground tissue: Irregular shaped parenchymatous
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymatous cap present (Fig. C)
Size: 9.56x11.36±3.16 µm
II^{o} IVB: Type P (Fig. E)
Size: 5x5.67±1.25 µm
III^{o} PVB: Type Q (Fig. B)
Size: 2x4±0.34 µm
Bar size: A = 50 µm, C = 10 µm, B, D - E = 5 µm
Differentiating features:

Sclerenchyma type E present……..…….……..…. *D. stricta*
Sclerenchyma type D present
Sclerenchyma in form of unicylinder……..*D. ciliaris*
Sclerenchyma in form of girder
III°IVB absent, obovate shaped I°IVB……. *D. granularis*
III°IVB present, vertically elliptical shaped I°IVB...……..*D. longiflora*



47. *Digitaria longiflora*

Fig. 82



48. *Digitaria stricta*

Echinichloa

49. *Echinichloa colona*

50. *Echinochloa crusgalli*

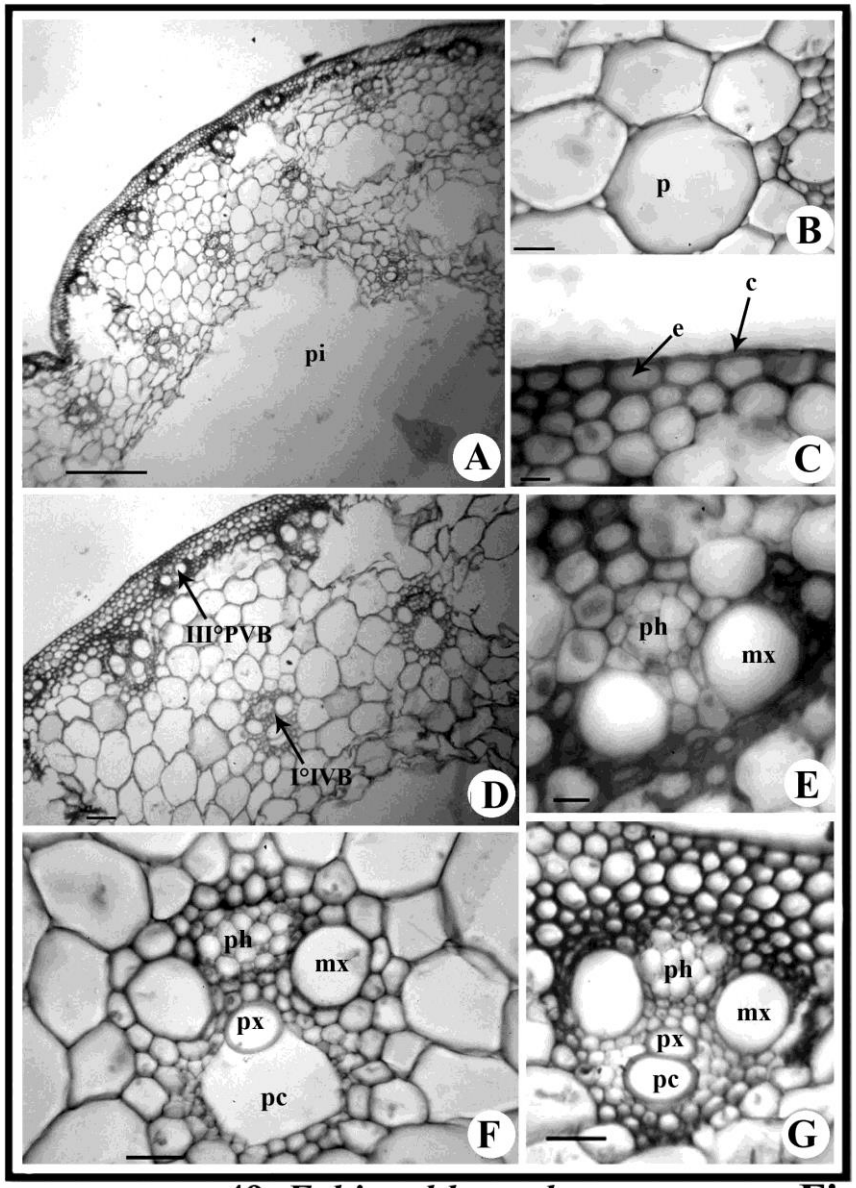
51. *Echionochloa stagnina*

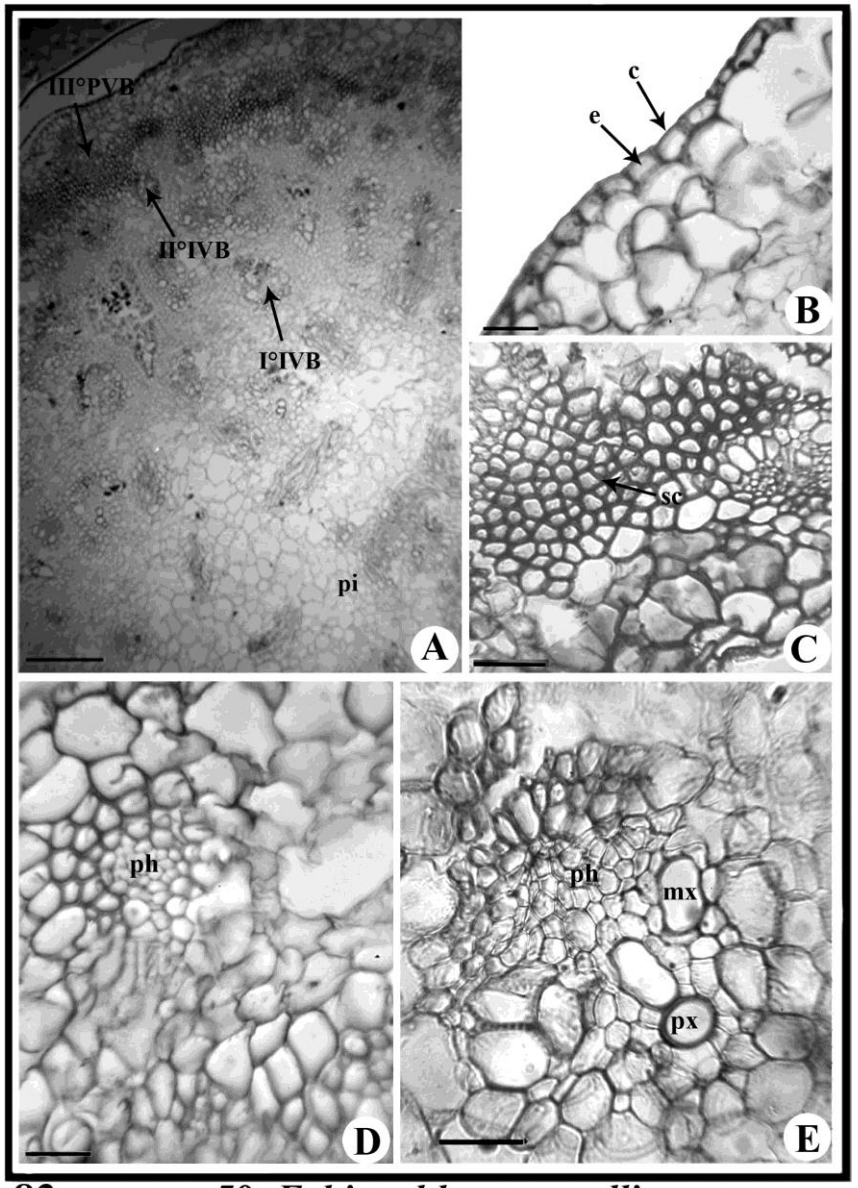
49. *Echinochloa colona* (Fig. 83(49) A-G)

Round in transection with smooth surface (Fig. A)
Size: 1123.08x1184.62±82.63 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Barrel Shaped-III (Fig. C)
Hypodermis: 3-4 layered sclerenchymatous (Fig. D)
With III^{o} PVB embedded
Type-D sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. B)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type I and E, sclerenchymatous cap present (Fig. F, G)
Size: 24.17x31.67±7.25 µm
II^{o} IVB: Type K
Size: 20.56x25.56±6.24 µm
III^{o} PVB: Type Q (Fig. E)
Size: 14x11.5±4.26 µm
Bar size: A = 50 µm, B-C, E-G = 5 µm, D = 10 µm

50. *Echinochloa crusgalli* (Fig. 83(50) A-E)

Round in transection with slightly undulating surface (Fig. A)
Size: 1584.61x1638.46±69.18 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Rectangular Shaped-III (Fig. B)
Hypodermis: 7-8 layered parenchyma
Than 6-7 layered sclerenchymatous
With III^{o} PVB embedded
Type-D sclerenchyma present (Fig. C)
Ground tissue: Round to oval shaped
Parenchymatous,
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type I, sclerenchymatous cap present (Fig. E)
Size: 14.64x14.29±3.12 µm
II^{o} IVB: Type M
Size: 0.09x9.55±3.17 µm
III^{o} PVB: Type Q (Fig. D)
Size: 4.09x3.64±2.13 µm
Bar size: A = 50 µm, B-E = 5 µm





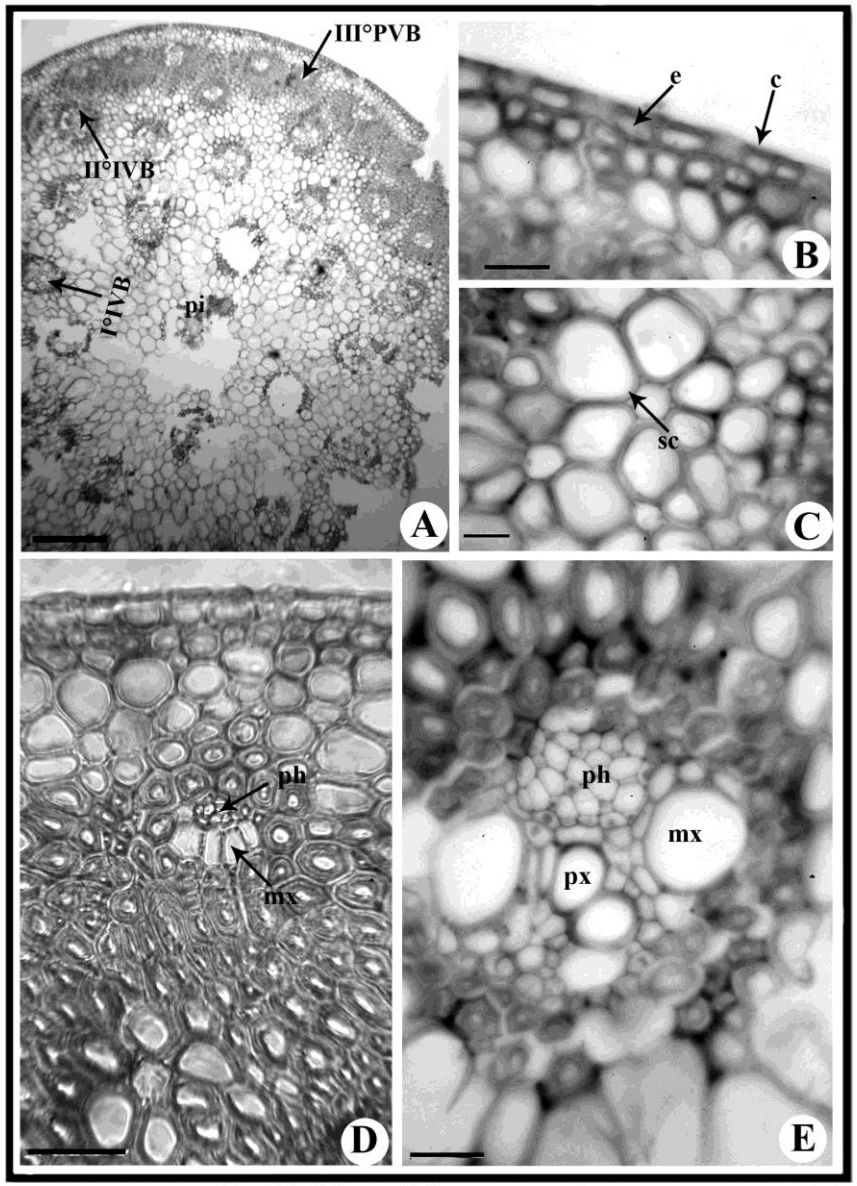
49. *Echinochloa colona* **Fig. 83** **50. *Echinochloa crusgalli***

51. *Echinochloa stagnina* (Fig. 84(51) A-E)

Round in transection with slightly undulating surface (Fig. A)
Size: 1050x1163±62.58 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Rectangular Shaped-II (Fig. B)
Hypodermis: 1-2 layered sclerenchymatous
Than thickend sclerenchyma 4-5 layered
With III^{o} PVB embedded
Type-B, E sclerenchyma present (Fig. C)
Ground tissue: Angular shaped parenchymatous (Fig. A)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymatous cell present surrounded VB (Fig. E)
Size: 29.17x25±7.14 µm
II^{o} IVB: Type O (Fig. A)
Size: 23.34x25±5.12 µm
III^{o} PVB: Type Q (Fig. D)
Size: 8.34x12.5±3.62 µm
Bar size: A = 50 µm, B-E = 5 µm
Differentiating featrures:
Barrel shaped epidermal cell……..……. *E. colona*
Rectangular shaped epidermal cell
Sclerenchyma in form of unicylinder……..…… *E. crusgalli*
Sclerenchyma in form of bicylinder…….……*E. stagnina*

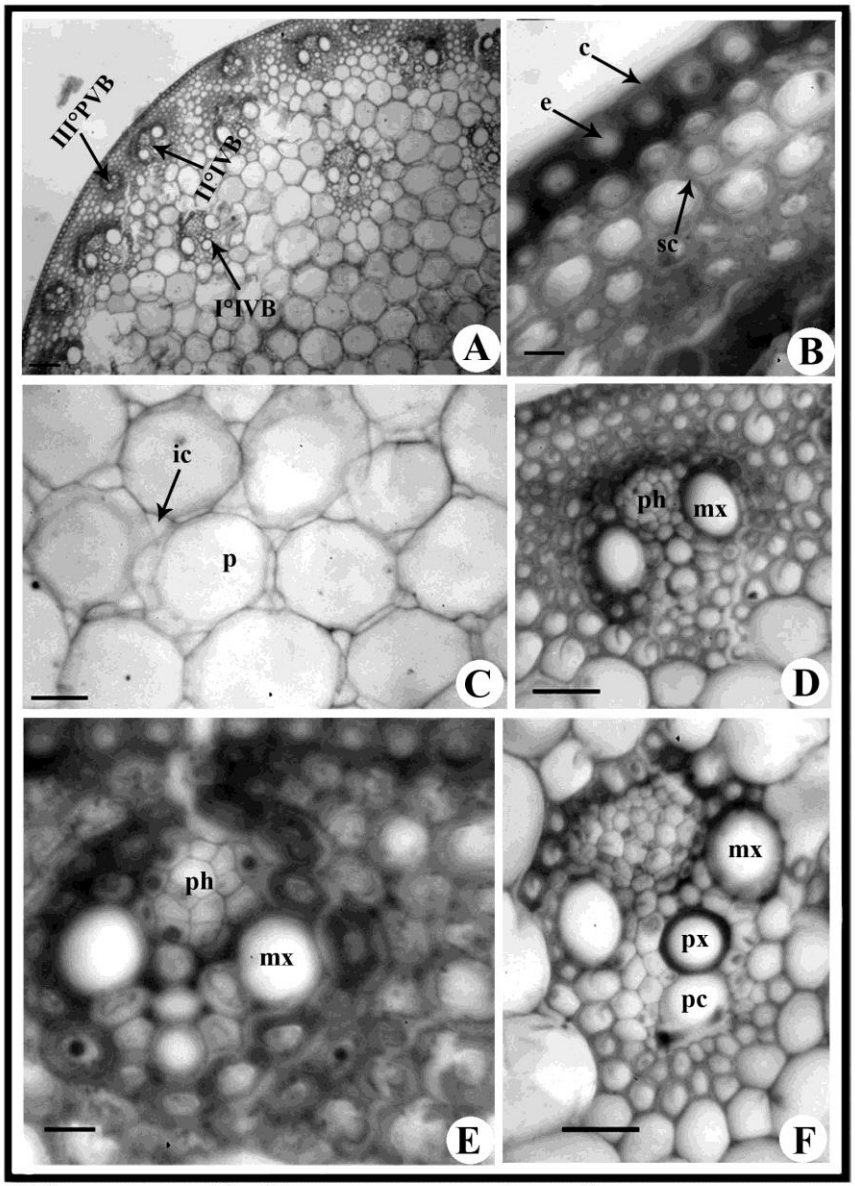
52. *Eremopogon foveolatus* (Fig. 84(52) A-F)

Round to oval in transection with smooth surface (Fig. A)
Size: 1210x1560±102.13 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Barrel Shaped-V (Fig. B)
Hypodermis: 5-6 layered sclerenchymatous
With III^{o} PVB embedded
Type-E sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type F, sclerenchymatous cell present around phloem (Fig. F)
Size: 26.12x16.24±6.15 µm
II^{o} IVB: Type O (Fig. E)
Size: 21.92x16.15±7.36 µm
III^{o} PVB: Type Q (Fig. D)
Size: 7x14±3.16 µm
Bar size: A = 50 µm, B-F = 5 µm



51. *Echinochloa stagnina*

Fig. 84



52. *Eremopogon foveolatus*

53. *Eriochloa procera* (Fig. 85(53) A-G)

Round in transection with smooth surface (Fig. A)
Size: 261.90x304.76±36.41 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith. Kranz anatomy present.
Epidermis: Round Shaped (Fig. D)
Hypodermis: 4-5 layered chloenchymatous (Fig. B)
Than 1-2 layered sclerenchyma with III^{o} PVB embedded
Type-B sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymatous cap absent (Fig. G)
Size: 12.72x16.82±4.52 µm
II^{o} IVB: Type K (Fig. F)
Size: 7.73x11.36±3.17 µm
III^{o} PVB: Type Q (Fig. E)
Size: 6.07x8.03±2.76 µm
Kranz arc: Half circle (Fig. E)
Chloroplast type: Centrifugal
Shape of kranz cell: Round to oval
Mestome: Single layered
Bar size: A = 50 µm, B = 10 µm, C-G = 5 µm

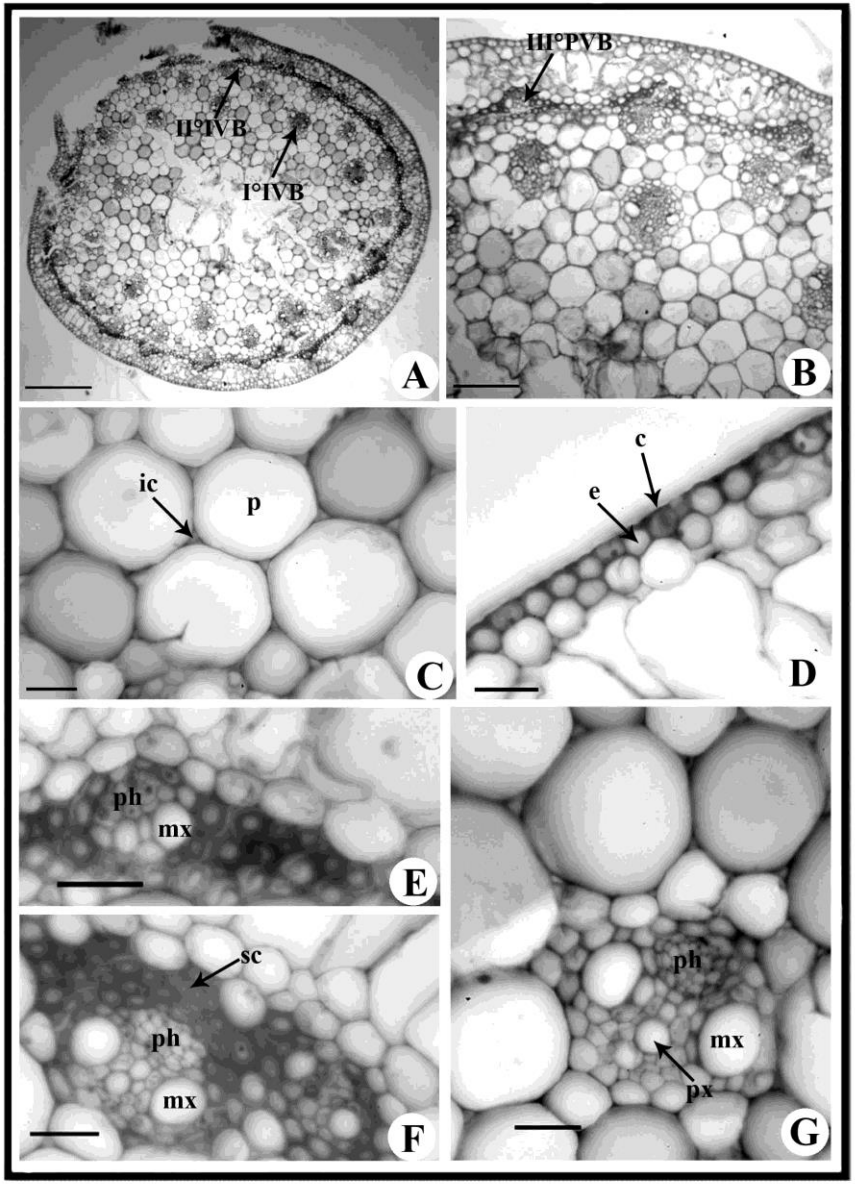
Oplismenus

54. *Oplismenus burmannii*

55. *Oplismenus composites*

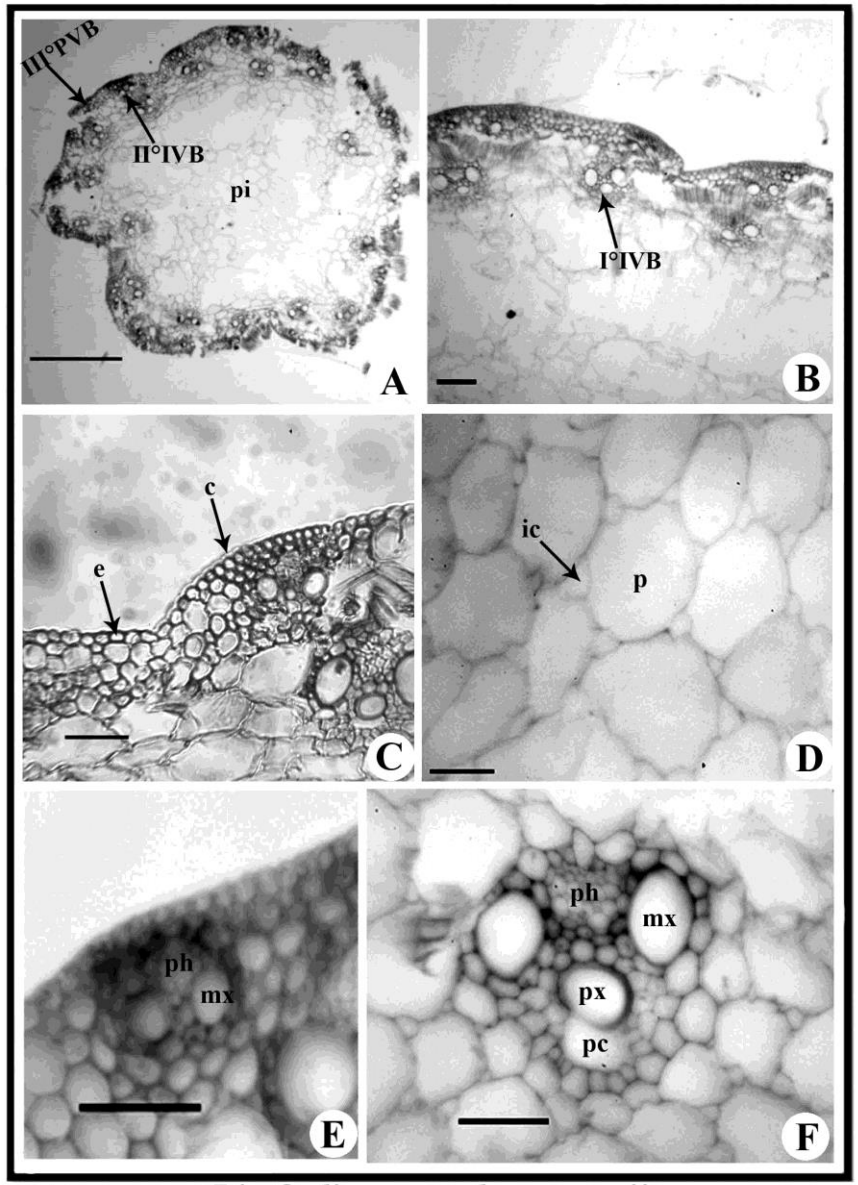
54. *Oplismenus burmannii* (Fig. 85(54) A-F)

Irregular round in transection with undulating surface (Fig. A)
Size: 173.34x193.34±36.29 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Barrel Shaped-IV (Fig. C)
Hypodermis: 3-4 layered parenchymatous (Fig. C)
Interrupted by sclerenchymatous girder
With III^{o} PVB embedded
Type-E sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. D)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type E (Fig. F)
Size: 14.34x13.34±5.26 µm
II^{o} IVB: Type M (Fig. E)
Size: 12.34x11.34±4.26 µm
III^{o} PVB: Type Q (Fig. A)
Size: 4x5±2.16 µm
Bar size: A = 50 µm, B = 10 µm, C-F = 5 µm



53. *Eriochloa procera*

Fig. 85



54. *Oplismenus burmannii*

55. *Oplismenus composites* (Fig. 86(55) A-F)

Oval in transection with undulating surface (Fig. A)
Size: 214.28x257.14±37.34 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Barrel Shaped-V (Fig. B)
Bulliform cell present (Fig. D)
Hypodermis: 4-5 layered sclerenchymatous (Fig. C), with III^{o} PVB embedded
Type-D sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: III^{o} PVB absent
I^{o} IVB: Type D, sclerenchymatous cap absent (Fig. F)
Size: 12.5x14.75±3.71 µm
II^{o} IVB: Type P (Fig. E)
Size: 5.22x6.52±2.53 µm
III^{o} PVB: -
Bar size: A = 50 µm, B-F = 5 µm
Differentiating features:
Sclerenchyma type E present……..…….…… *O. burmanii*
Sclerenchyma type D present……..…….. *O. composites*

Panicum

56. *Panicum antidotale*

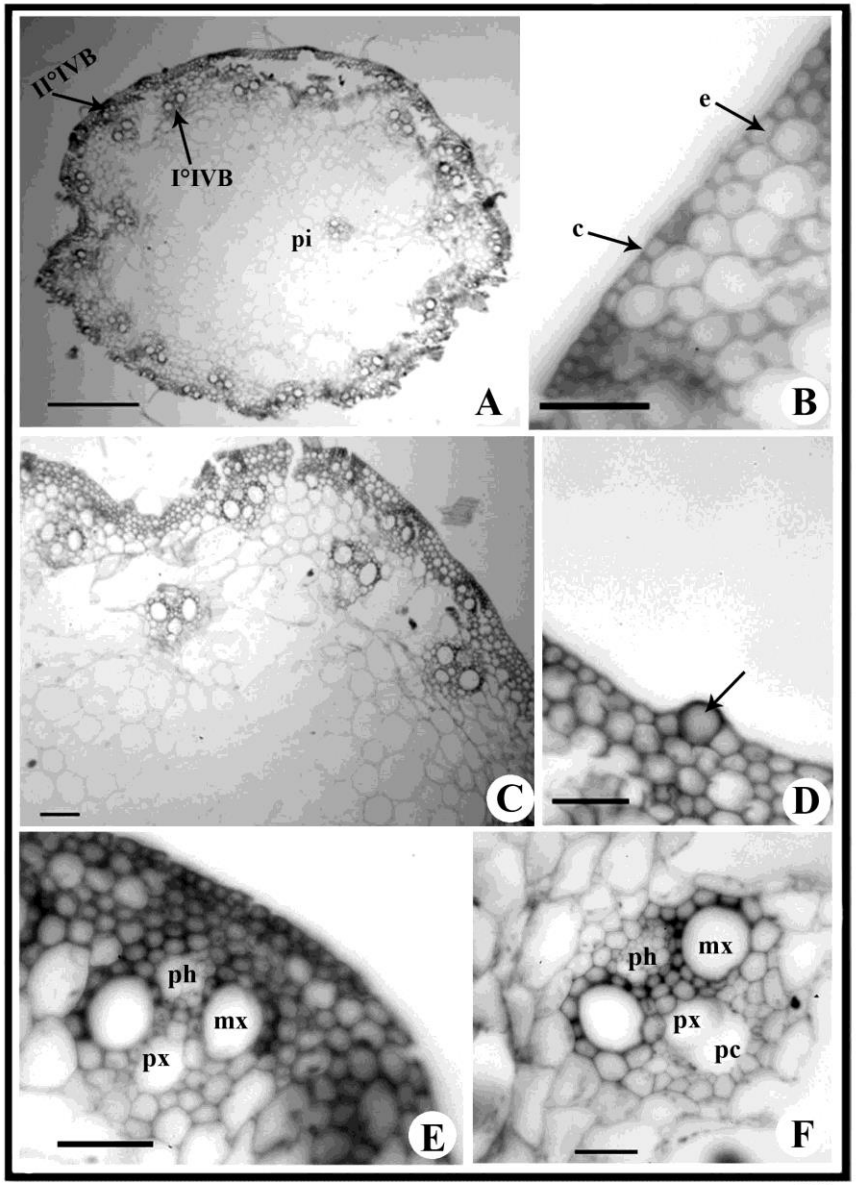
57. *Panicum maximum*

58. *Panicum miliaceum*

59. *Panicum trypheron*

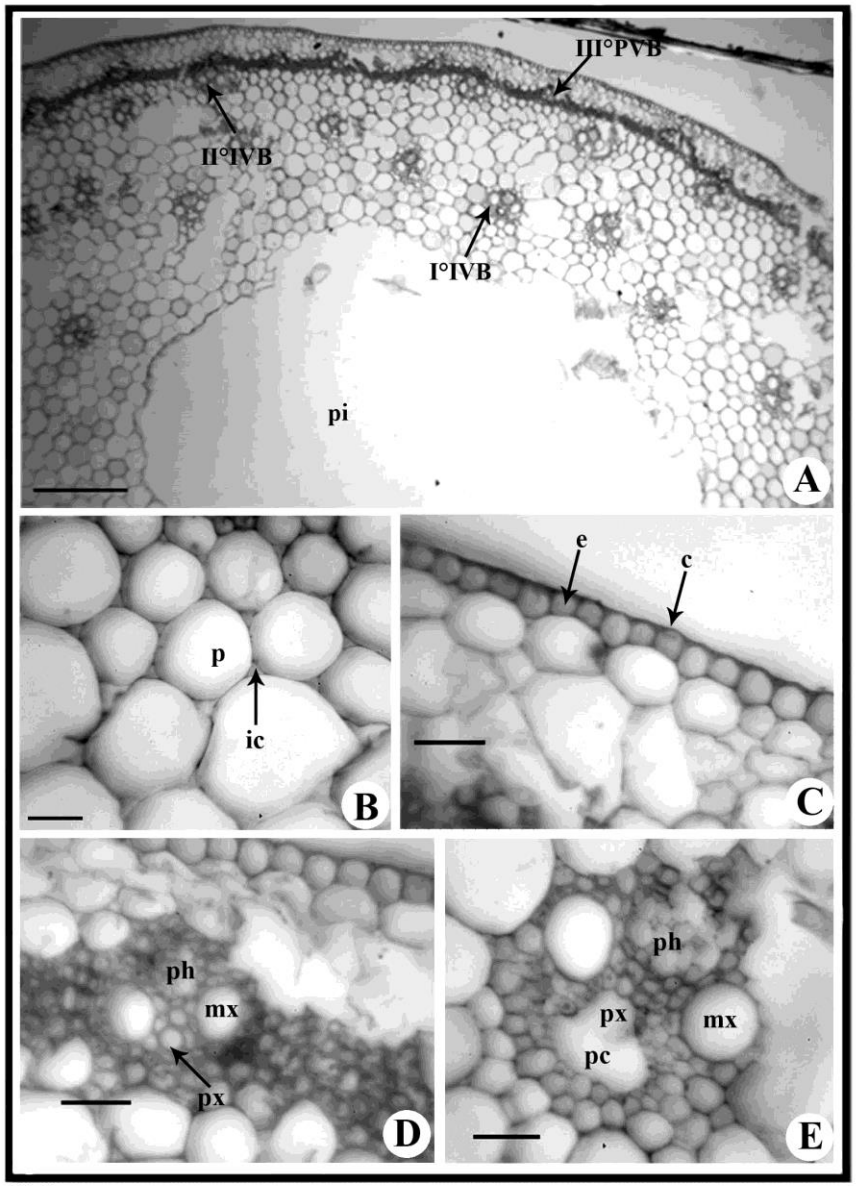
56. *Panicum antidotale* (Fig. 86(56) A-E)

Oval in transection with slightly undulating surface (Fig. A)
Size: 480x1146.67±62.25 µm, Hairs/Prickles absent.
Hollow internode.
Epidermis: Elongated Shaped-I (Fig. C)
Hypodermis: 3-4 layered parenchymaotus , than 1-2 layered sclerenchymatous cells
With III^{o} PVB embedded
Type-D sclerenchyma presents
Ground tissue: Round to oval shaped parenchymatous (Fig. B)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymatous cap absent (Fig. E)
Size: 19.55x20.91±7.21 µm
II^{o} IVB: Type P (Fig. D)
Size: 10x12.61±4.14 µm
III^{o} PVB: Type Q
Size: 6.67x10±3.61 µm
Bar size: A = 50 µm, B-E = 5 µm



55. *Oplismenus composites*

Fig. 86



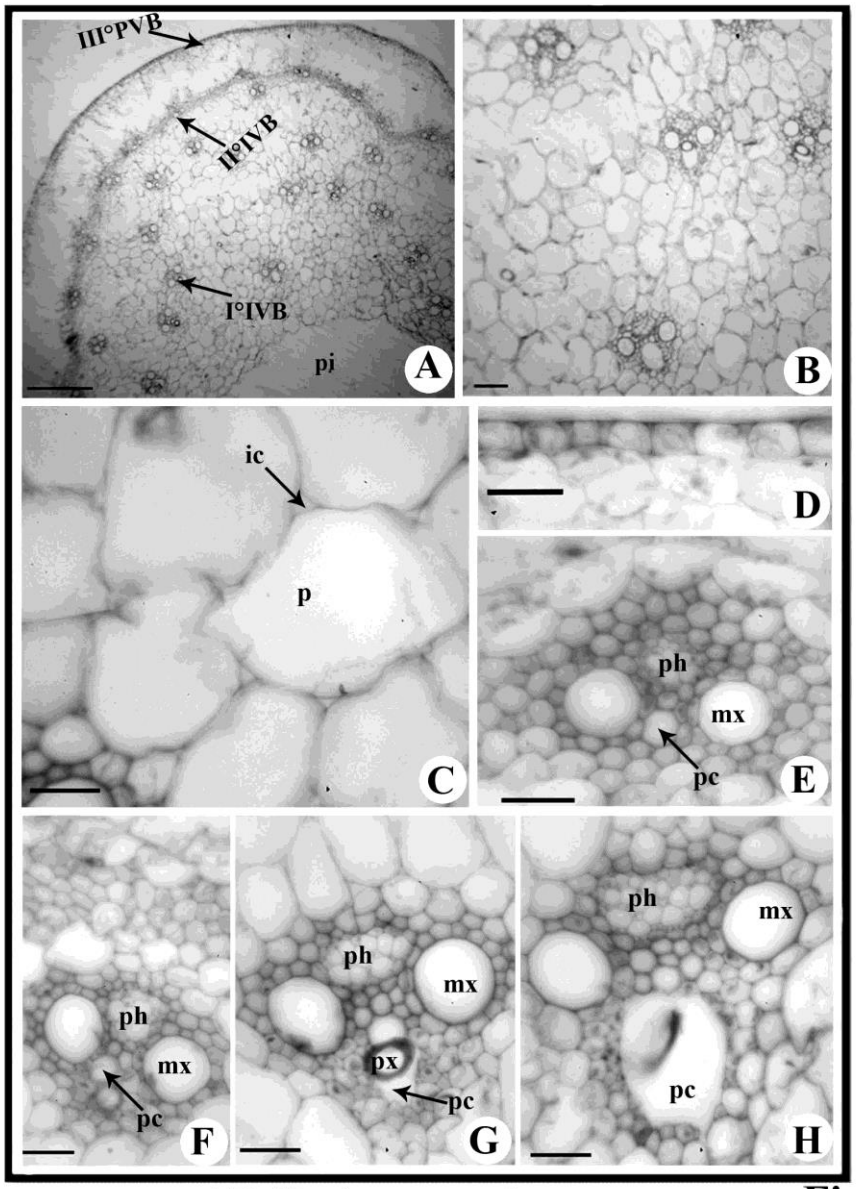
56. *Panicum antidotale*

57. *Panicum maximum* (Fig. 87(57) A-H)

Round in transection with smooth surface (Fig. A)
Size: 533.34x438.09±36.26 µm, Hairs/Prickles absent.
Hollow internode.
Epidermis: Rectangular Shaped-III (Fig. D)
Hypodermis: 6-7 layered parenchymatous
Than 3-4 layered sclerenchymatous cells
With III^{o} PVB embedded
Type-D sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. C, D)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type C (Fig. H, G)
Size: 22.5x23.5±7.25 µm
II^{o} IVB: Type N (Fig. F)
Size: 8.69x16.95±2.47 µm
III^{o} PVB: Type Q (Fig. E)
Size: 5.16x4.17±2.13 µm
Bar size: A = 50 µm, B = 10 µm, C-H = 5 µm

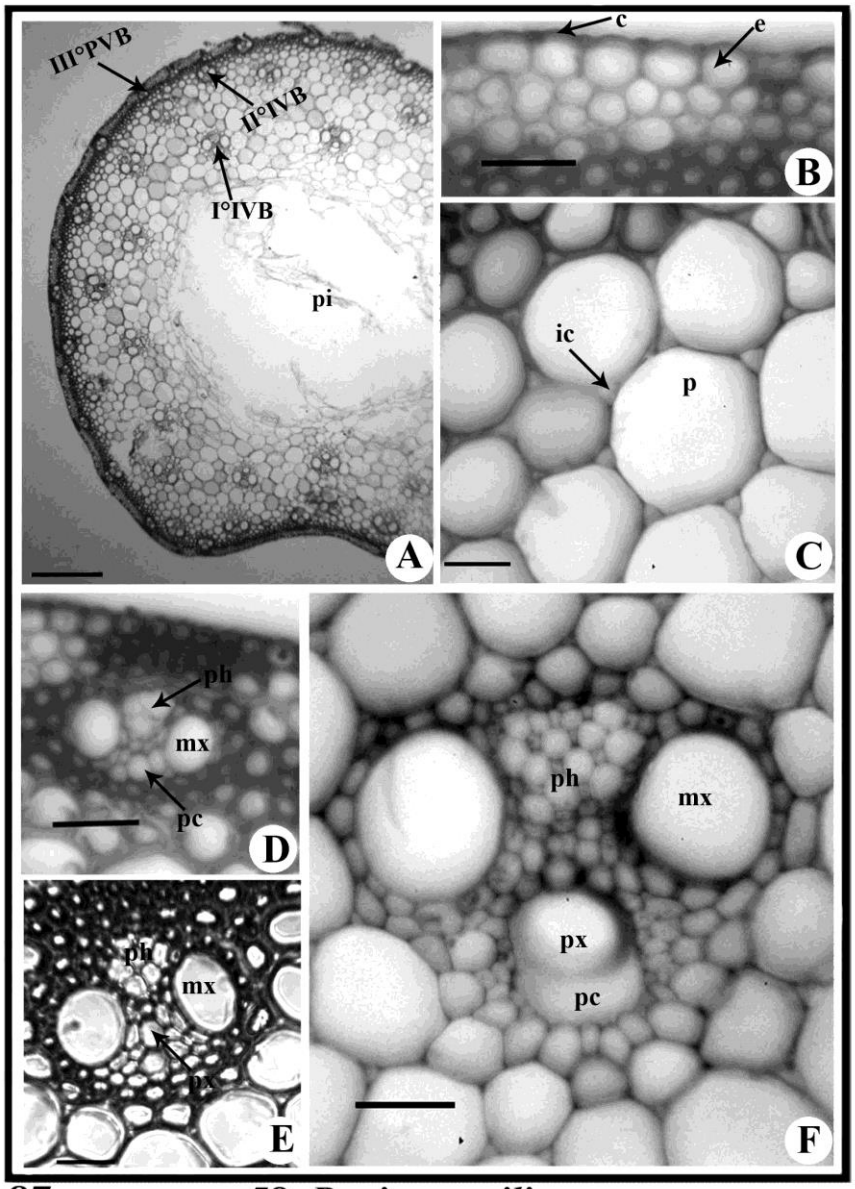
58. *Panicum miliaceum* (Fig. 87(58) A-F)

Horseshoe in transection with smooth surface (Fig. A)
Size: 315.38x323.07±25.16 µm, Hairs/Prickles absent.
Hollow internode.
Epidermis: Round shaped (Fig. B)
Hypodermis: 2-3 layered parenchymatous cells interrupted by sclerenchymatous cells (Fig. B).
With III^{o} PVB embedded
Type-B sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type E (Fig. F)
Size: 19.68x23.22±5.27 µm
II^{o} IVB: Type M (Fig. E)
Size: 17.23x19.45±6.16 µm
III^{o} PVB: Type Q (Fig. D)
Size: 6.07x9.28±2.72 µm
Bar size: A = 50 µm, B-F = 5 µm



57. *Panicum maximum*

Fig. 87



58. *Panicum miliaceum*

59. *Panicum trypheron* (Fig. 88(59) A-F)

Horseshoe in transection with smooth surface (Fig. A)

Size: 316.67x308.34±51.56 µm, Hairs/Prickles absent.

Hollow internode. Kranz anatomy present (Fig. C).

Epidermis: Elongated Shaped-II (Fig. B)

Hypodermis: 3-4 layered chlorenchymatous cells

Interrupted by sclerenchymatous cells with III^{o} PVB embedded

Type-E sclerenchyma present (Fig. C)

Ground tissue: Round to oval shaped parenchymatous (Fig. E)

Vascular bundles arranged in ring form

Vascular system: all present

I^{o} IVB: Type E (Fig. F)

Size: 15.94x19.69±6.17 µm

II^{o} IVB: Type P (Fig. D)

Size: 8.34x12.5±3.17 µm

III^{o} PVB: Type Q (Fig. C)

Size: 6.39x10±2.15 µm

Kranz arc: Half circle (Fig. C)

Chloroplast type: Centrifugal

Shape of kranz cell: Round to oval

Mestome: single layered

Bar size: A = 50 µm, B-F = 5 µm

Differentiating features:

Presence of kranz arc……..…… *P. trypheron*

Absence of kranz arc

Sclerenchyma type B present……..…….…… *P. miliaceum*

Sclerenchyma type D present

Elongated shaped epidermal cell…….……..*P. antidotalae*

Rectangular shaped epidermal cell…..……..*P. maximum*

Paspalidium

60. *Paspalidium flavidum*

61. *Paspalidium geminatum*

60. *Paspalidium flavidum* (Fig. 88(60) A-G)

Oval with distal end flat in transection with slightly undulating surface (Fig. A)

Size: 361.90x280.95±47.25 µm, Hairs/Prickles absent.

Solid internode with parechymatous pith. Kranz anatomy present (Fig. E).

Epidermis: Rectangular Shaped-III (Fig. C)

Hypodermis: 3-4 layered chlorenchyma (Fig. B)

Than 2-3 layered sclerenchymatous with III^{o} PVB embedded

Type-D sclerenchyma present

Ground tissue: Round to oval shaped parenchymatous (Fig. D)

Vascular bundles arranged in ring form

Vascular system: all present

I^{o} IVB: Type I, sclerenchymatous small cap present (Fig. G)

Size: 15.43x16.08±3.16 µm

II^{o} IVB: Type P (Fig. F)

Size: 11.78x19.28±3.26 µm

III^{o} PVB: Type Q (Fig. E)

Size: 3.13x3.13±1.25 µm

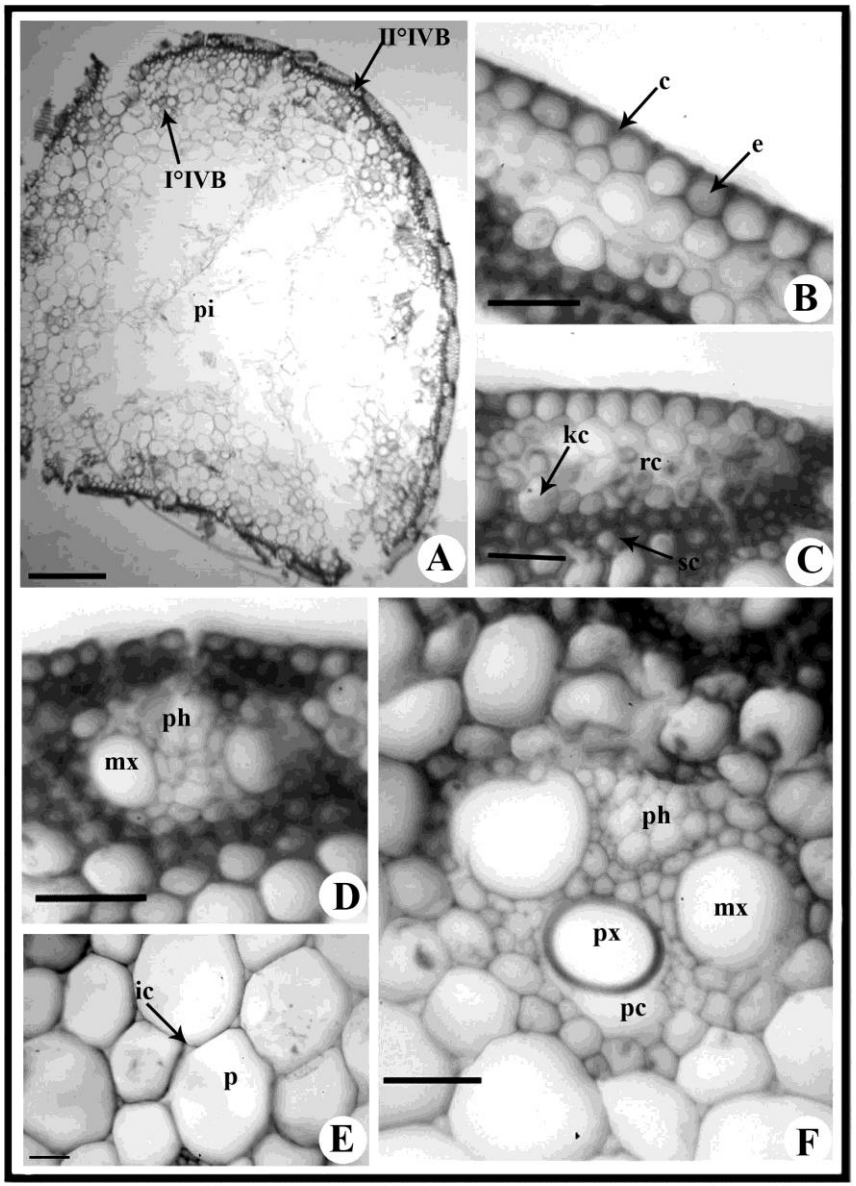
Kranz arc: Half circle (Fig. E)

Chloroplast type: Centripetal

Shape of kranz cell: Round to oval

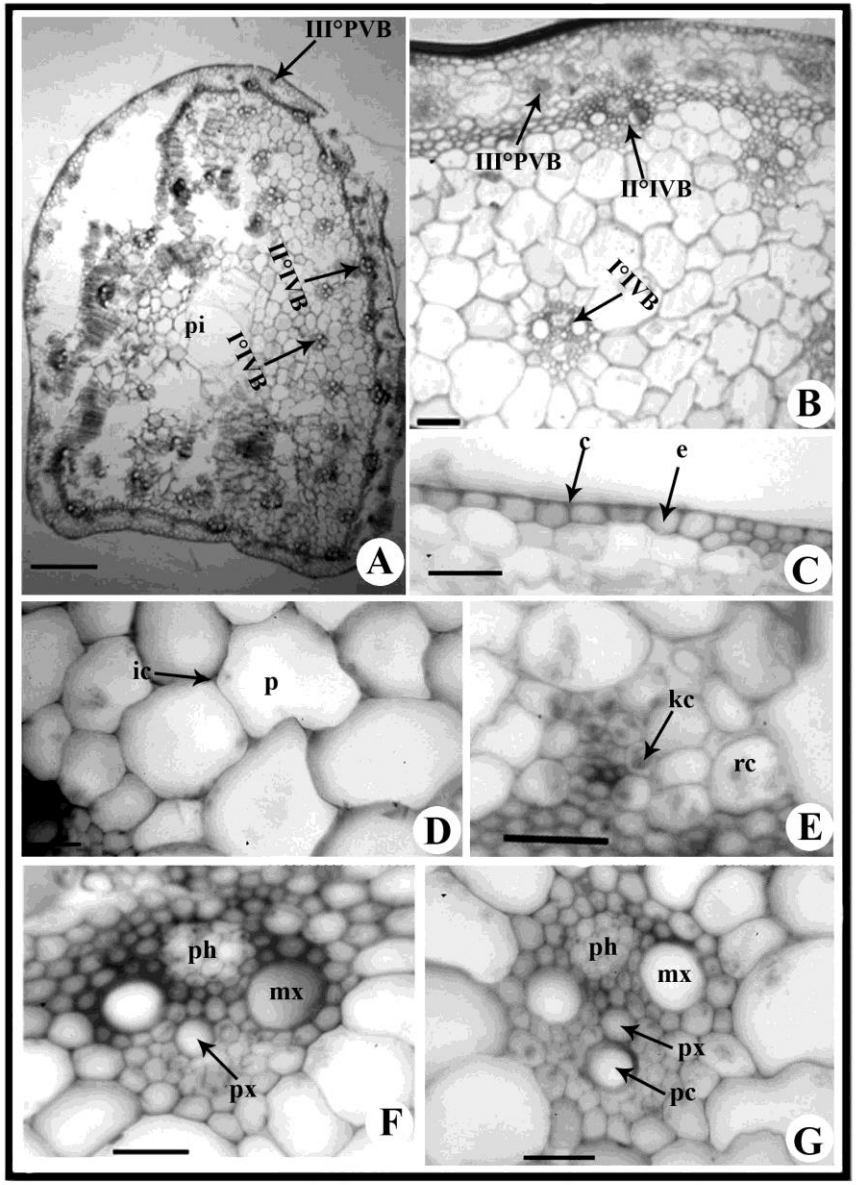
Mestome: single layered

Bar size: A = 50 µm, B = 10 µm, C-G = 5 µm



59. *Panicum trypheron*

Fig. 88



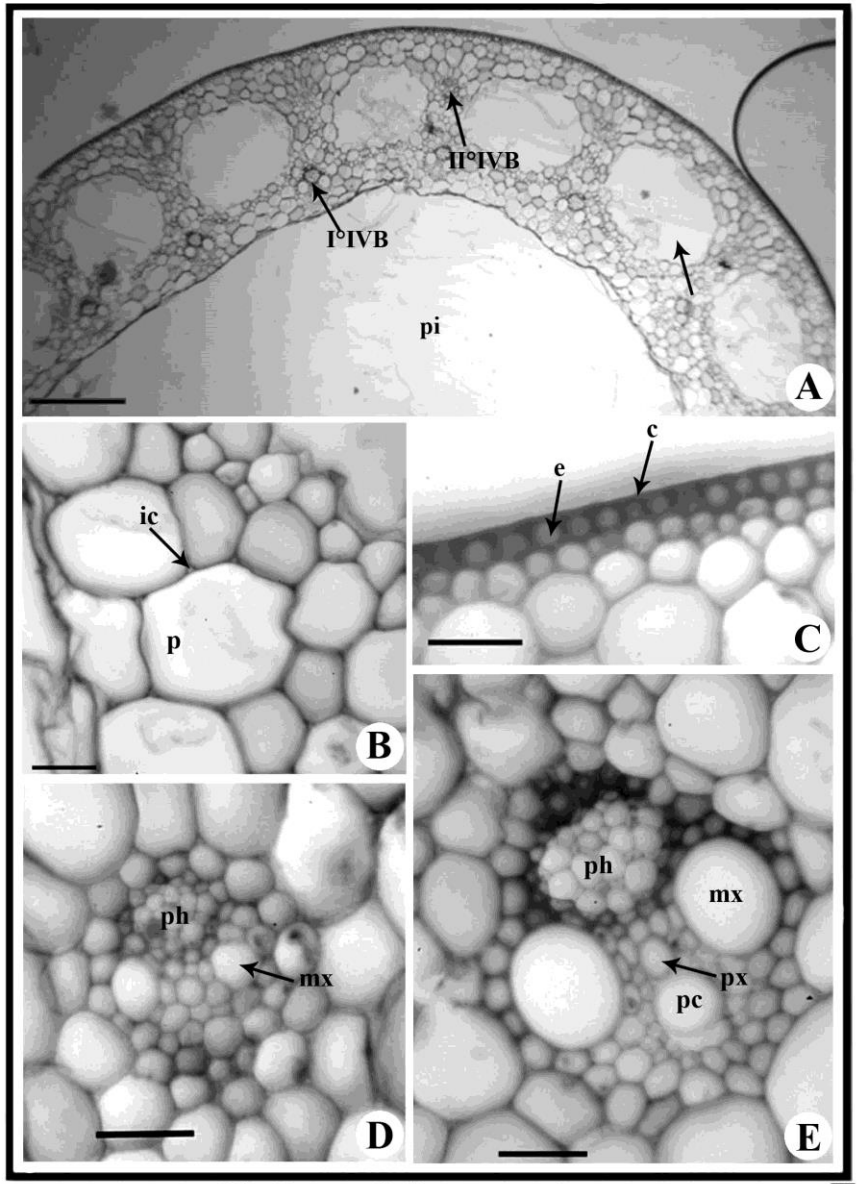
60. *Paspalidium flavidum*

61. *Paspalidium geminatum* (Fig. 89(61) A-E)

Round to oval in transection with smooth surface (Fig. A)
Size: 1080.64x1677.42 µm, Hairs/Prickles absent.
Hollow internode.
Epidermis: Round Shaped (Fig. C)
Hypodermis: 3-4 layered parenchymatous cells
Few sclerenchymatous cells interrupted
With III^{o} PVB embedded
Type-D sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. B)
Air cavity presents (Fig. A)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymatous cap present (Fig. E)
Size: 18.21x18.39±4.15 µm
II^{o} IVB: Type M (Fig. D)
Size: 10.78x11.56±2.36 µm
III^{o} PVB: Type Q
Size: 4.27x4.03±1.82 µm
Bar size: A = 50 µm, B-E = 5 µm
Differentiating features:
Rectangular shaped epidermal cell……..…….. *P. geminatum*
Round shaped epidermal cell……...…….……*P. flavidum*

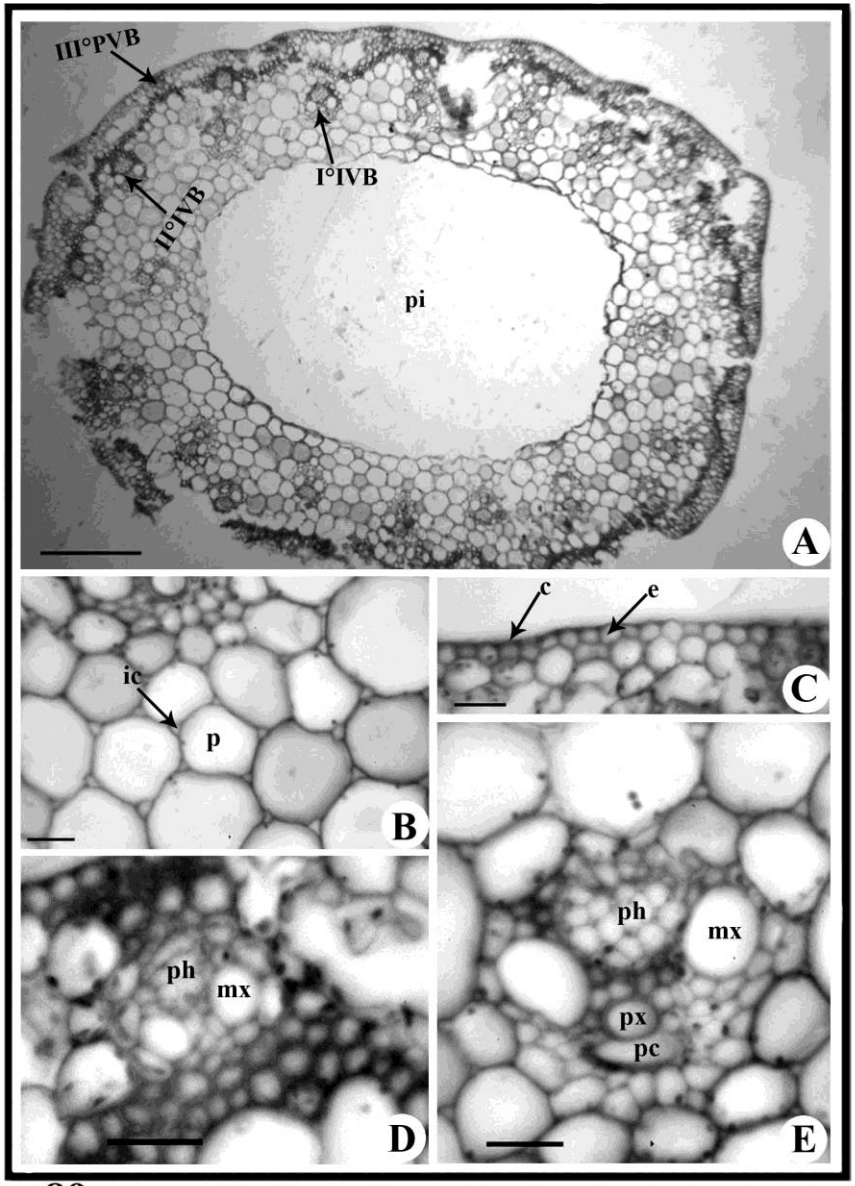
62. *Paspalum scrobiculatum* (Fig. 89(62) A-E)

Oval in transection with undulating surface (Fig. A)
Size: 275x362.5±13.54 µm, Hairs/Prickles absent.
Hollow internode.
Epidermis: Rectangular Shaped-IV (Fig. C)
Hypodermis: 3-4 layered parenchymatous cells (Fig. A)
Than 2-3 layered sclerenchymatous cells
With III^{o} PVB embedded
Type-D sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. B)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymatous cap absent (Fig. E)
Size: 18.75x15.63±3.27 µm
II^{o} IVB: Type P (Fig. D)
Size: 17.08x21.04±3.65 µm
III^{o} PVB: Type Q
Size: 6.34x8.34±2.56 µm
Bar size: A = 50 µm, B-E = 5 µm



61. *Paspalidium geminatum*

Fig. 89



62. *Paspalum scrobiculatum*

63. *Pennisetum setosum* (Fig. 90(63) A-F)

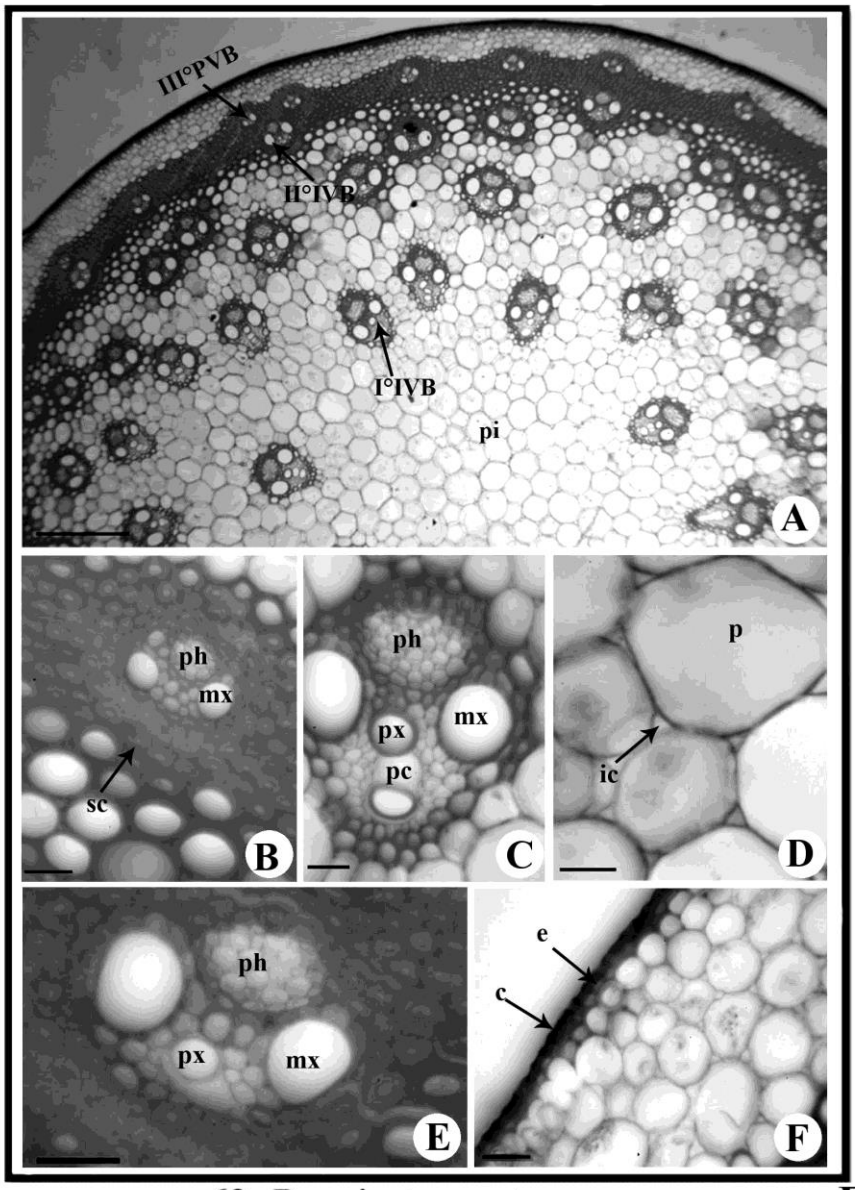
Oval in transection with smooth surface (Fig. A)
Size: 742.23x1151.13±92.36 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Rectangular Shaped-II (Fig. F)
Hypodermis: 3-4 layered of parenchymatous cells (Fig. A)
6-7 layered sclerenchymatous cells
With III^{o} PVB embedded
Type-B sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. D)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type F and B (Fig. C)
sclerenchymatous cells around VB Scatterly arranged
Size: 31.43x27.85±8.62 µm
II^{o} IVB: Type K (Fig. E)
Size: 13.46x17.69±4.28 µm
III^{o} PVB: Type Q (Fig. B)
Size: 8.12x12.5±3.28 µm
Bar size: A = 50 µm, B-F = 5 µm

Setaria

64. *Setaria glauca*
65. *Setaria tomentosa*
66. *Setaria verticillata*

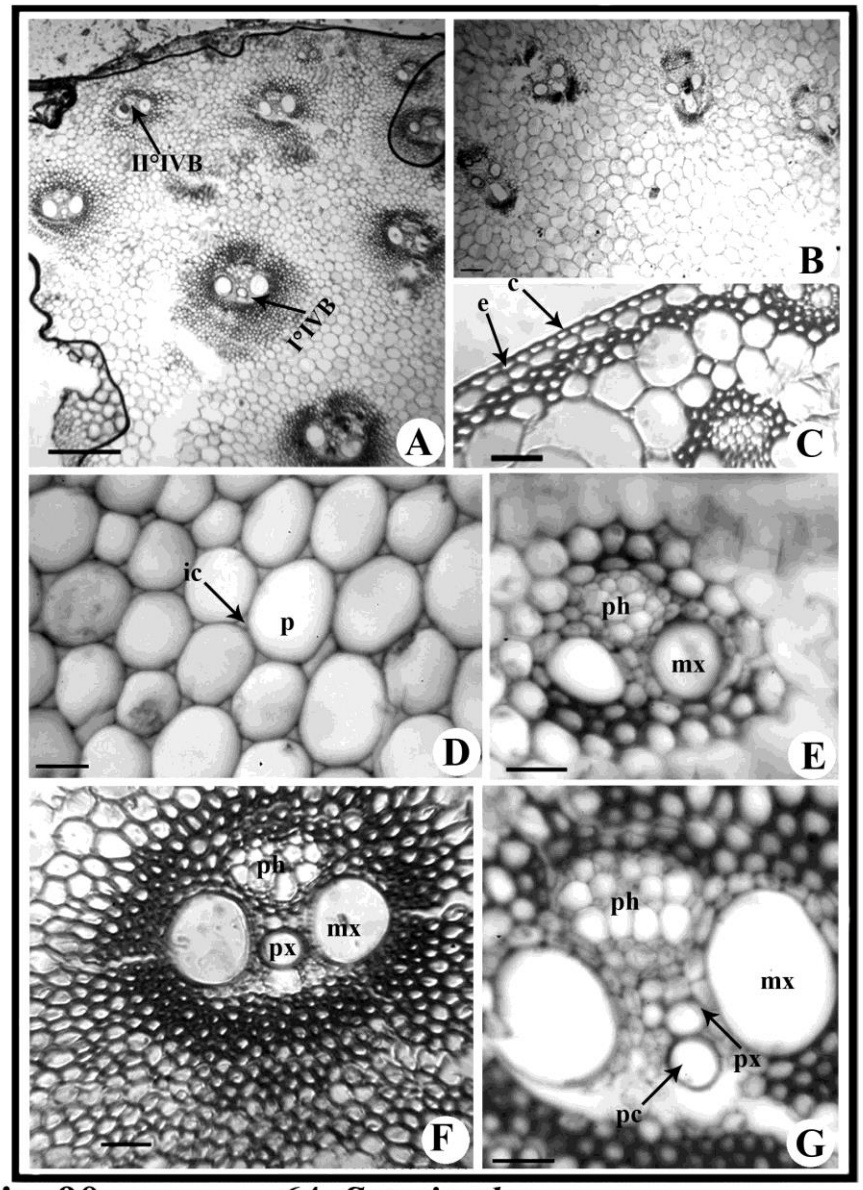
64. *Setaria glauca* (Fig. 90(64) A-G)

Oval in transection with smooth surface (Fig. A)
Size: 777.79x1100±104.26 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Barrel Shaped-IV (Fig. C)
Hypodermis: 1 layered parenchymatous (Fig. B)
Than 3-4 layered sclerenchymatous
Type-E sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. D)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type H, sclerenchymatous cells around VB (Fig. G)
Size: 22.5x29.37±6.37 µm
II^{o} IVB: Type J (Fig. F)
Size: 21.36x26.36±5.89 µm
III^{o} PVB: Type Q (Fig. E)
Size: 15x17±4.72 µm
Bar size: A-B = 50 µm, C-G = 5 µm



63. *Pennisetum setosum*

Fig. 90



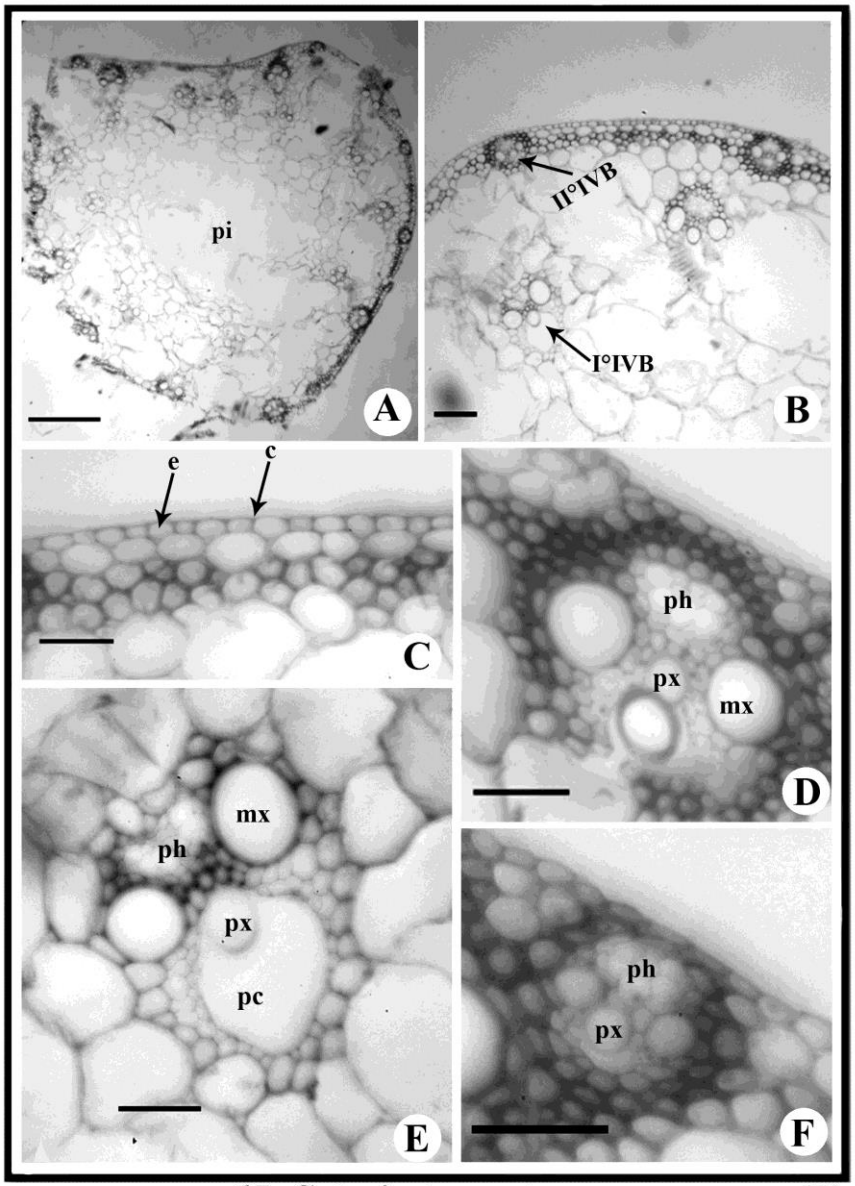
64. *Setaria glauca*

65. *Setaria tomentosa* (Fig. 91(65) A-F)

Triangular in transection with smooth surface (Fig. A)
Size: 263.64x290.90±14.52 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Barrel Shaped-III
Hypodermis: 1 layered parenchymatous cells (Fig. C)
Than 2-3 layered sclerenchymatous
With III^{o} PVB embedded
Type-D sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type I, sclerenchymatous cap absent (Fig. E)
Size: 20.38x13.07±5.28 µm
II^{o} IVB: Type P (Fig. D)
Size: 12.67x15±3.52 µm
III^{o} PVB: Type Q (Fig. F)
Size: 5.23x6.36±2.45 µm
Bar size: A = 50 µm, B = 10 µm, C-F = 5 µm

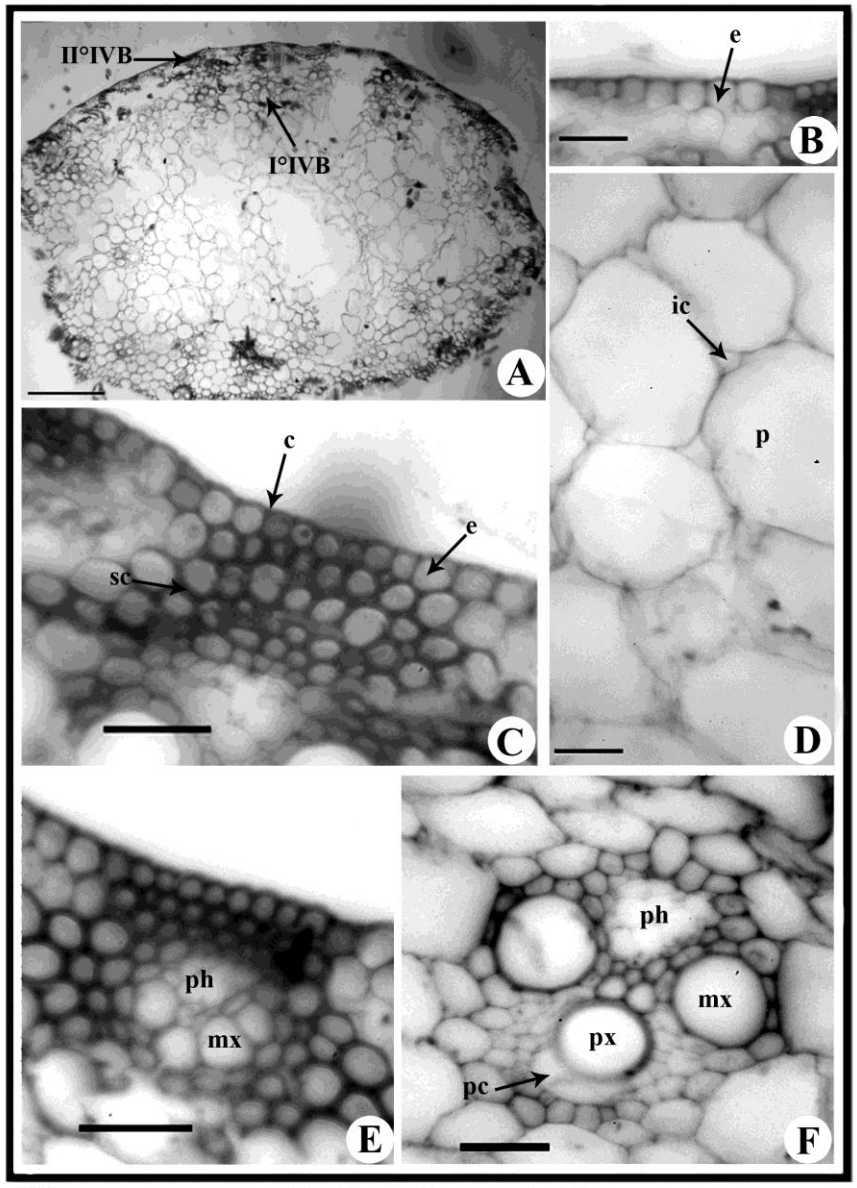
66. *Setaria verticillata* (Fig. 91(66) A-F)

Oblong in transection with slightly undulating surface (Fig. A)
Size: 241.67x325±21.68 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Barrel Shaped-IV (Fig. B)
Hypodermis: 3-4 layered parenchymatous
Interrupted by sclerenchymatous girder
With III^{o} PVB embedded
Type-D sclerenchyma present (Fig. C)
Ground tissue: Round to oval shaped irregular parenchymatous,
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymatous cap present (Fig. F)
Size: 16.43x18.21±4.27 µm
II^{o} IVB: Type O (Fig. E)
Size: 9.26x10.27±3.79 µm
III^{o} PVB: Type Q
Size: 6.11x6.67±2.74 µm
Bar size: A = 50 µm, B-F = 5 µm
Differentiating features:
Sclerenchyma in form of girder……..…….. *S. verticillata*
Sclerenchyma in form of unicylinder
Sclerenchyma type E present…….…..……. *S. glauca*
Sclerenchyma type D present……...…….*S. tomentosa*



65. *Setaria tomentosa*

Fig. 92



66. *Setaria verticillata*

67. *Isachne globosa* (Fig. 92(67) A-F)

Cordate in transection with slightly undulating surface (Fig. A)
Size: 268.18x431.82±16.29 µm, Hairs/Prickles absent.
Hollow internode. Kranz anatomy present (Fig. B).
Epidermis: Barrel Shaped-IV (Fig. C)
Hypodermis: 3-4 layered chlorenchymatous cells (Fig. B)
Interrupted by sclerenchymatous with III^{o} PVB embedded
Type-E sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous,
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type E (Fig. F)
Size: 20.84x25.42±6.42 µm
II^{o} IVB: Type J (Fig. F)
Size: 11.25x13.75±4.82 µm
III^{o} PVB: Type Q (Fig. D)
Size: 8.37x8.75±2.38 µm
Kranz arc: Half circle (Fig. D) **Chloroplast type:** Centrifugal
Shape of kranz cell: Round to oval **Mestome:** single layered
Bar size: A = 50 µm, B = 10 µm, C-F = 5 µm

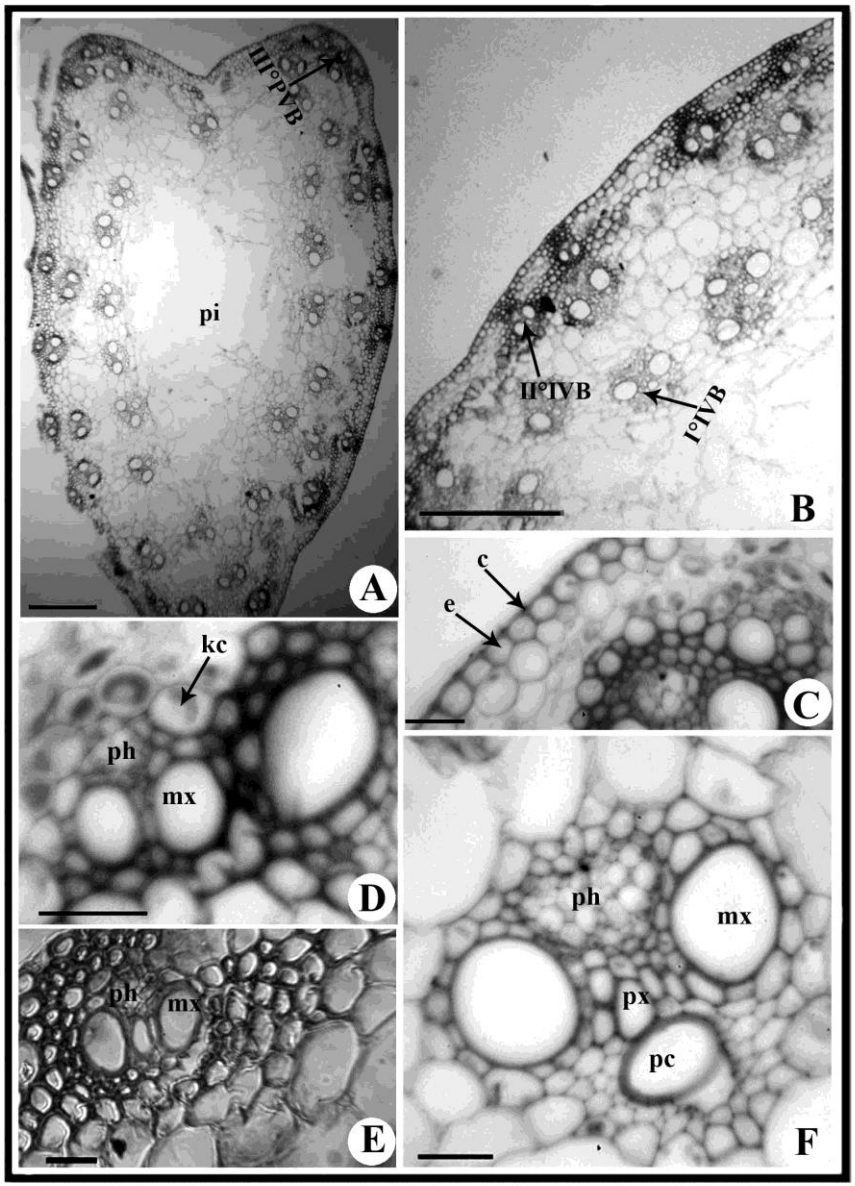
Aristida

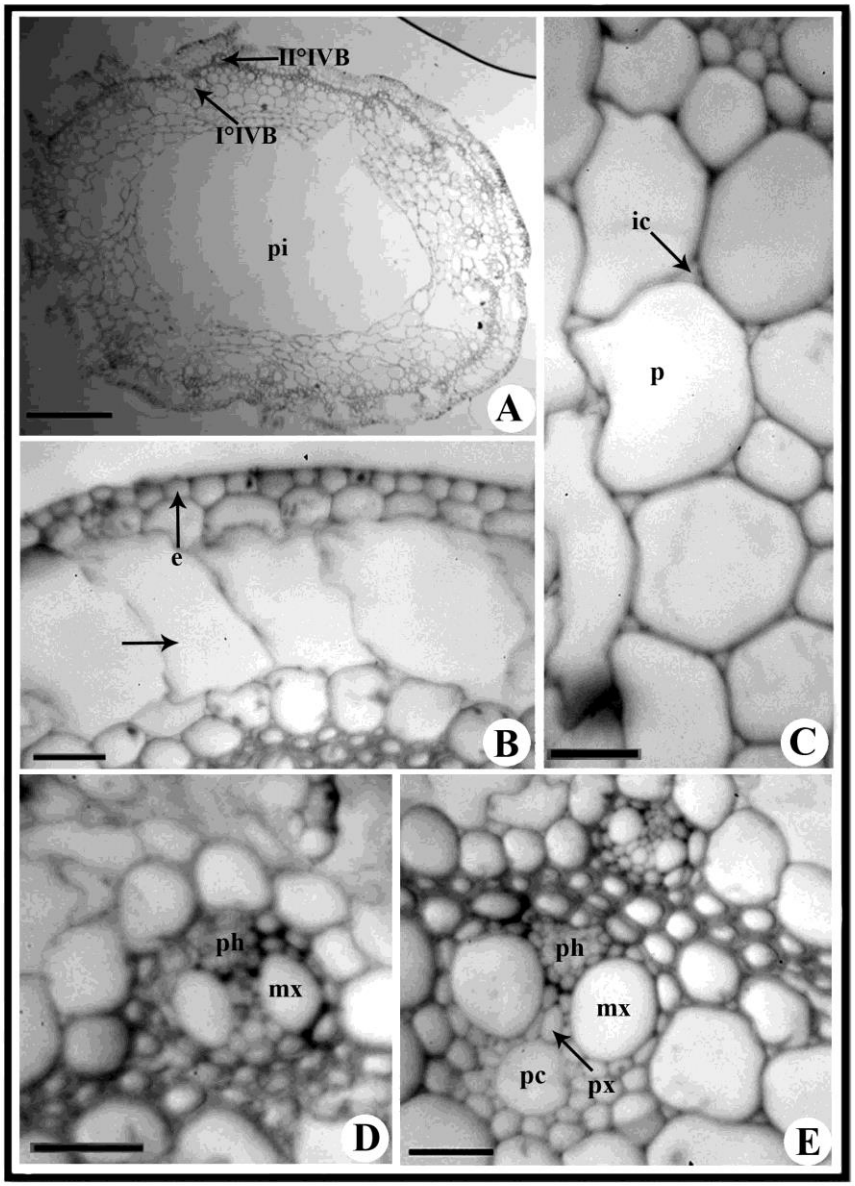
68. *Aristida adscensionis*

69. *Aristida funiculata*

68. *Aristida adscensionis* (Fig. 92(68) A-E)

Oblong in transection with slightly undulating surface (Fig. A)
Size: 225.92x229.63±15.38 µm, Hairs/Prickles absent.
Hollow internode. Kranz anatomy is present.
Epidermis: Barrel Shaped-IV
Hypodermis: 2-3 layered chlorenchymatous (Fig. B)
Middle layer cell big in size than sclerenchymatouscells present (Fig. B)
With III^{o} PVB embedded
Type-D sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type E, sclerenchymatous cap present (Fig. E)
Size: 13.57x12.86±4.89 µm
II^{o} IVB: Type O
Size: 8.28x9.14±2.19 µm
III^{o} PVB: Type Q (Fig. D)
Size: 3.28x3.81±1.34 µm
Kranz arc: Half circle (Fig. D) **Chloroplast type:** Centrifugal
Shape of kranz cell: Round to oval **Mestome:** single layered
Bar size: A = 50 µm, B-E = 5 µm





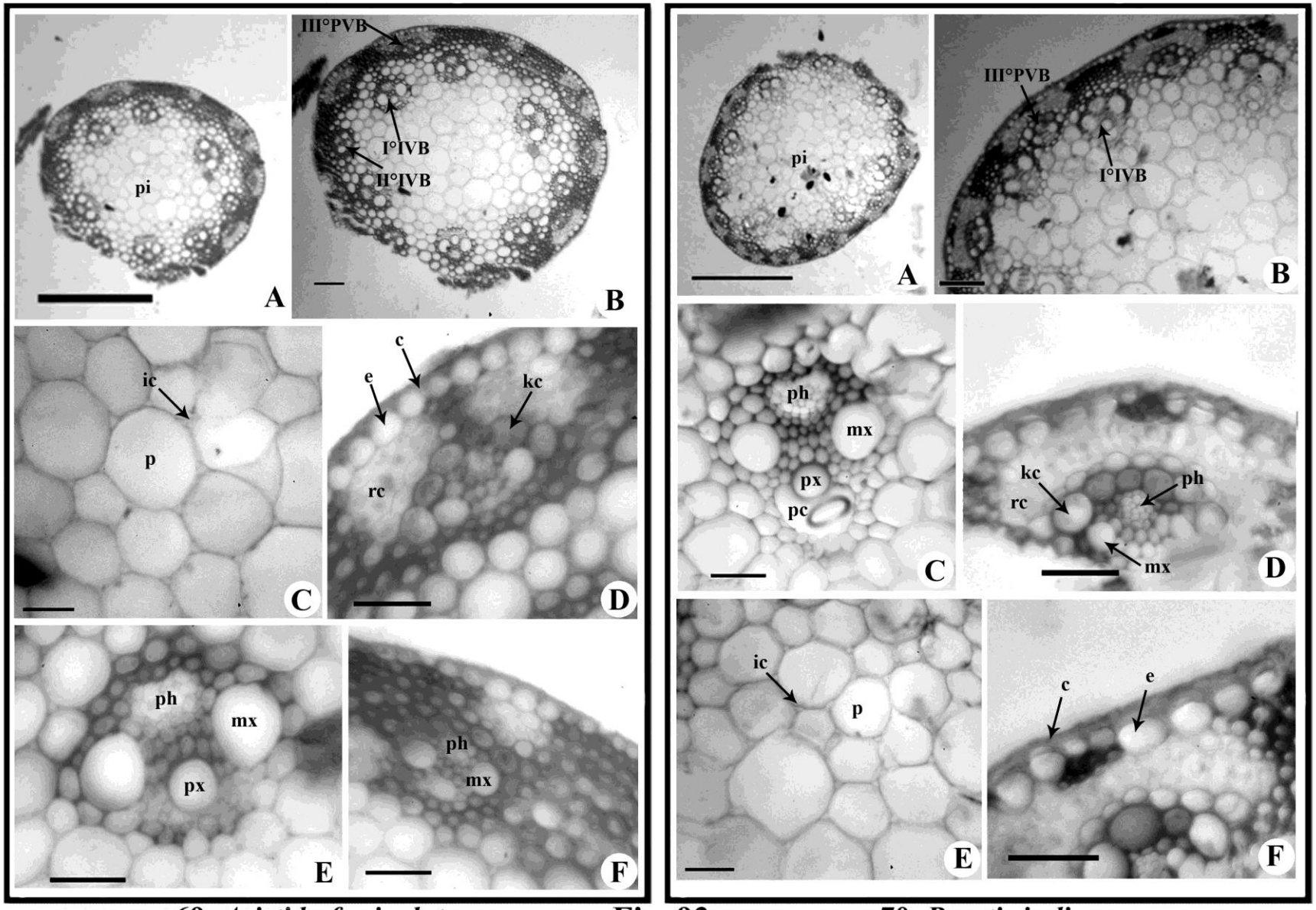
67. *Isachne globosa* **Fig. 92** 68. *Aristida adscensionis*

69. *Aristida funiculata* (Fig. 93(69) A-F)

Round in transection with slightly undulating surface (Fig. A)
Size: 196.37x198.3221.38 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith. Kranz anatomy present (Fig. D).
Epidermis: Barrel Shaped-III
Hypodermis: 3-4 layered chlorenchyma (Fig. B)
Interrupted by sclerenchymatous with III^{o} PVB embedded
Type-E sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymatous samll cap present (Fig. E)
Size: 11.25x15±3.16 µm
II^{o} IVB: Type P (Fig. F)
Size: 5.71x8.57±2.46 µm
III^{o} PVB: Type Q (Fig. D)
Size: 3.44x6.25±1.37 µm
Kranz arc: Horseshoe (Fig. D) **Chloroplast type:** Centrifugal
Shape of kranz cell: Round to oval (Fig. D) **Mestome:** single layered
Bar size: A = 50 µm, B = 10 µm, C-F = 5 µm
Differentiating features:
Half circle shaped kranz arc, sclerenchyma type D present...……*A. adscensionis*
Horseshoe shaped kranz arc, sclerenchyma type E present ...……*A. funiculata*

70. *Perotis indica* (Fig. 93(70) A-F)

Round to oval in transection with smooth surface (Fig. A)
Size: 98.54x47.81±9.24 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith. Kranz anatomy is present (Fig. B).
Epidermis: Round Shaped (Fig. F)
Hypodermis: 3-4 layered chlorenchymatous interrupted by sclerenchymatous (Fig.B)
With III^{o} PVB embedded
Type-E sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. E)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type D, sclerenchymatous cap absent (Fig. C)
Size: 12.5x16.67±3.74 µm
II^{o} IVB: Type M
Size: 10.36x11.73±2.46 µm
III^{o} PVB: Type Q (Fig. D)
Size: 7.92x10.42±1.53 µm
Kranz arc: Horseshoe (Fig. D) **Chloroplast type:** Centrifugal
Shape of kranz cell: Round to oval (Fig. D) **Mestome:** absent
Bar size: A = 50 µm, B = 10 µm, C-F = 5 µm



69. *Aristida funiculata* **Fig. 93** 70. *Perotis indica*

Chloris

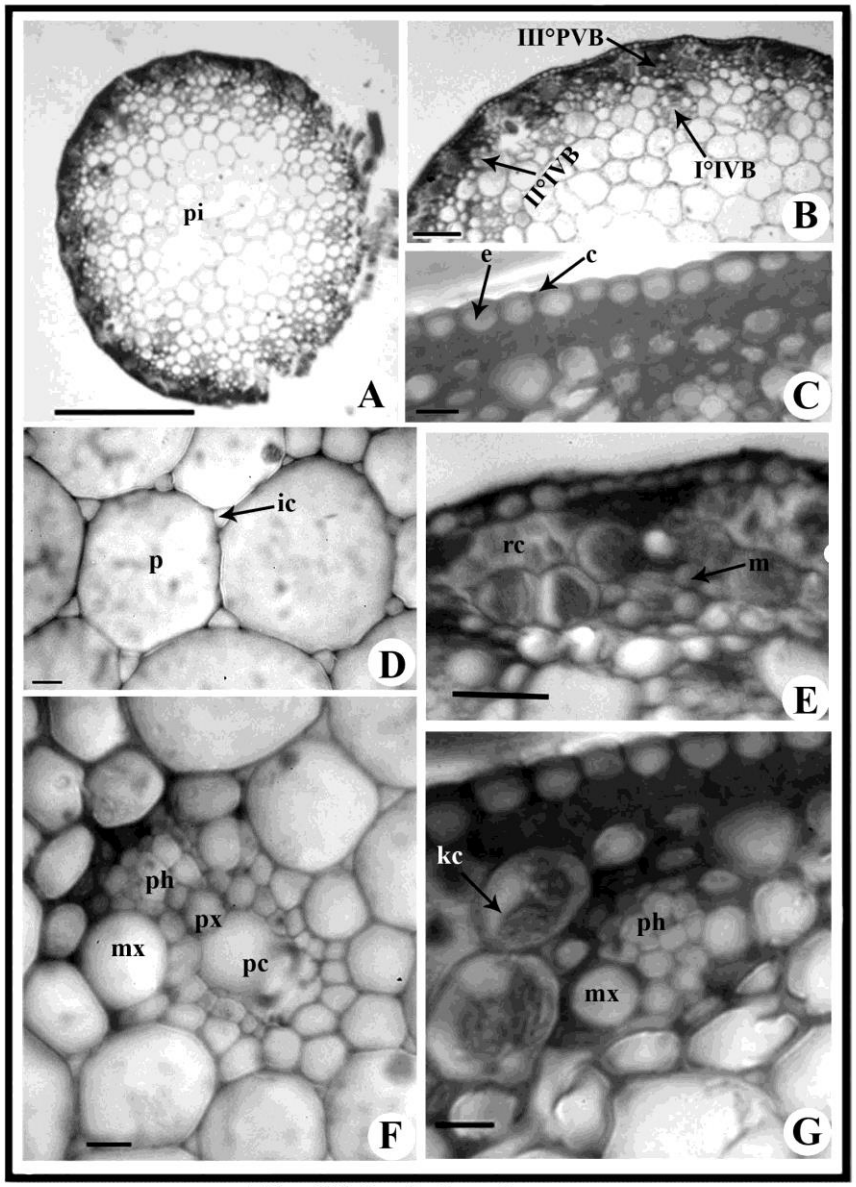
71. *Chloris barbata*
72. *Choris montana*
73. *Chloris virgata*

71. *Chloris barbata* (Fig. 94(71) A-G)

Round in transection with slightly undulating surface (Fig. A)
Size: 129.54x118.18±32.64 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith. Kranz anatomy is present (Fig. E).
Epidermis: Barrel Shaped-V (Fig. C)
Hypodermis: 3-4 layered chlorenchymatous
Interrupted by sclerenchymatous, Type-B sclerenchyma
Ground tissue: Round to oval shaped parenchymatous (Fig. D)
Vascular bundles arranged in ring form
Vascular system: all present
Iº IVB: Type I, sclerenchymatous small cap present (Fig. F)
Size: 25x10.71±6.63 µm
IIº IVB: Type M
Size: 12.78x17.22±3.46 µm
IIIº PVB: Type Q (Fig. G)
Size: 3.67x2.33±1.63 µm
Kranz arc: Horseshoe (Fig. G) **Chloroplast type:** Centripetal (Fig. G)
Shape of kranz cell: Trapezoid (Fig. E) **Mestome:** single layered
Bar size: A = 50 µm, B = 10 µm, C-G = 5 µm

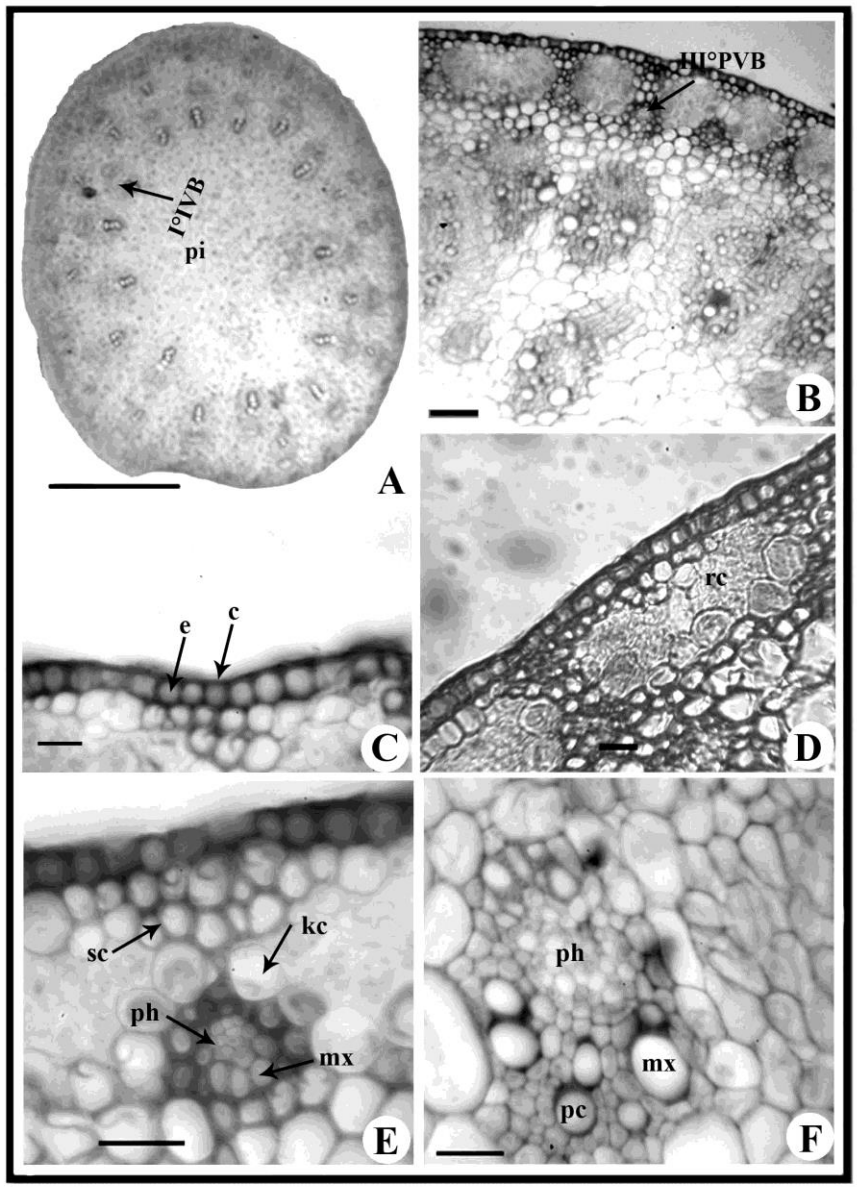
72. *Choris montana* (Fig. 94(72) A-F)

Round in transection with smooth surface (Fig. A)
Size: 171.44x145.24±17.37 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Square Shaped-I (Fig. C)
Hypodermis: 3-4 layered chlorenchymatous interrupted by sclerenchymatous (Fig.B)
With IIIº PVB embedded
Type-D sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous,
Vascular bundles arranged in ring form
Vascular system: all present
Iº IVB: Type I, sclerenchymatous small cap present (Fig. F)
Size: 20x15.45±4.17 µm
IIº IVB: Type M
Size: 9.25x10.15±3.89 µm
IIIº PVB: Type Q (Fig. E)
Size: 6.67x7.34±2.34µm
Kranz arc: Horseshoe (Fig. E) **Chloroplast type:** Centripetal
Shape of kranz cell: Round to oval (Fig. E) **Mestome:** single layered
Bar size: A = 50 µm, B = 10 µm, C-F = 5 µm



71. *Chloris barbata*

Fig. 94



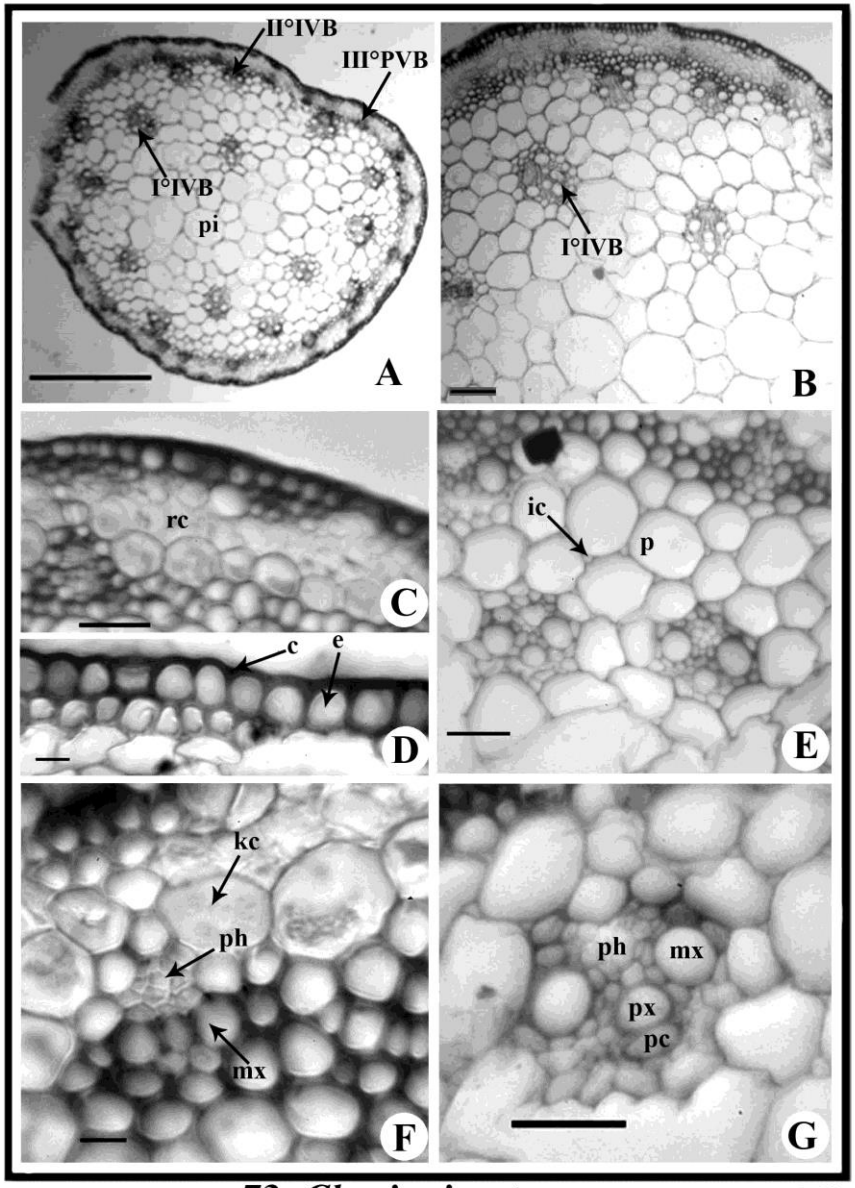
72. *Chloris montana*

73. *Chloris virgata* (Fig. 95(73) A-G)

Oblong in transection with smooth surface (Fig. A)
Size: 130x157.5±26.27 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith. Kranz anatomy is present.
Epidermis: Square Shaped-III (Fig. D)
Hypodermis: 3-4 layered chlorenchymatous interrupted by sclerenchymatous (Fig.B)
Type-D sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. E)
Vascular bundles arranged in ring form
Vascular system: all present
Iº IVB: Type B, Scatterly arranged (Fig. G)
Size: 13.72x14.26±2.36 µm
IIº IVB: Type M
Size: 7.63x8.68±2.16 µm
IIIº PVB: Type Q (Fig. F)
Size: 5x4.37±1.25 µm
Kranz arc: Horseshoe (Fig. F) **Chloroplast type:** Centrifugal
Shape of kranz cell: Round to oval **Mestome:** single layered
Bar size: A = 50 µm, B = 10 µm, C-G = 5 µm
Differentiating features:
Half circle shaped kranz arc……...…… *C. barbata*
Straight shaped kranz arc
Centripetal arrangement of chloroplast.……..……. *C. montana*
Centrifugal arrangement of chloroplast...……*C. virgata*

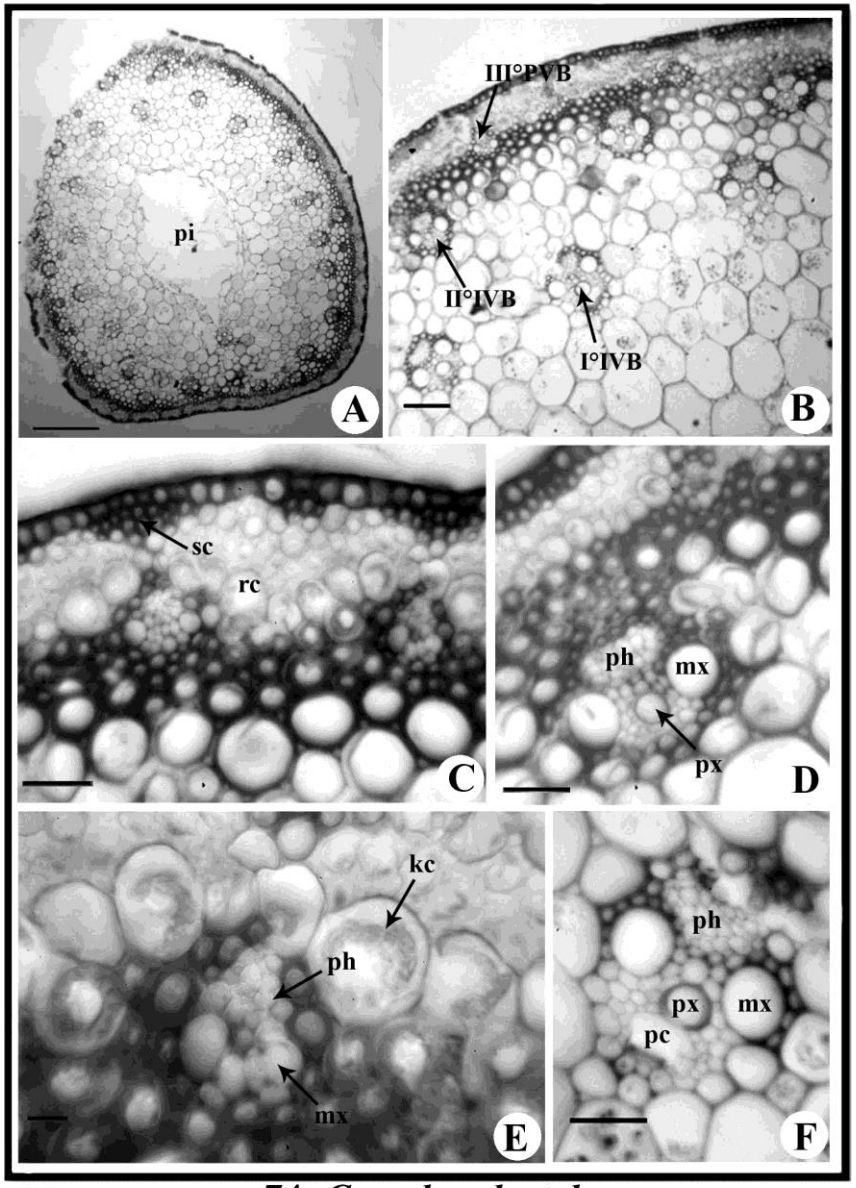
74. *Cynodon dactylon* (Fig. 95(74) A-F)

Triangular in transection with smooth surface (Fig. A)
Size: 277.27x265.09±41.26 µm, Hairs/Prickles absent.
Hollow internode. Kranz anatomy is present (Fig. C).
Epidermis: Elongated Shaped-II (Fig. C)
Hypodermis: 4-5 layered chlorenchymatous interrupted by sclerenchymatous (Fig.B) with IIIº PVB embedded
Type-E sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. B)
Vascular bundles arranged in ring form
Vascular system: all present
Iº IVB: Type C, sclerenchymatous cap present (Fig. F)
Size: 14.58x13.75±2.18 µm
IIº IVB: Type P (Fig. D)
Size: 9.09x12.73±3.17 µm
IIIº PVB: Type Q (Fig. C)
Size: 6.34x6.82±2.37 µm
Kranz arc: Half circle (Fig. E) **Chloroplast type:** Centrifugal
Shape of kranz cell: Round to oval (Fig. E) **Mestome:** single layered
Bar size: A = 50 µm, B = 10 µm, C-F = 5 µm



73. *Choris virgata*

Fig. 95



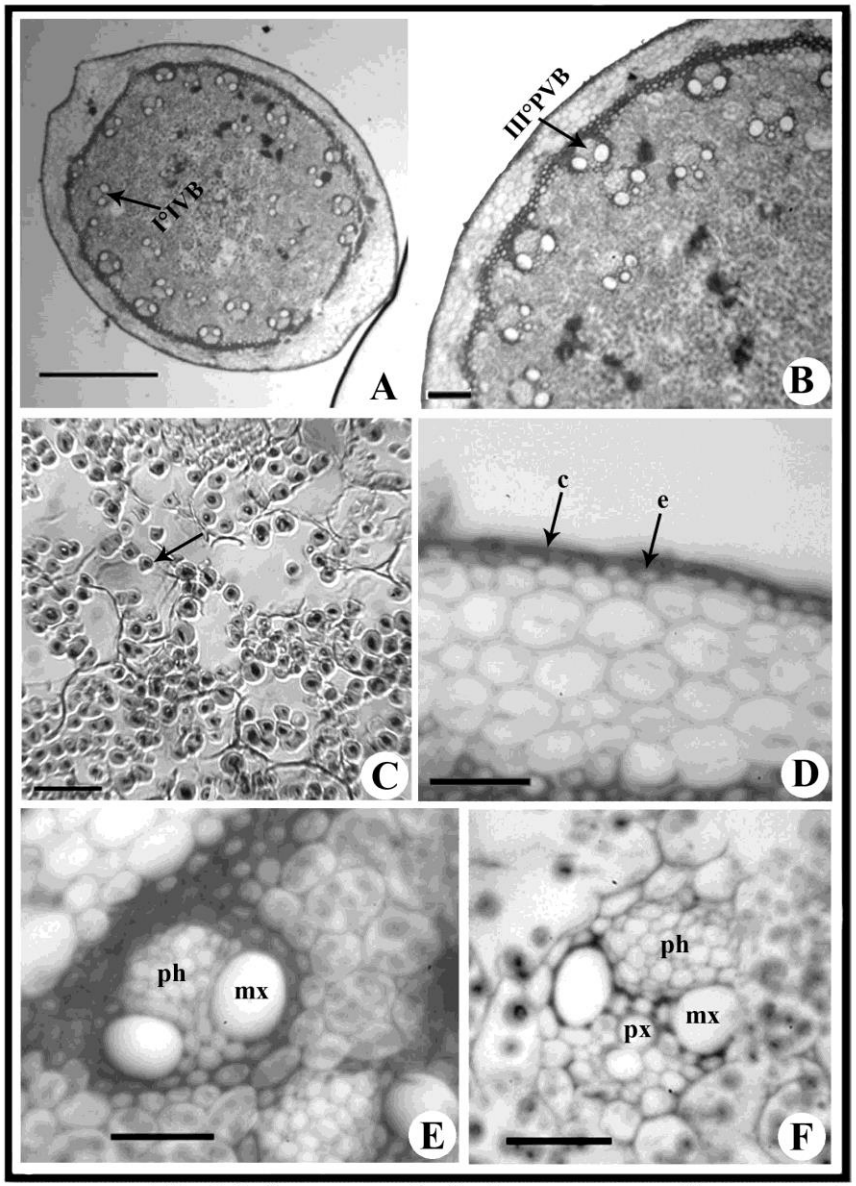
74. *Cynadon dactylon*

75. *Melanocenchris jaequemontii* (Fig. 96(75) A-F)

Oblong in transection with smooth surface (Fig. A)
Size: 115.79x126.32±36.26 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Rectangular Shaped-II (Fig. D)
Hypodermis: 4-5 layered parenchymatous cells (Fig. B)
Than 2-3 layered sclerenchymatous
With III^{o} PVB embedded
Type-B sclerenchyma present
Ground tissue: Round to oval shaped prenchymatous (Fig. B)
Starch grains present (Fig. C)
Vascular bundles arranged in ring form
Vascular system: III^{o} PVB absent
I^{o} IVB: Type I, sclerenchymatous cap absent (Fig. F)
Size: 10x10.59±3.16 µm
II^{o} IVB: Type K (Fig. E)
Size: 7.81x10.31 µm
III^{o} PVB: -
Size: -
Bar size: A = 50 µm, B = 10 µm, C-F = 5 µm

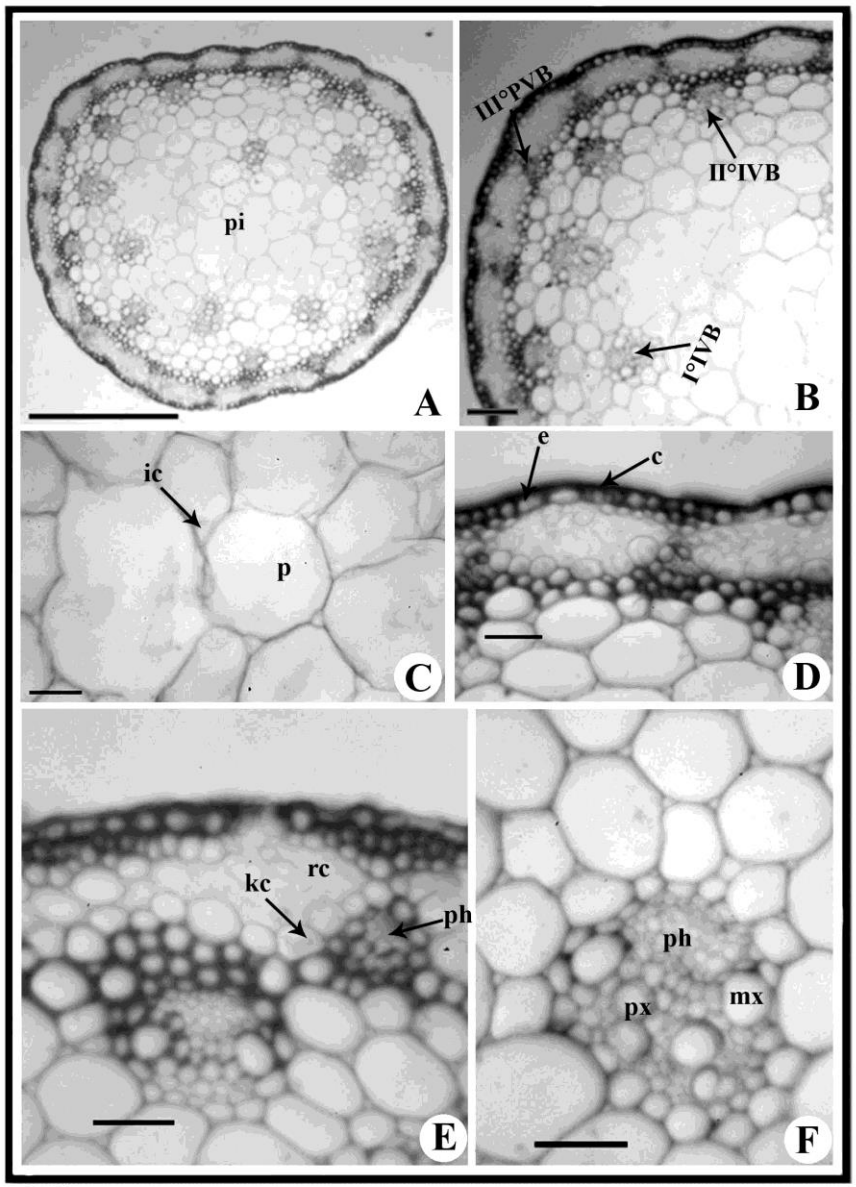
76. *Oropetium villosulum* (Fig. 96(76) A-F)

Round in transection with slightly undulating surface (Fig. A)
Size: 116x136±17.28 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith. Kranz anatomy is present.
Epidermis: Square Shaped-III (Fig. D)
Hypodermis: 3-4 layered chlorenchymatous (Fig. B)
Interrupted by sclerenchymatous with III^{o} PVB embedded
Type-D sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type H (Fig. F)
Size: 13x12±4.17 µm
II^{o} IVB: Type M
Size: 7.78x10±2.19 µm
III^{o} PVB: Type Q (Fig. E)
Size: 3.70x5.18±1.27 µm
Kranz arc: Half circle (Fig. E)
Chloroplast type: Centrifugal
Shape of kranz cell: Round to oval (Fig. E)
Mestome: single layered
Bar size: A = 50 µm, B = 10 µm, C-F = 5 µm



75. *Melanocenchris jaequemontii*

Fig. 96



76. *Oropetium villosulum*

77. *Schoenefeldia gracilis* (Fig. 97(77) A-F)

Round to oblong in transection with smooth surface (Fig. A)
Size: 47.62x73.81±11.43 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith.
Epidermis: Barrel Shaped-III (Fig. B)
Hypodermis: 3-4 layered parenchymatous (Fig. D)
Than 3-4 layers sclerenchymatous
With III^{o} PVB embedded
Type-E sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. C)
Starch grains present
Vascular bundles arranged in ring form
Vascular system: III^{o} PVB absent
I^{o} IVB: Type C, sclerenchymatous cap present (Fig. E)
Size: 14.28x15±4.27 µm
II^{o} IVB: Type P (Fig. F)
Size: 6.04x6.25±2.17 µm
III^{o} PVB: -
Bar size: A = 50 µm, B-F = 5 µm

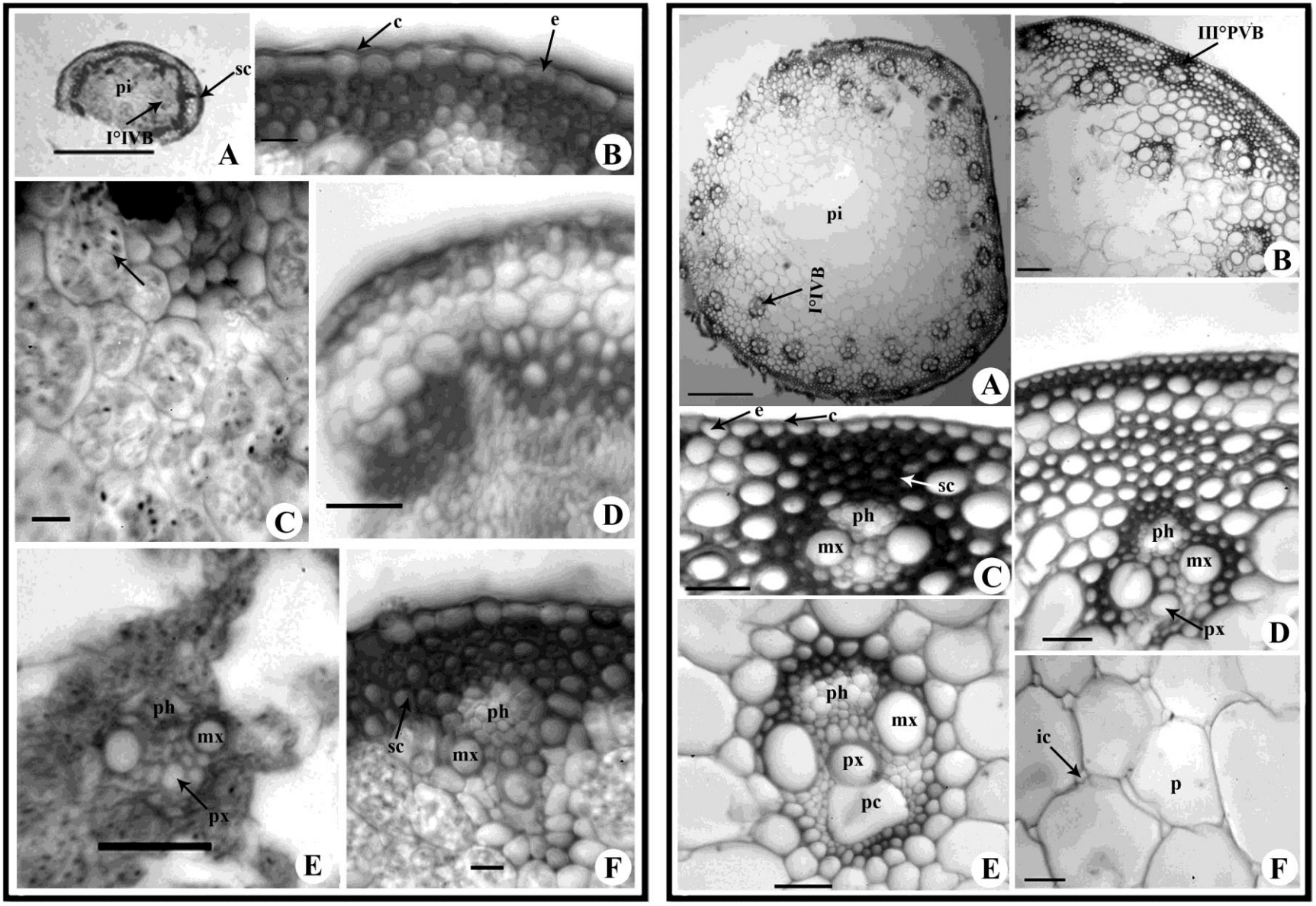
Tetrapogon

78. *Tetrapogon tenellus*

79. *Tetrapogon villosus*

78. *Tetrapogon tenellus* (Fig. 97(78) A-F)

Round with flat distal end in transection with slightly undulating surface (Fig. A)
Size: 239.28x271.43±32.46 µm, Hairs/Prickles absent.
Hollow internode. Kranz anatomy is present.
Epidermis: Barrel Shaped-IV (Fig. C)
Hypodermis: 3-4 layered chlorenchymatous
Interrupted by sclerenchymatous with III^{o} PVB embedded
Type-E sclerenchyma present (Fig. C)
Ground tissue: Round to oval shaped parenchymatous (Fig. F)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type I, sclerenchymaotus small cap present (Fig. E)
scatterly arranged
Size: 19.55x25.45±5.28 µm
II^{o} IVB: Type P (Fig. D)
Size: 13.5x14.5±3.17 µm
III^{o} PVB: Type Q (Fig. C)
Size: 7.86x11.78±2.16 µm
Kranz arc: Half circle (Fig. C)
Chloroplast type: Centrifugal
Shape of kranz cell: Round to oval (Fig. C) **Mestome:** single layered
Bar size: A = 50 µm, B = 10 µm, C-F = 5 µm



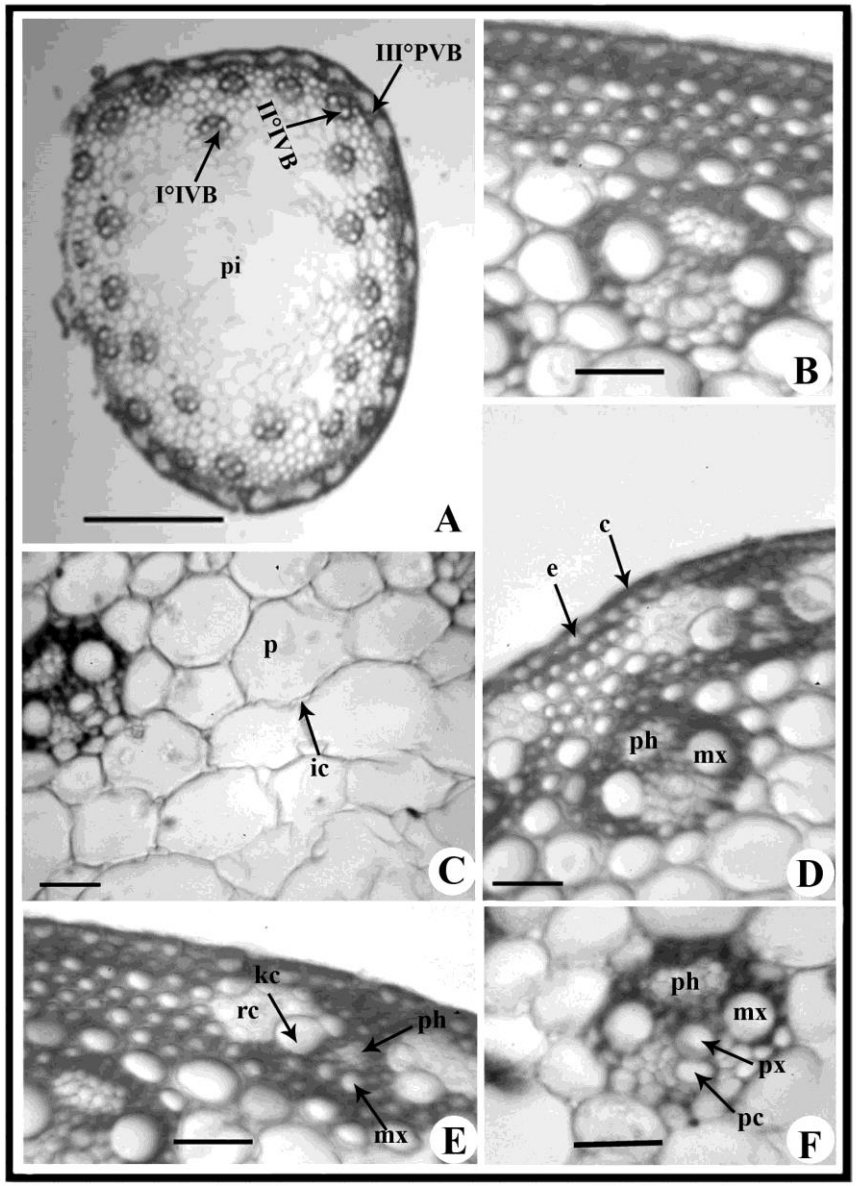
77. *Sachoenefeldia gracilis* **Fig. 97** 78. *Tetrapogon tenellus*

79. *Tetrapogon villosus* (Fig. 98(79) A-F)

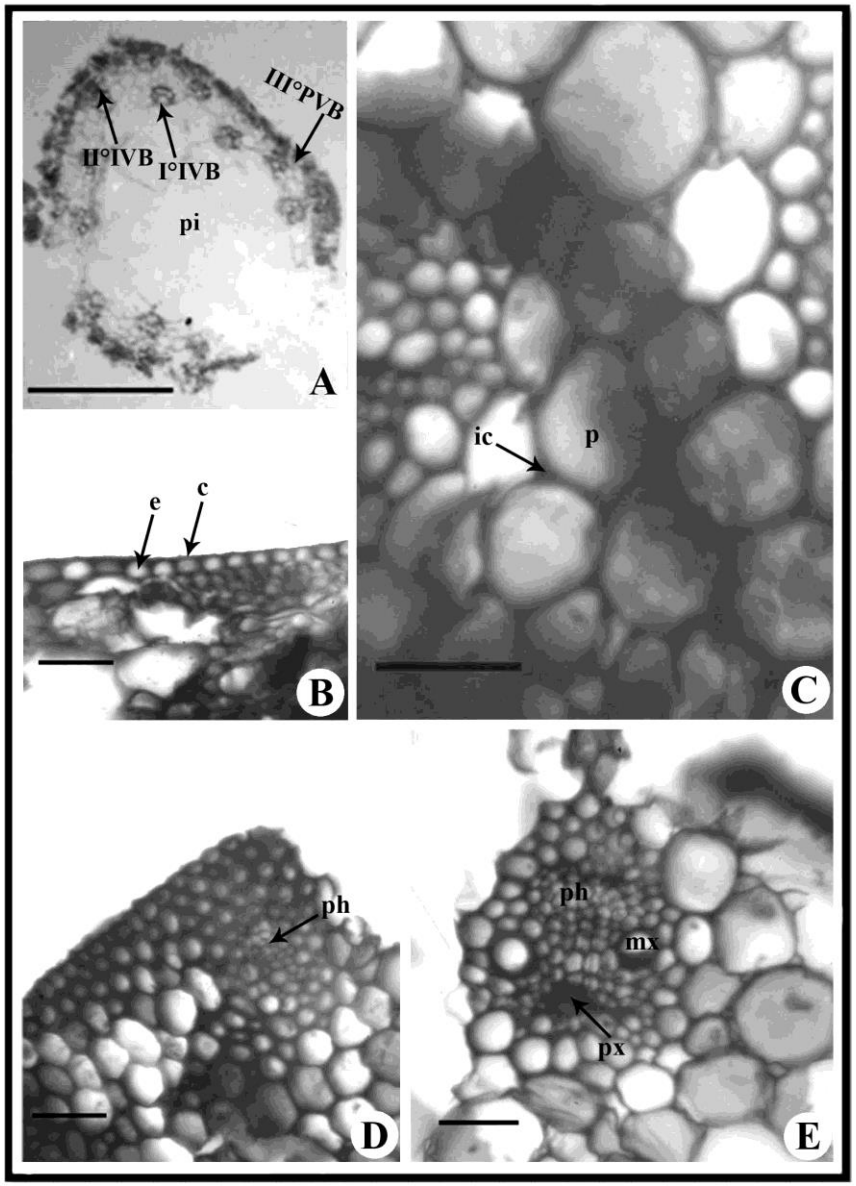
Oblong in transection with smooth surface (Fig. A)
Size: 131.82x168.18±27.46 µm, Hairs/Prickles absent.
Hollow internode. Kranz anatomy is present.
Epidermis: Square Shaped-III (Fig. D)
Hypodermis: 3-4 layered chlorenchymatous interrupted by sclerenchymatous
With III^{o} PVB embedded
Type-B sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymaotus cap present (Fig. F)
Size: 10.36x6.43±2.17 µm
II^{o} IVB: Type P (Fig. D)
Size: 8.64x11.36±3.12 µm
III^{o} PVB: Type Q (Fig. E)
Size: 4.62x6.15±2.15 µm
Kranz arc: Half circle (Fig. E) **Chloroplast type:** Centrifugal
Shape of kranz cell: Round to oval (Fig. E) **Mestome:** single layered
Bar size: A = 50 µm, B-F = 5 µm
Differentiating features:
Round shaped in transection, barrel shaped epidermal cells…...……*T. tenellus*
Oblong shaped in transection, square shaped epidermal cells……*T. villosus*

80. *Acrachne racemosa* (Fig. 98(80) A-E)

Oval in transection with slightly undulating surface (Fig. A)
Size: 86.96x93.48±13.70 µm, Hairs/Prickles absent.
Hollow internode. Kranz anatomy is present.
Epidermis: Barrel Shaped-IV (Fig. B)
Hypodermis: 3-4 layered chlorenchymatous
Interrupted by sclerenchymatous with III^{o} PVB embedded
Type-E sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymaotus cap present (Fig. E)
Size: 11.67x12.92±1.38 µm
II^{o} IVB: Type P
Size: 8.75x9.58±2.61 µm
III^{o} PVB: Type Q (Fig. D)
Size: 5.83x5±2.15 µm
Kranz arc: Half circle **Chloroplast type:** Centrifugal
Shape of kranz cell: Round to oval **Mestome:** single layered
Bar size: A = 50 µm, B-E = 5 µm



79. *Tetrapogon villosus*



80. *Acrachne racemosa*

Fig. 98

Dactyloctenium

81. *Dactyloctenium aegyptium*

82. *Dactyloctenium scindicus*

81. *Dactyloctenium aegyptium* (Fig. 99(81) A-F)

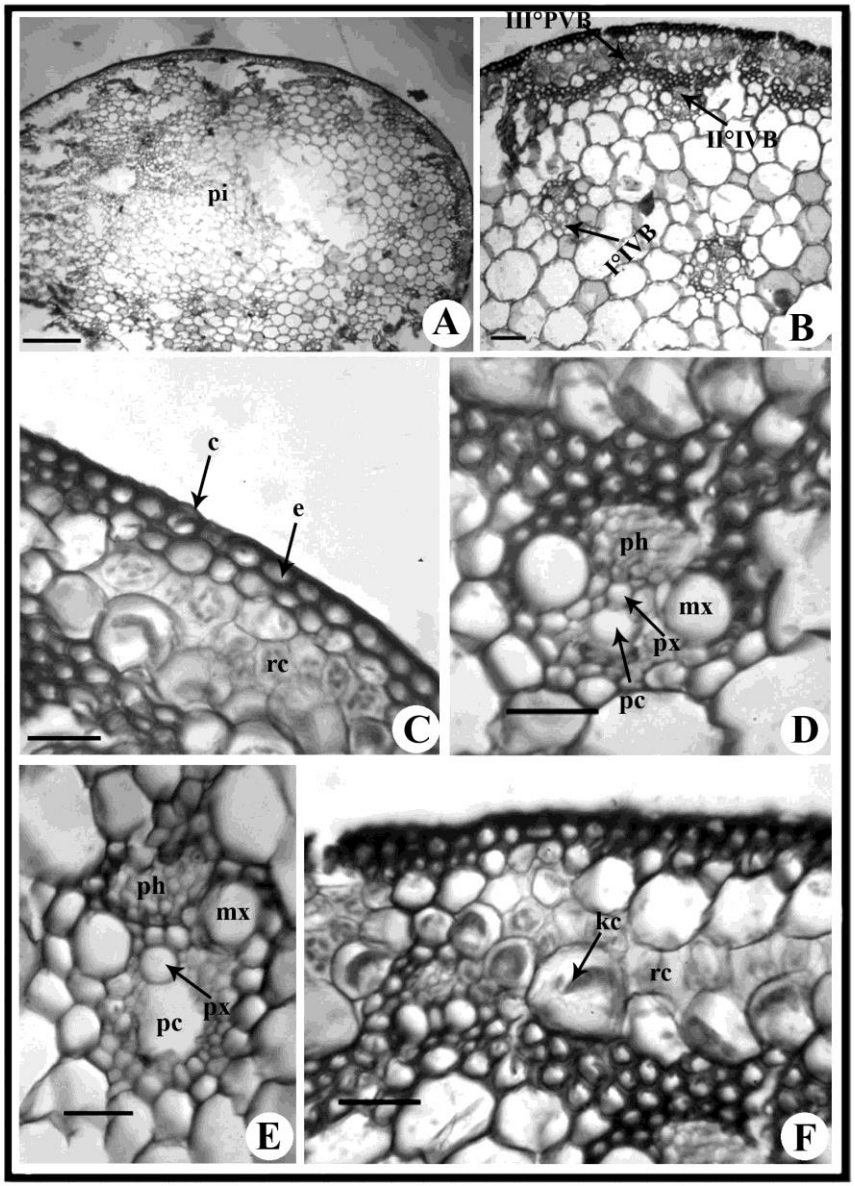
Oblong in transection with slightly undulating surface (Fig. A)
Size: 294.45x433.34±18.64 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith. Kranz anatomy is present (Fig. F).
Epidermis: Barrel Shaped-IV (Fig. C)
Hypodermis: 2-3 layered chlorenchymatous interrupted by sclerenchyma cell (Fig.B)
With III^{o} PVB embedded, Type-E sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous,
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type C, sclerenchymaotus cap present (Fig. E)
Size: 18.64x17.5±3.26 µm
II^{o} IVB: Type P (Fig. D)
Size: 10.52x14.83±3.17 µm
III^{o} PVB: Type Q (Fig. F)
Size: 5.77x6.15±2.62 µm
Kranz arc: Half circle (Fig. F) **Chloroplast type:** Centrifugal
Shape of kranz cell: Round to oval (Fig. F) **Mestome:** single layered
Bar size: A = 50 µm, B = 10 µm, C-E = 5 µm

82. *Dactyloctenium scindicus* (Fig. 99(82) A-F)

Round in transection with slightly undulating surface (Fig. A)
Size: 242.31x226.92±38.57 µm, Hairs/Prickles absent.
Hollow internode. Kranz anatomy is present (Fig. D).
Epidermis: Barrel Shaped-IV (Fig. C)
Hypodermis: 2-3 layered chlorenchymatous
Interrupted by sclerenchymatous with III^{o} PVB embedded
Type-E sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. B)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type C, sclerenchymaotus cap present (Fig. E, F)
Size: 17.39x22.61±4.27 µm
II^{o} IVB: Type P
Size: 4.23x8.46±2.37 µm
III^{o} PVB: Type Q (Fig. D)
Size: 2.18x2.61±0.26 µm
Kranz arc: Straight (Fig. D) **Chloroplast type:** Centrifugal
Shape of kranz cell: Square (Fig. D) **Mestome:** single layered
Bar size: A = 50 µm, B-F = 5 µm

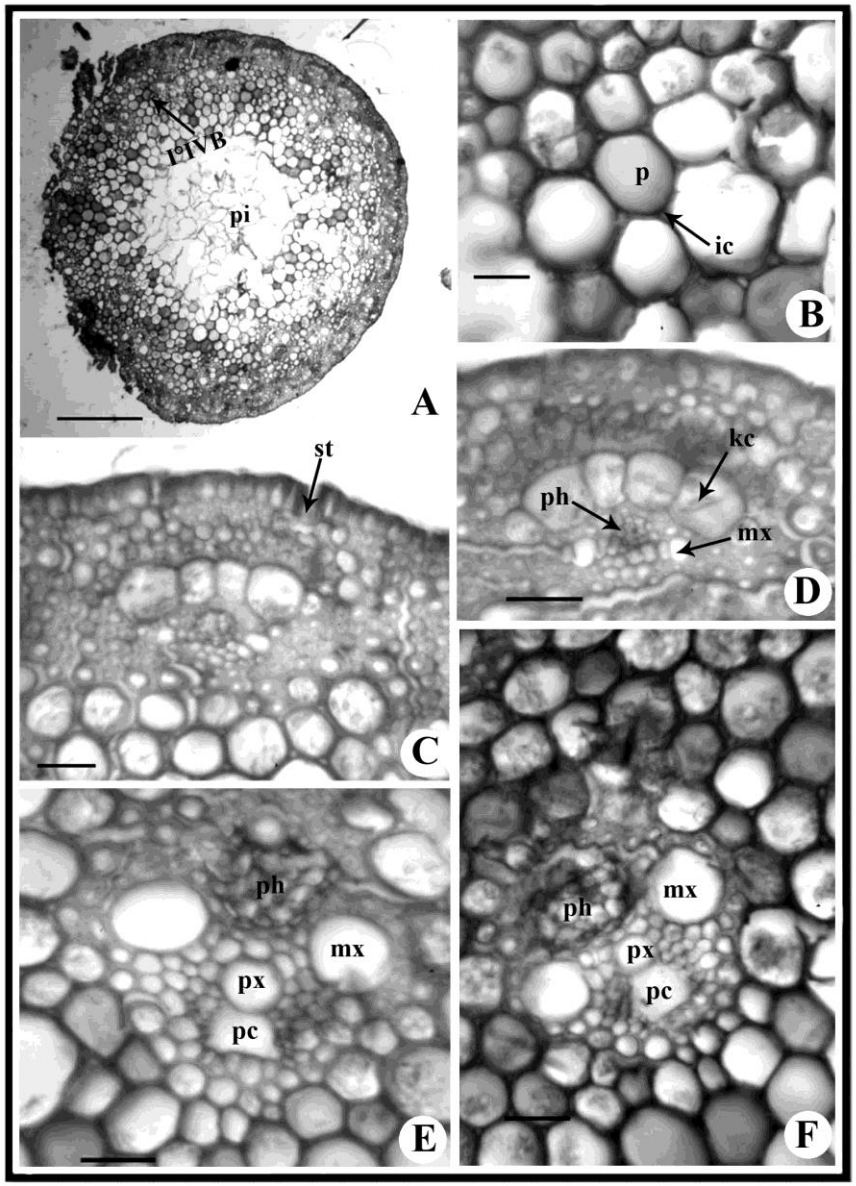
Differentiating features:

Half circle shaped kranz arc, round to oval shaped kranz cell..……..…..*D. aegyptium*
Straight shaped kranz arc, square to trapezoid shaped kranz cell……*D. sindicus*



81. *Dactyloctenium aegyptium*

Fig. 99



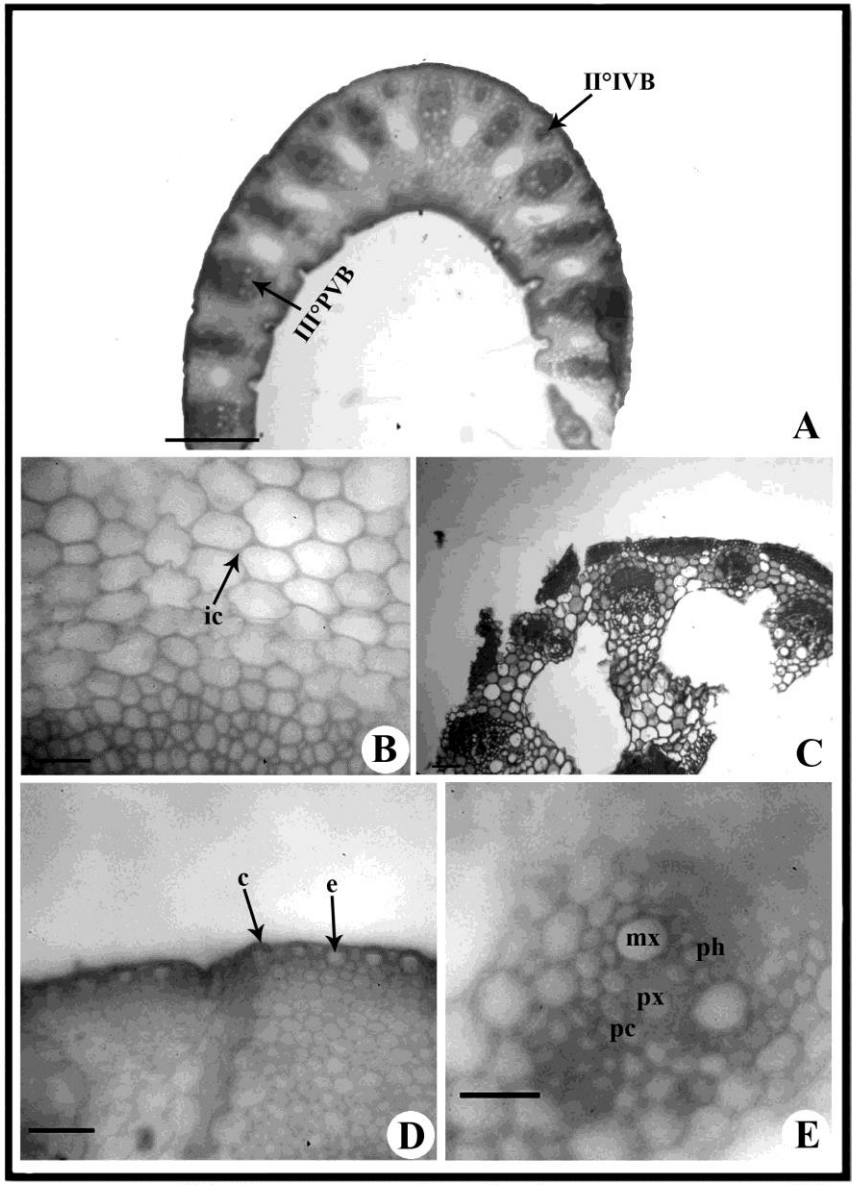
82. *Dactyloctenium sindicum*

83. *Desmostachya bipinnata* (Fig. 100(83) A-E)

Round in transection with slightly undulating surface (Fig. A)
Size: 326.67x240±21.80 µm, Hairs/Prickles absent.
Hollow internode. Kranz anatomy is present.
Epidermis: Round Shaped (Fig. D)
Hypodermis: 2-3 layered chlorenchymatous
Interrupted by sclerenchymatous with III^{o} PVB embedded
Type-D sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. B)
Air cavities present (Fig. C)
Vascular bundles arranged in ring form
Vascular system: III^{o} PVB absent
I^{o} IVB: Type B, sclerenchymaotus cap present (Fig. E)
Size: 11.67x11.67±1.84 µm
II^{o} IVB: Type P
Size: 10x6.67±2.16 µm
III^{o} PVB: -
Size: -
Kranz arc: Half circle
Chloroplast type: Centrifugal
Shape of kranz cell: Round to oval **Mestome:** single layered
Bar size: A = 50 µm, B-E = 5 µm

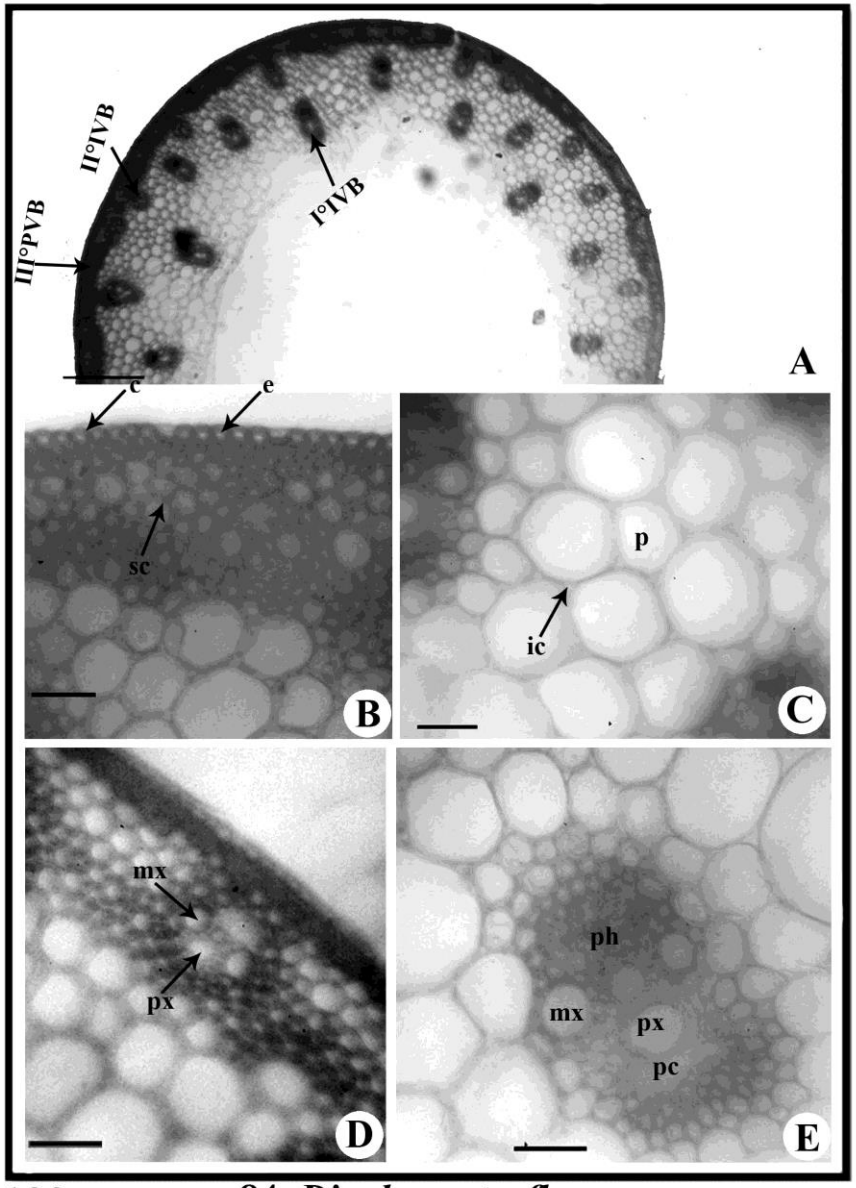
84. *Dinebra retroflexa* (Fig. 100(84) A-E)

Round in transection with smooth surface (Fig. A)
Size: 423.07x346.15±36.18 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith. Kranz anatomy is present.
Epidermis: Barrel Shaped-IV (Fig. B)
Hypodermis: 3-4 layered chlorenchymatous interrupted by sclerenchymatous
With III^{o} PVB embedded
Type-E sclerenchyma present (Fig. B)
Ground tissue: Round to oval shaped parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type F, sclerenchymaotus cap absent (Fig. E)
Size: 17.5x11.67±2.87 µm
II^{o} IVB: Type M
Size: 5.42x6.67±1.73 µm
III^{o} PVB: Type Q (Fig. D)
Size: 3.17x3.17±1.25 µm
Kranz arc: Half circle (Fig. D)
Chloroplast type: Centrifugal
Shape of kranz cell: Round to oval (Fig. D) **Mestome:** single layered
Bar size: A = 50 µm, B-E = 5 µm



83. *Desmostachya bipinnata*

Fig. 100



84. *Dinebra retroflexa*

85. *Eleusine indica* (Fig. 101(85) A-F)

Round to oblong in transection with smooth surface (Fig. A)
Size: 78.94x71.05±6.26 µm, Hairs/Prickles absent.
Hollow internode. Kranz anatomy is present.
Epidermis: BarrelShaped-II (Fig. B)
Hypodermis: 3-4 layered chlorenchymatous
Interrupted by sclerenchymatous, with III^{o} PVB embedded
Type-E sclerenchyma present (Fig. C)
Ground tissue: Round to oval shaped parenchymatous (Fig. D)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type F (Fig. F)
Size: 8.34x7.5±2.17 µm
II^{o} IVB: Type P (Fig. E)
Size: 8.24x7.94±3.17 µm
III^{o} PVB: Type Q
Size: 5.17x4.83±1.56 µm
Kranz arc: Half circle **Chloroplast type:** Centrifugal
Shape of kranz cell: Round to oval **Mestome:** single layered
Bar size: A = 50 µm, B-F = 5 µm

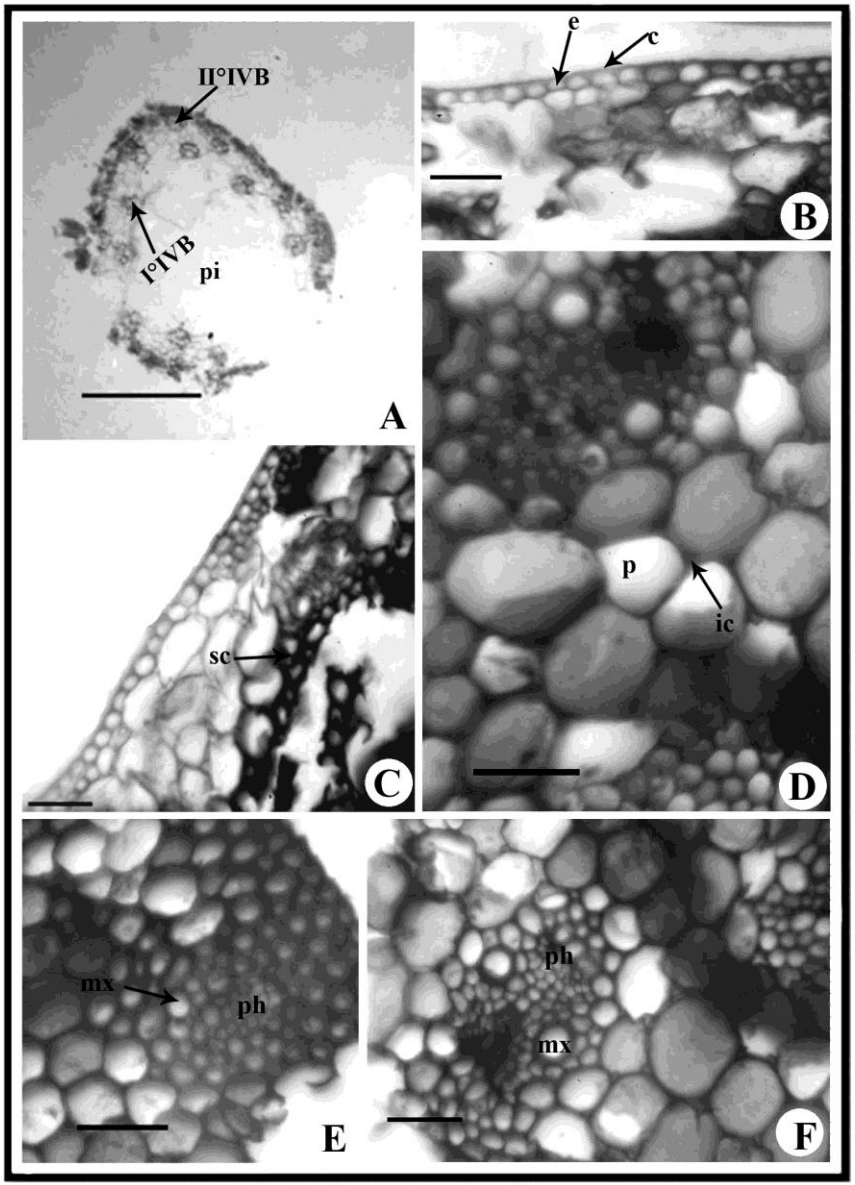
Eragrostiella

86. *Eragrostiella bachyphylla*

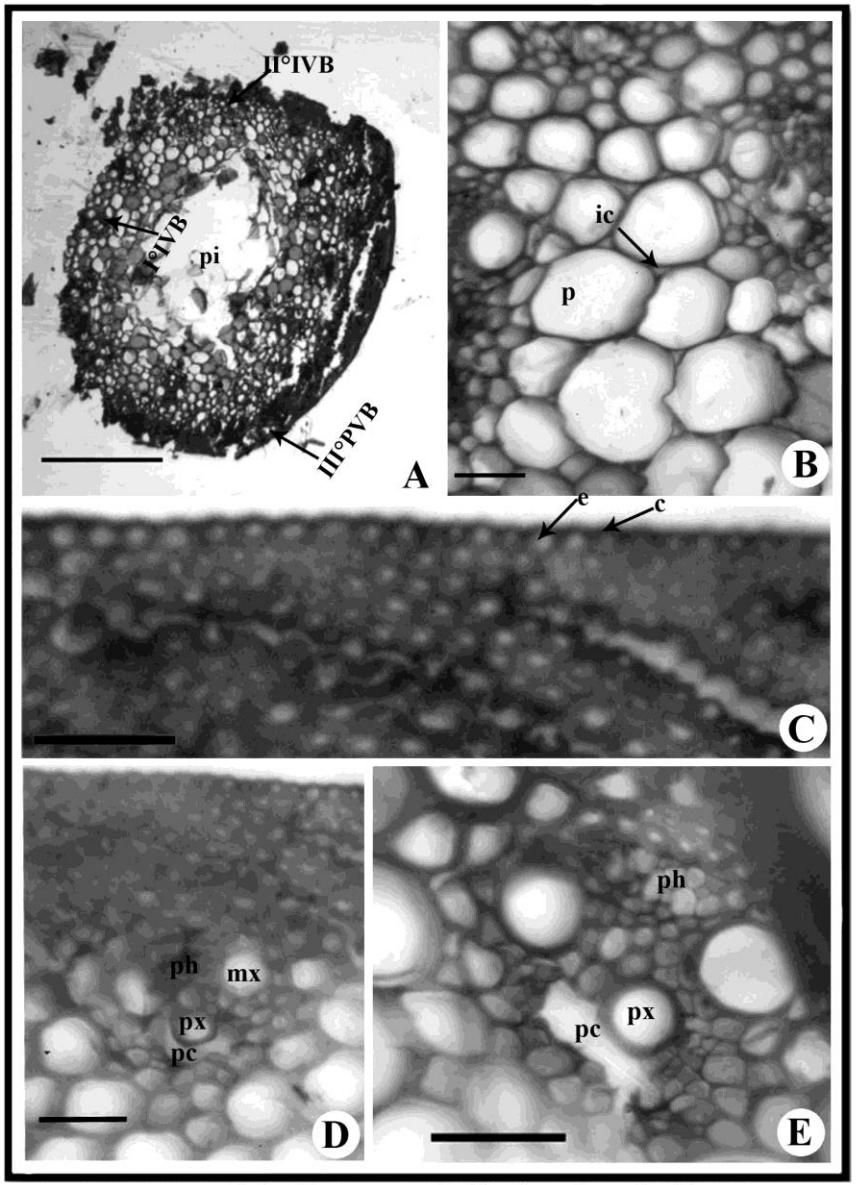
87. *Eragrostiella bifaria*

86. *Eragrostiella bachyphylla* (Fig. 101(86) A-E)

Oblong in transection with smooth surface (Fig. A)
Size: 121.25x142.5±10.27 µm, Hairs/Prickles absent.
Hollow internode. Kranz anatomy is present.
Epidermis: Barrel Shaped-V (Fig. C)
Hypodermis: 2-3 layered chlorenchymatous interrupted by 6-7 layered sclerenchymatous cells
With III^{o} PVB embedded
Type-E sclerenchyma present(Fig. E)
Ground tissue: Round to oval shaped parenchymatous (Fig. B)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type C, sclerenchymatous cap present (Fig. E)
Size: 9.52x13.57±1.56 µm
II^{o} IVB: Type P (Fig. D)
Size: 8.89x11.12±2.18 µm
III^{o} PVB: Type Q
Size: 4.27x4.18±1.78 µm
Kranz arc: Half circle **Chloroplast type:** Centrifugal
Shape of kranz cell: Square **Mestome:** single layered
Bar size: A = 50 µm, B-E = 5 µm



85. *Eleusine indica*



86. *Eragrostiella bachyphylla*

Fig. 101

87. *Eragrostiella bifaria* (Fig. 102(87) A-F)

Round in transection with slightly undulating surface (Fig. A)

Size: 120x112.5±34.72 µm, Hairs/Prickles absent.

Hollow internode. Kranz anatomy is present (Fig. C).

Epidermis: Barrel Shaped-V (Fig. D)

Hypodermis: 4-5 layered chlorenchymatous interrupted by 6-7 layered sclerenchymatous cells

With III^{o} PVB embedded, Type-B sclerenchyma present

Ground tissue: Round to oval shaped parenchymatous (Fig. B)

Vascular bundles arranged in ring form

Vascular system: all present

I^{o} IVB: Type C, sclerenchymatous cap present (Fig. E, F)

Size: 14.85x13.64±2.78 µm

II^{o} IVB: Type P

Size: 7.69x13.46±1.77 µm

III^{o} PVB: Type Q (Fig. C)

Size: 4.17x4.86±1.07 µm

Kranz arc: Half circle (Fig. C)

Chloroplast type: Centrifugal

Shape of kranz cell: Square (Fig. C) **Mestome:** single layered

Bar size: A = 50 µm, B-F = 5 µm

Differentiating features:

Oblong in transection, sclerenchyma type E present…… *E. bachyaphylla*

Round in transection, sclerenchyma type B present…..…….…… *E. bifaria*

Eragrostis

88. *Eragrostis cilianensis*

89. *Eragrostis ciliaris*

90. *Eragrostis japonica*

91. *Eragrostis nutans*

92. *Eragrostis pilosa*

93. *Eragrostis tenella*

94. *Eragrostis tremula*

95. *Eragrostis unioloides*

96. *Eragrostis viscosa*

88. *Eragrostis cilianensis* (Fig. 102(88) A-F)

Oblong in transection with smooth surface (Fig. A)

Size: 138.46x203.85±25.78 µm, Hairs/Prickles absent.

Hollow internode. Kranz anatomy is present.

Epidermis: Round Shaped (Fig. C)

Hypodermis: 2-3 layered chlorenchymatous interrupted by 2-3 layered sclerenchymatous cells

With III^{o} PVB embedded, Type-B sclerenchyma present (Fig. B)

Ground tissue: Round to oval shaped parenchymatous,

Vascular bundles arranged in ring form

Vascular system: all present

I^{o} IVB: Type F, sclerenchymatous cap present

Size: 13.75x14.58±4.28 µm

II^{o} IVB: Type P

Size: 10.84x13.34±1.54 µm

III^{o} PVB: Type Q

Size: 4.75x5.5±1.69 µm

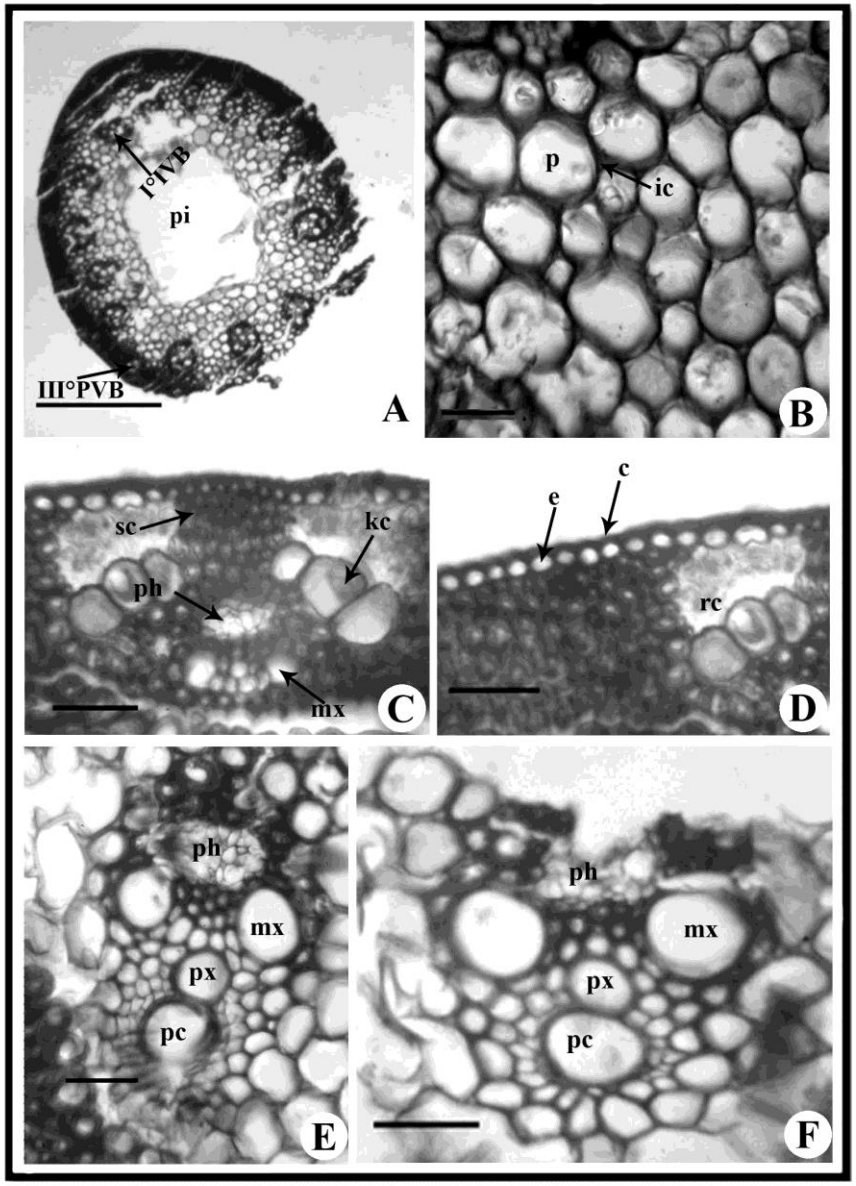
Kranz arc: Half circle

Chloroplast type: Centrifugal

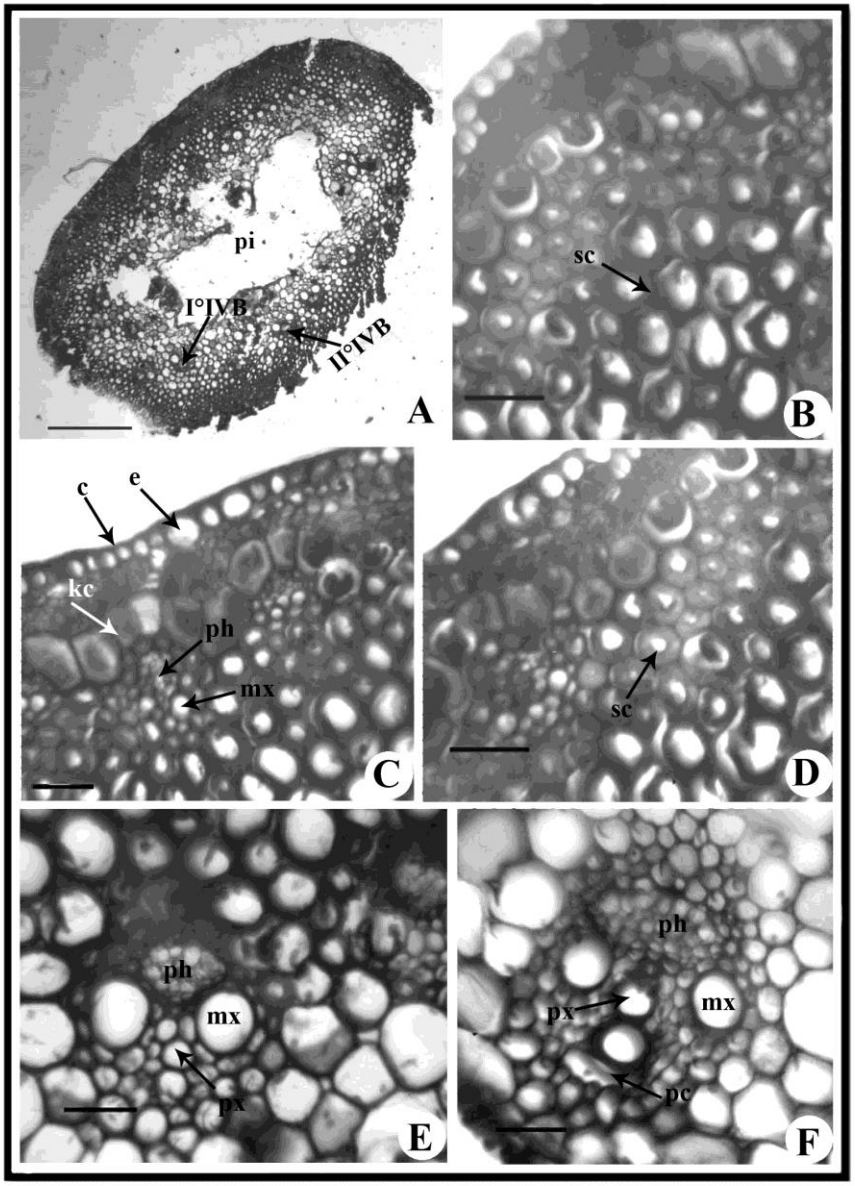
Shape of kranz cell: Square

Mestome: single layered

Bar size: A = 50 µm, B-F = 5 µm



87. *Eragrostiella bifaria*



88. *Eragrostis cilianensis*

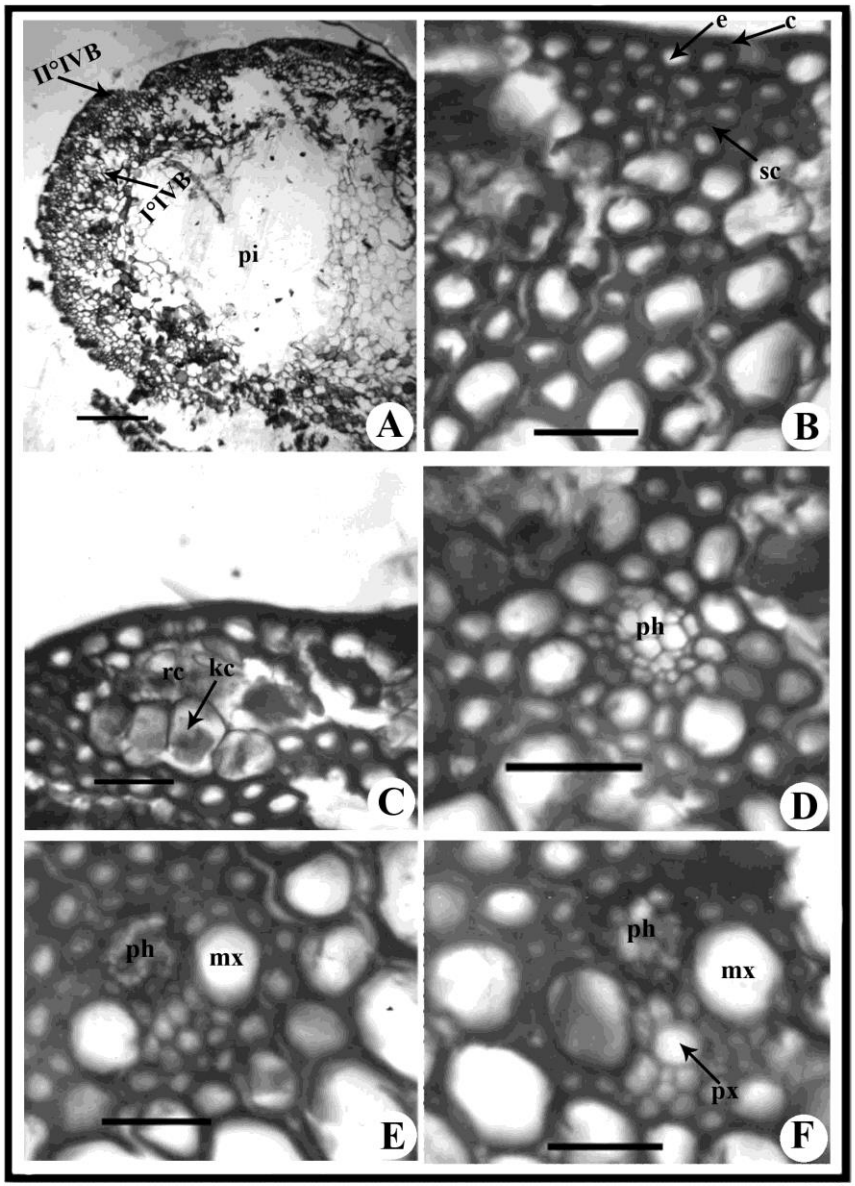
Fig. 102

89. *Eragrostis ciliaris* (Fig. 103(89) A-F)

Round in transection with smooth surface (Fig. A)
Size: 168x118.18±11.75 µm, Hairs/Prickles absent.
Hollow internode. Kranz anatomy is present (Fig. C).
Epidermis: Barrel Shaped-IV (Fig. B)
Hypodermis: 2-3 layered chlorenchymatous interrupted by 2-3 layered sclerenchymatous cells
With III^{o} PVB embedded, Type-B sclerenchyma present (Fig. B)
Ground tissue: Round to oval shaped parenchymatous,
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymatous cap present
Size: 11.12x11.81±3.32 µm
II^{o} IVB: Type P
Size: 6.76x6.32±2.17 µm
III^{o} PVB: Type Q
Size: 5.6x5.4±2.18 µm
Kranz arc: Straight
Chloroplast type: Centripetal
Shape of kranz cell: Square
Mestome: single layered
Bar size: A = 50 µm, B-F = 5 µm

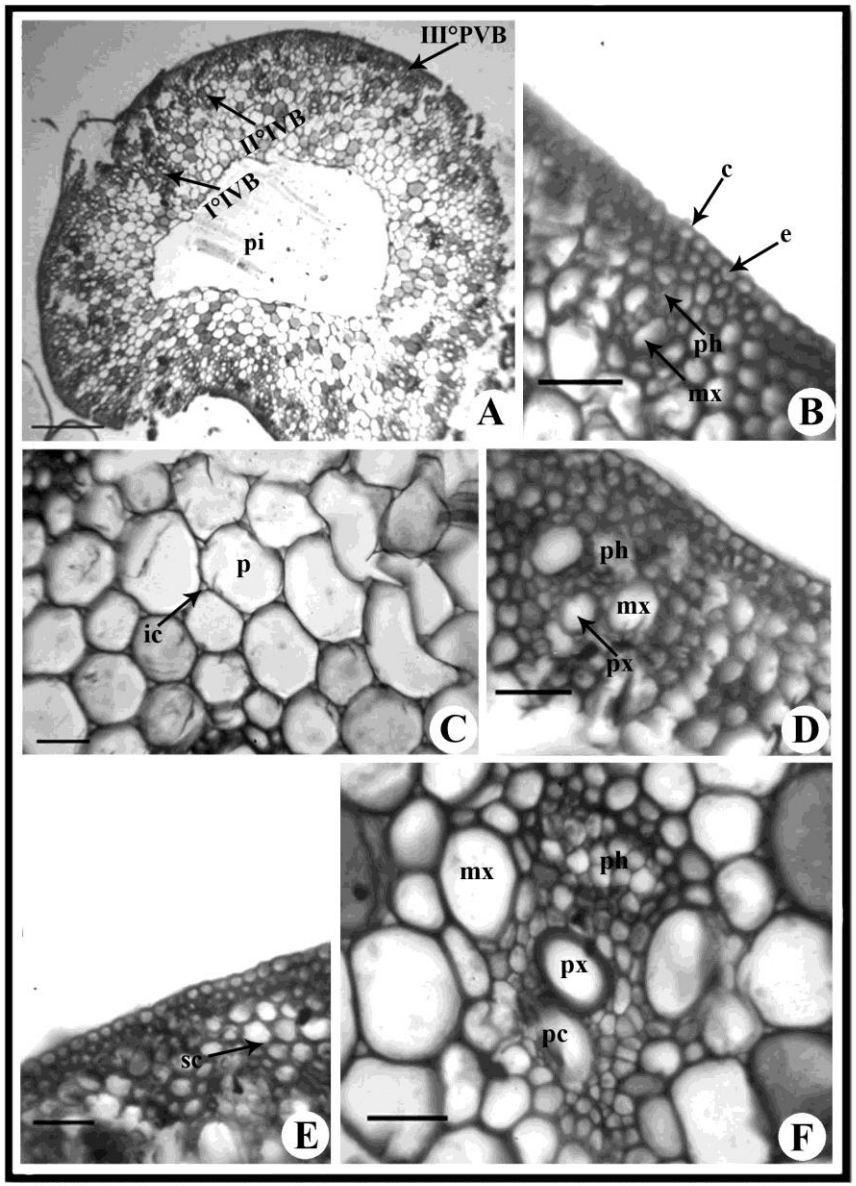
90. *Eragrostis japonica* (Fig. 103(90) A-F)

Horseshoe in transection with smooth surface (Fig. A)
Size: 160.87x201.35±48.63 µm, Hairs/Prickles absent.
Hollow internode.
Epidermis: Barrel Shaped-IV (Fig. B)
Hypodermis: 3-4 layered sclerenchymatous (Fig. B)
With III^{o} PVB embedded
Type-D sclerenchyma present (Fig. E)
Ground tissue: Round to oval shaped parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type I, sclerenchymatous cap present (Fig. F)
Size: 17.31x13.08±3.87 µm
II^{o} IVB: Type P (Fig. D)
Size: 7.69x6.35±2.89 µm
III^{o} PVB: Type Q (Fig. B)
Size: 3.39x3.57±1.66 µm
Bar size: A = 50 µm, B-F = 5 µm



89. *Eragrostis ciliaris*

Fig. 103



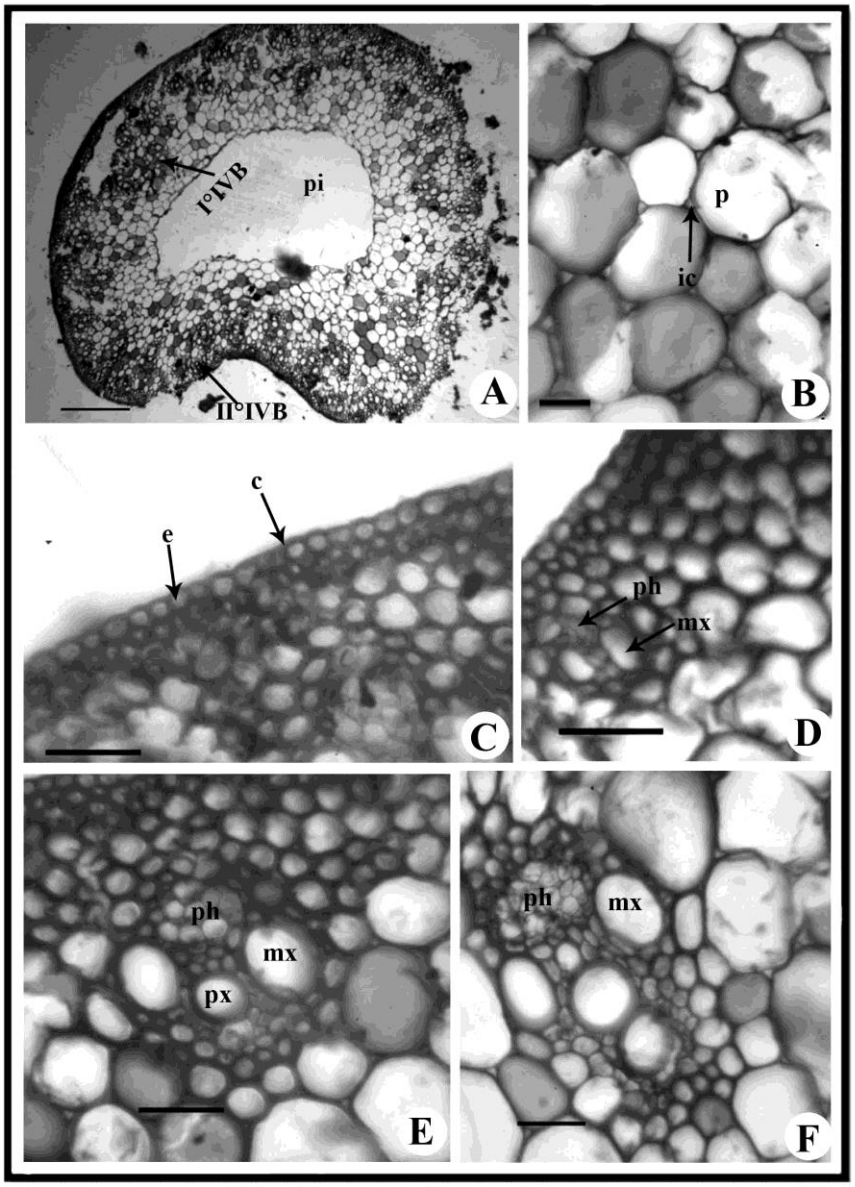
90. *Eragrostis japonica*

91. *Eragrostis nutans* (Fig. 104(91) A-F)

Horseshoe in transection with smooth surface (Fig. A)
Size: 150x127.27±24.18 µm, Hairs/Prickles absent.
Holow internode.
Epidermis: Barrel Shaped-IV (Fig. C)
Hypodermis: 3-4 layered sclerenchymatous
With III^{o} PVB embedded
Type-E sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. B)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type F, sclerenchymatous cap present (Fig. F)
Size: 16.82x11.36±3.65 µm
II^{o} IVB: Type P (Fig. E)
Size: 11.92x13.46±2.18 µm
III^{o} PVB: Type Q (Fig. D)
Size: 3.48x4.06±1.86 µm
Bar size: A = 50 µm, B-F = 5 µm

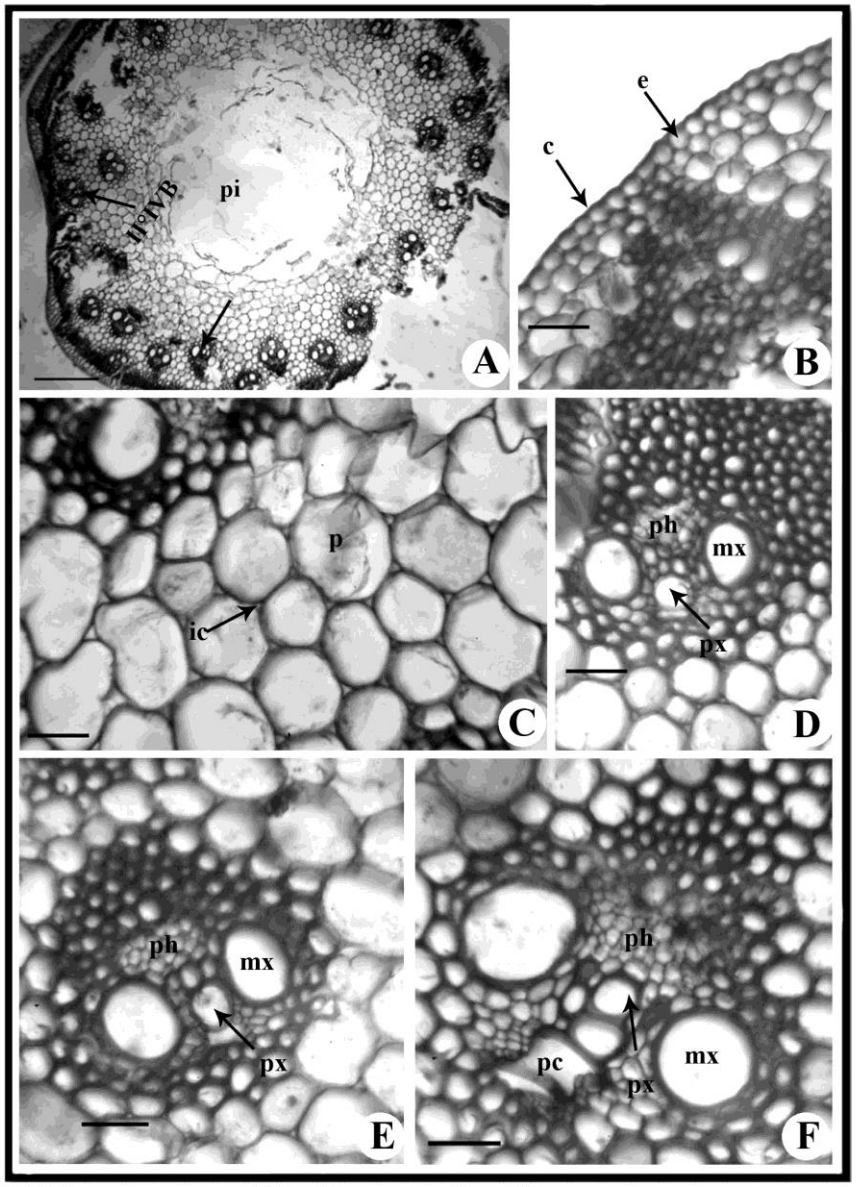
92. *Eragrostis pilosa* (Fig. 104(92) A-F)

Horseshoe with less concave distal end in transaction (Fig. A)
Size: 241.28x222.24±38.20 µm, Hairs/Prickles absent.
Hollw internode. Kranz anatomy is present.
Epidermis: Barrel Shaped-IV (Fig. B)
Hypodermis: 3-4 layered chlorenchymatous interrupted by 2-3 layered sclerenchymatous cells (Fig. B)
With III^{o} PVB embedded, Type-D sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymatous cap present (Fig. F)
Size: 15.42x21.67±3.81 µm
II^{o} IVB: Type P (Fig. D, E)
Size: 14.76x18.09±2.37 µm
III^{o} PVB: Type Q (Fig. B)
Size: 7.5x6.5±1.39 µm
Kranz arc: Half circle
Chloroplast type: Centrifugal
Shape of kranz cell: Round to oval
Mestome: single layered
Bar size: A = 50 µm, B-F = 5 µm



91. *Eragrostis nutans*

Fig. 104



92. *Eragrostis pilosa*

93. *Eragrostis tenella* (Fig. 105(93) A-F)

Round in transection with smooth surface (Fig. A)

Size: 163.64x209.09±25.98 µm, Hairs/Prickles absent.

Hollow internode.

Epidermis: Barrrel Shaped-V (Fig. D)

Hypodermis: 7-8 layered sclerenchymatous

With III^{o} PVB embedded

Type-D sclerenchyma present

Ground tissue: Round to oval shaped parenchymatous (Fig. B)

Vascular bundles arranged in ring form

Vascular system: all present

I^{o} IVB: Type A, sclerenchymatous cap present (Fig. F)

Size: 11.78x13.04±3.17µm

II^{o} IVB: Type P

Size: 8.32x8.96±2.41 µm

III^{o} PVB: Type Q

Size: 4.32x4.86±1.53 µm

Bar size: A = 50 µm, B-F = 5 µm

94. *Eragrostis tremula* (Fig. 105(94) A-E)

Round in transection with smooth surface (Fig. A)

Size: 175x193.75±21.29 µm, Hairs/Prickles absent.

Hollow internode.

Epidermis: Barrrel Shaped-V (Fig. C)

Hypodermis: Parenchymatous cells interrupted by sclerenchymatous cells

With III^{o} PVB embedded

Type-B sclerenchyma present

Ground tissue: Round to oval shaped parenchymatous (Fig. E)

Vascular bundles arranged in ring form

Vascular system: all present

I^{o} IVB: Type I, sclerenchymatous cap present (Fig. E)

Size: 11.43x12.5±3.17 µm

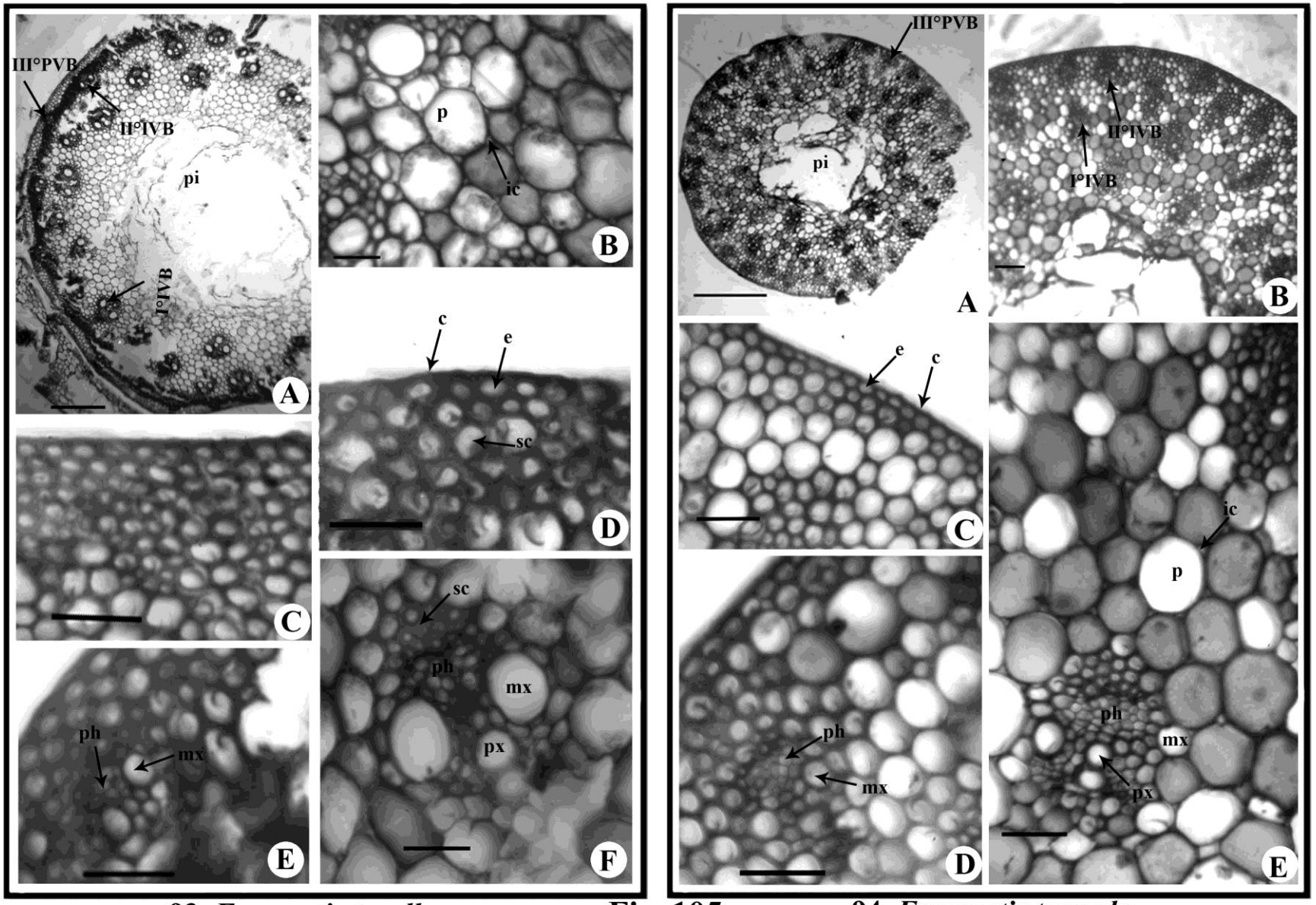
II^{o} IVB: Type M

Size: 7.93x7.86±2.18 µm

III^{o} PVB: Type Q (Fig. D)

Size: 4.45x4.45±0.83 µm

Bar size: A = 50 µm, B-E = 5 µm



93. *Eragrostis tenella* **Fig. 105** **94. *Eragrostis tremula***

95. *Eragrostis unioloides* (Fig. 106(95) A-F)

Round in transection with smooth surface (Fig. A)
Size: 168.75x159.38±14.75 µm, Hairs/Prickles absent.
Hollow internode. Kranz anatomy is present (Fig. C).
Epidermis: Barrel Shaped-V
Hypodermis: 3-4 layered chlorenchymatous (Fig. B)
Than 3-4 layered sclerenchymatous cells
With III^{o} PVB embedded, Type-E sclerenchyma present (Fig. B)
Ground tissue: Round to oval shaped
Parenchymatous,
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymatous cap present (Fig. F)
Size: 17.08x17.92±4.18 µm
II^{o} IVB: Type P
Size: 5.86x5.52±2.18 µm
III^{o} PVB: Type Q (Fig. E)
Size: 5x6.56±1.34 µm
Kranz arc: Half circle (Fig. E) **Chloroplast type:** Centrifugal
Shape of kranz cell: Square to trapezoid (Fig. E) **Mestome:** single layered
Bar size: A = 50 µm, B-F = 5 µm

96. *Eragrostis viscosa* (Fig. 106(96) A-F)

Round in transection with slightly undulating surface (Fig. A)
Size: 150x145±13.65 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith. Kranz anatomy is present.
Epidermis: Barrel Shaped-V (Fig. B)
Hypodermis: 2-3 layered chlorenchymatous (Fig. B)
Than 4-5 layered sclerenchymatous cells
With III^{o} PVB embedded
Type-E sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type E, sclerenchymatous cap present (Fig. F)
Size: 11.56x9.69±1.48 µm
II^{o} IVB: Type N (Fig. D)
Size: 8.82x8.82±2.68 µm
III^{o} PVB: Type (Fig. E)
Size: 5.43x5.92±1.54 µm
Kranz arc: Straight (Fig. E) **Chloroplast type:** Centrifugal
Shape of kranz cell: Square to trapezoid (Fig. E) **Mestome:** single layered
Bar size: A = 50 µm, B-F = 5 µm

Differentiating features:

Round shaped epidermal cells……..……. *E. cilianensis*

Barrel shaped epidermal cells

Sclerenchyma in form of girder...……..……. *E. tremula*

Sclerenchyma in form of unicylinder

Sclerenchyma type E present

Absence of kranz arc…… *E. nutans*

Presence of kranz arc

Half circle shaped kranz arc..……. *E. unioloides*

Straight shaped kranz arc

Centripetal arrangement of chloroplast…...*E. ciliaris*

Centrifugal arrangement of chloroplast.… *E. viscosa*

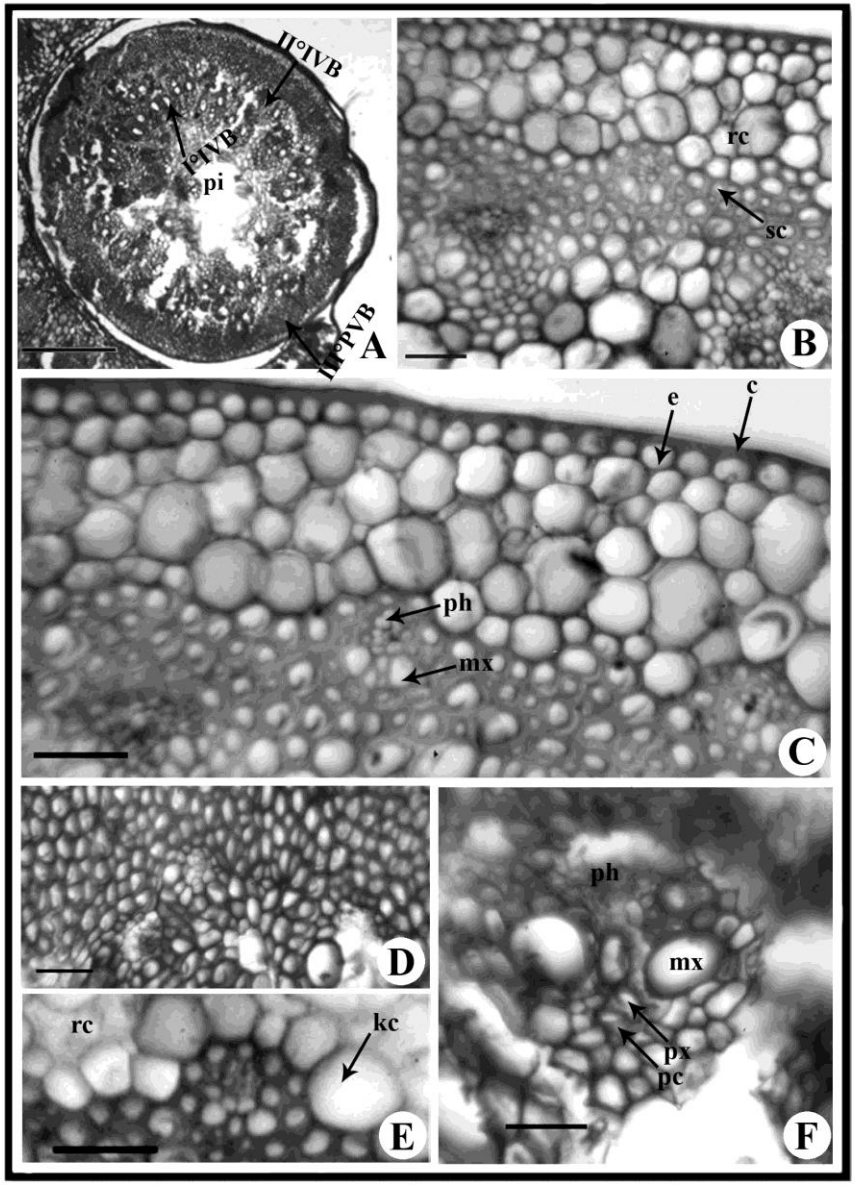
Sclerenchyma type D present

Presence of kranz arc ….…….……..*E. pilosa*

Absence of kranz arc

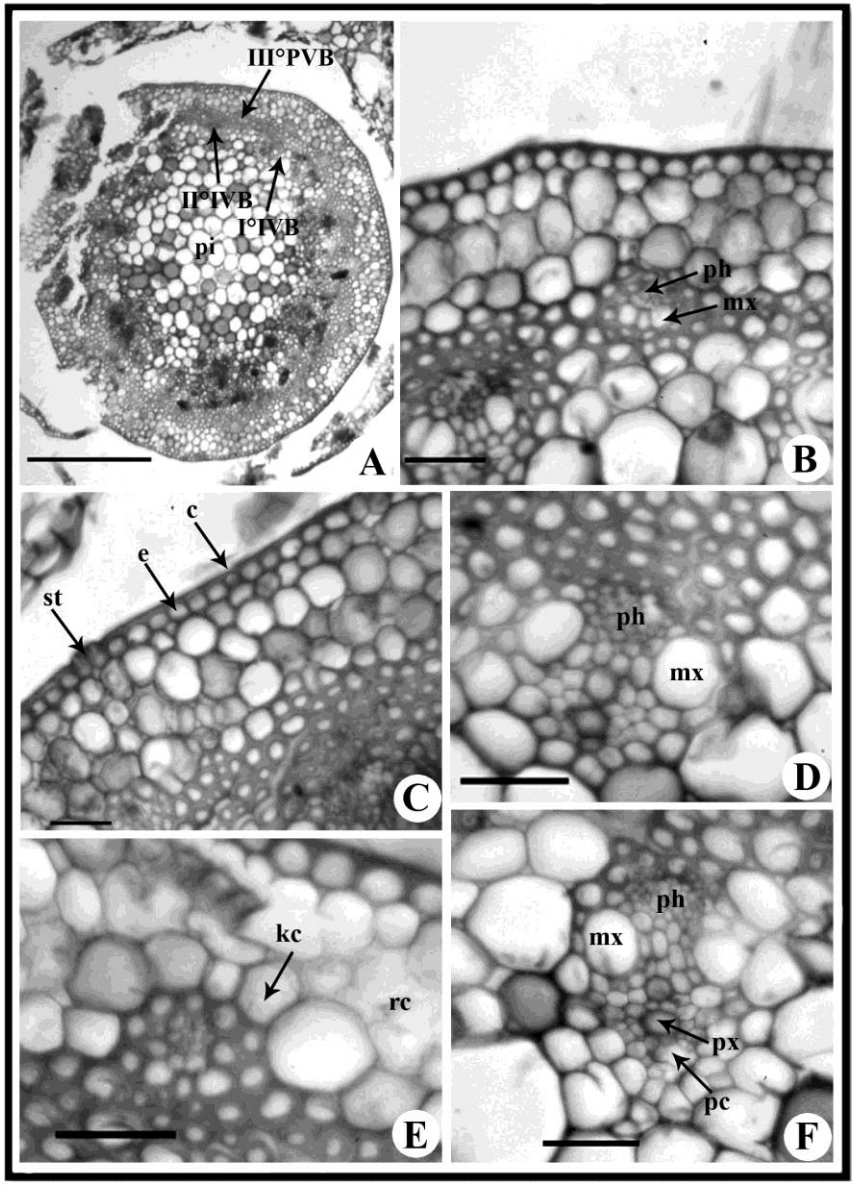
Horseshoe shaped in transection…..……. *E. japonica*

Round shaped in transection...…….……*E. tenella*



95. *Eragrostis unioloides*

Fig. 106



96. *Eragrostis viscosa*

Sporobolus

97. *Sporobolus coromandelianus*

98. *Sporobolus diander*

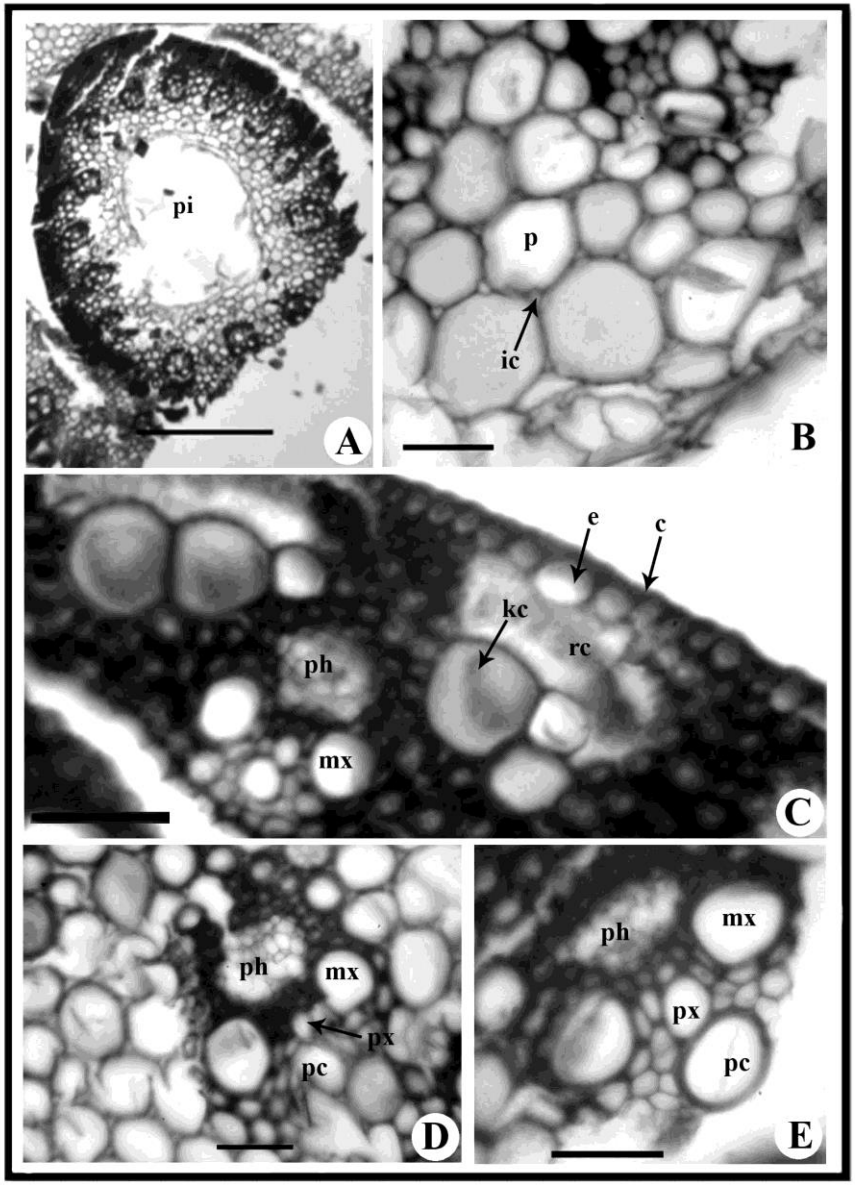
99. *Sporobolus indicus*

97. *Sporobolus coromandelianus* (Fig. 107(97) A-E)

Round to oval in transection with slightly undulating surface (Fig. A)
Size: 97.72x118.18±24.53 µm, Hairs/Prickles absent.
Hollow internode. Kranz anatomy is present.
Epidermis: Barrel Shaped-V (Fig. C)
Hypodermis: 2-3 layered chlorenchymatous
Than 4-5 layered sclerenchymatous cells
With III^{o} PVB embedded, Type-D sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous,
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type B, sclerenchymatous cap present (Fig. E)
Size: 12.5x13.34±3.17 µm
II^{o} IVB: Type P (Fig. D)
Size: 9.45x11.38±2.68 µm
III^{o} PVB: Type Q
Size: 7.04x7.27±1.13 µm
Kranz arc: Half circle (Fig. C) **Chloroplast type:** Centrifugal
Shape of kranz cell: Square to trapezoid (Fig. C) **Mestome:** single layered
Bar size: A = 50 µm, B-E = 5 µm

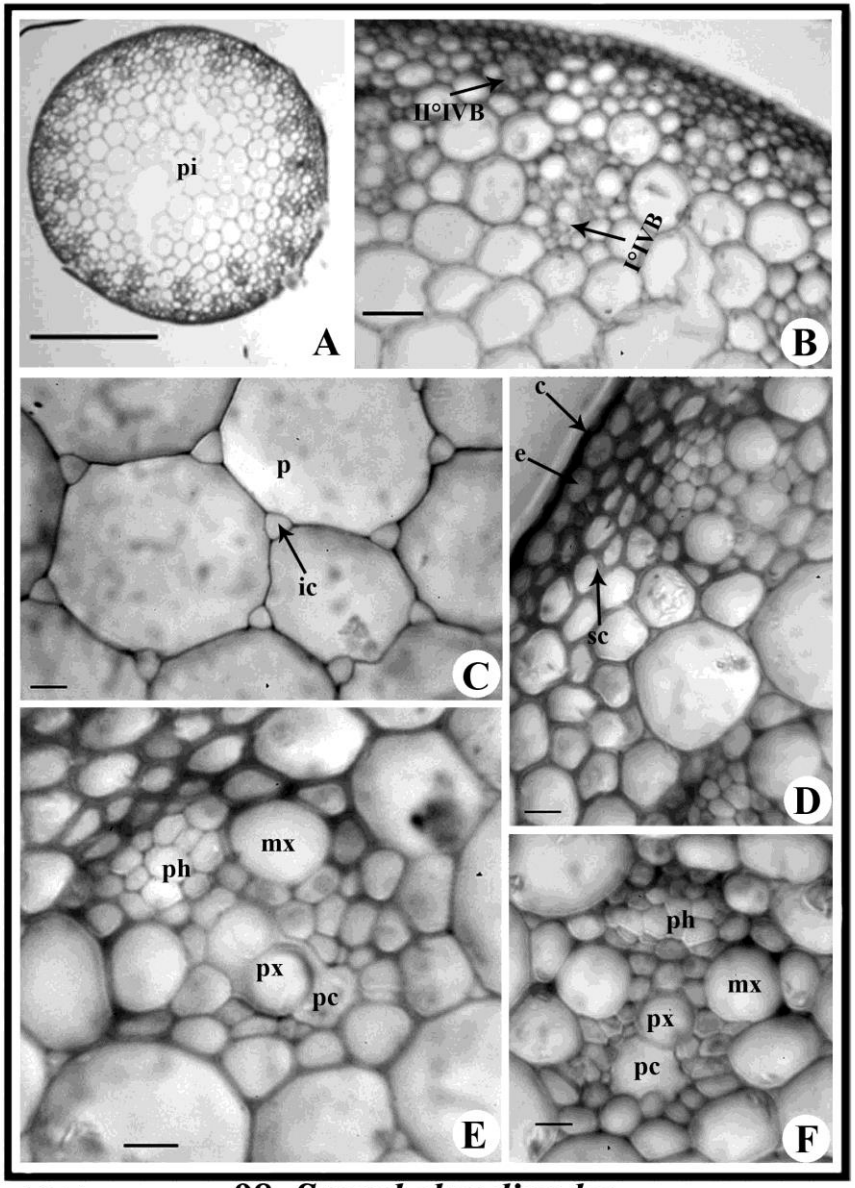
98. *Sporobolus diander* (Fig. 107(98) A-F)

Round in transection with smooth surface (Fig. A)
Size: 117.5x120±25.17 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith. Kranz anatomy absent.
Epidermis: Barrel Shaped-V (Fig. D)
Hypodermis: 2-3 layered chlorenchymatous
Than 2-3 layered sclerenchymatous cells
With III^{o} PVB embedded
Type-D sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type I, sclerenchymatous small cap present (Fig. F)
Size: 22.5x22.3±4.96 µm
II^{o} IVB: Type M (Fig. B)
Size: 17.65x20.17±5.28 µm
III^{o} PVB: - -
Size: - -
Bar size: A = 50 µm, B-F = 5 µm



97. *Sporobolus coromardelianus*

Fig. 107



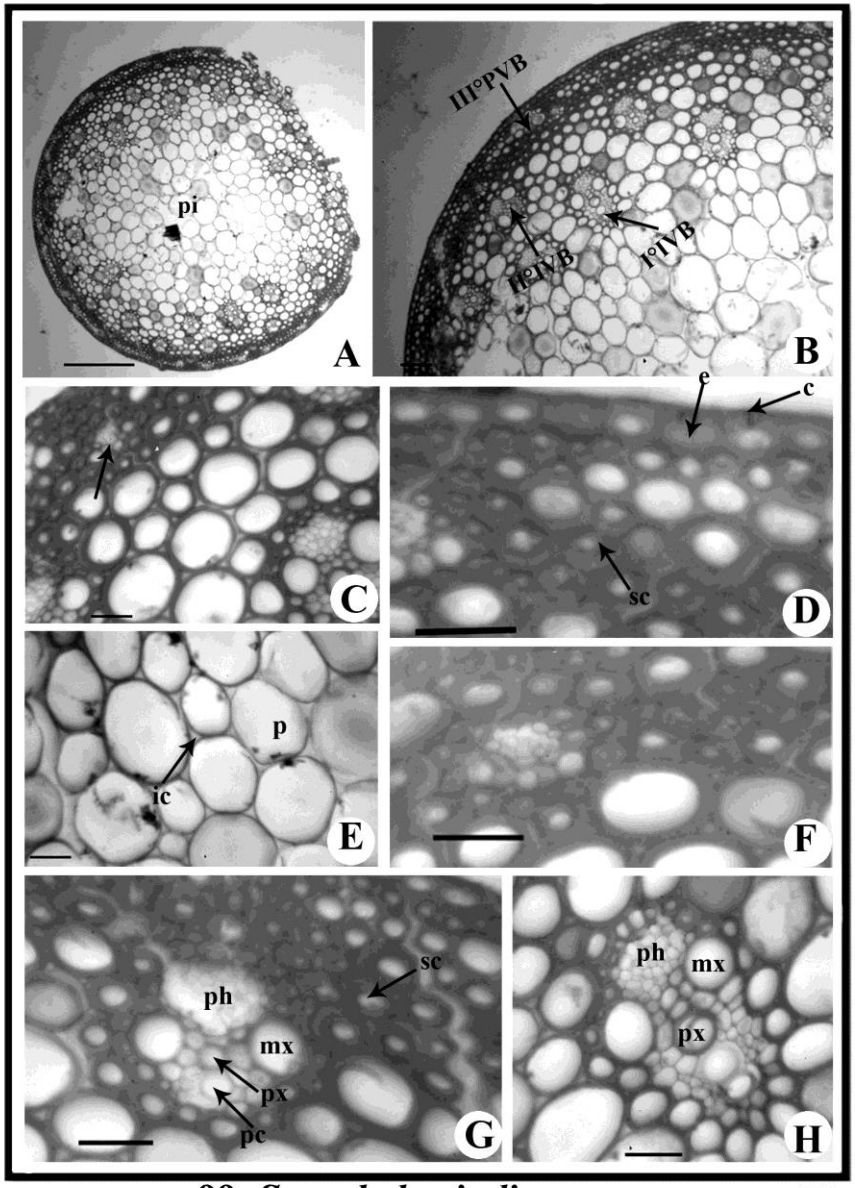
98. *Sporobolus diander*

99. *Sporobolus indicus* (Fig. 108(99) A-F)

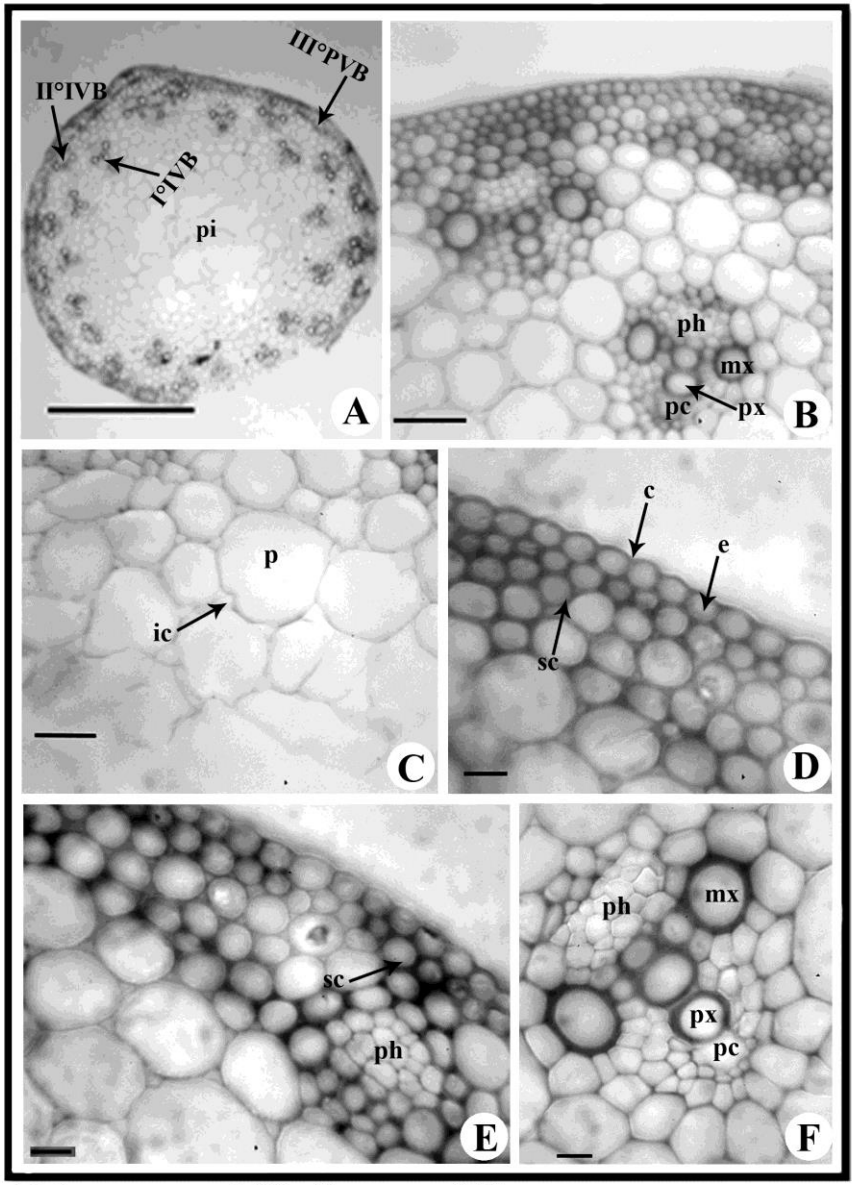
Round in transection with smooth surface (Fig. A)
Size: 216.67x220.84±25.18 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith. Kranz anatomy is present.
Epidermis: Square Shaped-III (Fig. D)
Hypodermis: 2-3 layered chlorenchymatous (Fig. B)
Interrupted by 5-6 layered sclerenchymatous cells, with III^{o} PVB embedded
Type-E sclerenchyma present
Ground tissue: Round to oval shaped parenchymatous (Fig. D)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type F, sclerenchymatous cap present (Fig. H)
Size: 20x14.45±3.17 µm
II^{o} IVB: Type O (Fig. F)
Size: 11.25x13.34±3.15 µm
III^{o} PVB: Type P (Fig. E)
Size: 3.5x5.67±1.78 µm
Kranz arc: Half circle **Chloroplast type:** Centrifugal
Shape of kranz cell: Round to oval **Mestome:** single layered
Bar size: A = 50 aµm, B = 10 µm, C-F = 5 µm
Differentiating features:
Half circle shaped kranz arc……..*S. coromardelianus*
Straight shaped kranz arc
Square shaped epidermal cell……..…..*S. indicus*
Barrel shaped epidermal cell……..……..*S. diander*

100. *Tragus biflorus* (Fig. 108(100) A-F)

Round with notch in transection with slightly undulating surface (Fig. A)
Size: 115.96x119.5±9.54 µm, Hairs/Prickles absent.
Solid internode with parechymatous pith. Kranz anatomy is present.
Epidermis: Barrel Shaped-III (Fig. D)
Hypodermis: 3-4 layered chlorenchymatous interrupted by 2-3 layered sclerenchymatous cells (Fig. B), with III^{o} PVB embedded,
Type-D sclerenchyma present (Fig. E)
Ground tissue: Round to oval shaped parenchymatous (Fig. C)
Vascular bundles arranged in ring form
Vascular system: all present
I^{o} IVB: Type E, sclerenchymatous cap absent (Fig. F)
Size: 26x27±6.28 µm
II^{o} IVB: Type O
Size: 14x16±5.17 µm
III^{o} PVB: Type Q (Fig. E) Size: 5.28x7.69±2.17 µm
Kranz arc: Half circle (Fig. E) **Chloroplast type:** Centripetal
Shape of kranz cell: Round to ova **Mestome:** single layered
Bar size: A = 50 µm, B = 10 µm, C-F = 5 µm



99. *Sporobolus indicum*



100. *Tragrus biflorus*

Fig. 108

Table 2: Quantitative anatomical features of grass culm (anatomy)

Sr No.	Name of plant	Cross section area (µm)	Number of Vascular bundles			Size of Vascular bundles (µm)			Size of metaxylem (µm)			No. of kranz cells
			I°	II°	III°	I°	II°	III°	I°	II°	III°	
Tribe: Maydeae												
1.	*Chionachne koenigii*	295x275±24.87	31±3	19±6	28±4	14.68x12.5 ±3.87	7x9.67±1.73	4.5x3±0.84	3.75x3.43 ±1.31	4x3.34±1.62	2.25x1.5± 0.08	absent
2	*Coix lachryma-jobi*	923.07x646.15 ±31.49	68±5	36±3	27±5	17.78x15.56 ±2.32	11.07x10.36 ±3.72	7.34x6.27± 1.47	2.78x2.23 ±0.36	2.85x3.21±0 .71	2.04x2.94 ±0.81	absent
Tribe: Andropogoneae												
3	*Andropogon pumilus*	161.17x91.67± 18.37	9±2	8±1	10±2	13.22x16.37 ±3.28	12.34x15.34 ±2.98	3.62x4.82± .73	3.75x4.25 ±1.29	2.67x3.67±0 .83	1.83x2.21 ±0.35	absent
4	*Apluda mutica*	358.25x433.38 ±28.73	32±8	17±3	15±2	35.71x31.43 ±6.42	15x18.21±3. 72	7.08x14.17 ±1.38	3.57x13.3 7±4.28	6.08x4.64±1 .35	4.58x3.75 ±0.72	Absen t
5	*Arthraxon lanceolatus*	116.67x138.09 ±17.82	14±4	10±2	8±3	14x11.34±4 .83	11.07x12.86 ±2.63	6.67x7.08± 1.72	3.67x3±0. 13	3.21x3.21±1 .62	1.67x1.67 ±0.08	Absen t
6	*Bothriochloa pertusa*	15.56x13.89±3. 78	18±5	10±1	-	11x12.67±3 .29	7.5x9.32±2.8 5	-	4x3.67±1. 83	2.72x2.27±0 .36	-	Absen t
7	*Capillipedium hugelii*	152.94x138.24 ±18.63	19±5	14±3	12±4	16x17±6.37	11.36x13.18 ±2.84	5.67x7.34± 1.35	5.5x4.5±0. 92	4.54x4.09±1 .26	2x1.84±0. 74	Absen t
8	*Chrysopogon fulvus*	277.78x283.34 ±35.22	17±4	12±1	16±3	28.89x21.67 ±5.18	15.47x20.16 ±6.18	6.30x10±2. 73	7.78x6.12 ±2.62	4.27x4.92±1 .63	2.61x2.61 ±0.74	Absen t
9	*Cymbopogon martini*	759x900±48.22	42±7	24±3	18±4	24.5x27.5± 3.73	14.09x14.09 ±4.62	3.86x7.95± 1.37	7.5x7±2.7 6	5.45x4.55±2 .83	2.5x2.27± 0.84	Absen t
10	*Dichanthium annulatum*	253.72x241.67 ±27.56	18±3	16±3	20±3	21x24.5±7. 29	12x16.5±3.8 1	7.5x11±1.3 8	5.5x4.5±2. 83	5.5x2.75±1. 38	3x2.75±0. 95	Absen t
11	*Dichanthium*	527.2x613.23±	24±4	19±5	20±4	22x23.5±4.	13.18x11.82	7.1x9.13±2	6.5x7.5±1.	3.64x3.18±0	2.97x2.36	Absen

Sr No.	Name of plant	Cross section area (µm)	Number of Vascular bundles			Size of Vascular bundles (µm)			Size of metaxylem (µm)			No. of kranz cells
			I°	II°	III°	I°	II°	III°	I°	II°	III°	
	caricosum	61.78				83	±1.92	.73	83	.94	±0.72	t
12	*Hackelochloa granularis*	218.18x254.54 ±31.37	22±7	20±6	-	16x23±4.73	8.08x3.85±1. 36	-	5.5x4±1.4 9	3.08x3.85±1 .38	-	Absen t
13	*Heteropogon contortus var. genuinus sub var. typicus*	241.67x316.67 ±28.82	36±8	21±6	23±4	16.82x17.73 ±4.39	12.92x16.25 ±3.82	9.17x9.58± 3.78	5.45x4.54 ±0.63	5x3.75±1.38	2.92x2.5± 0.96	absent
14	*Heteropogon contortus var. genuinus sub var. hispidissimus*	256.25x384.37 ±28.84	23±6	17±2	13±4	15x18.75±4 .25	10.36x14.93 ±4.72	7.5x9.87±4 .83	5x5.52±1. 38	3.43x3.75±0 .36	2.64x2.71 ±0.92	absent
15	*Heteropogon ritchiei*	260x335±35.59	33±5	14±2	11±5	19.61x18.07 ±3.28	10.84x13.34 ±4.18	9.23x10±3. 75	5.77x4.62 ±1.37	3.34x3.34±0 .76	3.08x2.69 ±1.74	absent
16	*Heteropogon triticeus*	1155.56x1444. 45±47.28	38±9	30±6	21±3	25x27.27±5 .18	16.67x16.78 ±5.38	10.5x14±3. 28	6.81x7.33 ±2.47	7.86x5.36±3 .48	5x4±1.38	absent
17	*Imperata cylindrica*	183x118.27±34 .25	29±4	15±2	14±3	22.5x20±4. 27	11.12x13.89 ±2.78	6x5.71±1.3 9	6x5.5±2.8 1	3.34x3.34±1 .36	2x1.71±0. 93	absent
18	*Ischaemum indicus*	280x420±21.38	26±3	24±5	20±3	27.5x23±6. 28	9.6x11.6±2.7 4	6.26x7.93± 1.83	7x4.75±1. 36	4.4x4±1.97	2.04x1.95 ±0.63	6±2
19	*Ischaemum molle*	216x224±34.87	18±2	13±2	12±3	15.5x16±3. 8	8.6x12.4±3.1 9	4.38x6.15± 1.83	3.5x3.5±1. 36	2.4x1.8±0.8 3	1.98x1.85 ±0.73	6±1
20	*Ischaemum pilosum*	250±331.82±41 .73	20±4	26±4	19±3	16.36x14.55 ±4.78	12.73x13.82 ±3.28	7.27x6.36± 2.73	4.54x4.54 ±1.63	2.73x2.27±0 .62	2.03x1.96 ±0.72	12±6
21	*Ischaemum rugosum*	330.43x321.74 ±15.12	19±3	11±1	12±2	24.63x22.37 ±4.62	9.55x8.64±2. 16	8.89x10±1. 63	6.28x4.26 ±2.94	4.55x3.18±1 .64	4.45x3.34 ±0.73	7±3

Sr No.	Name of plant	Cross section area (µm)	Number of Vascular bundles			Size of Vascular bundles (µm)			Size of metaxylem (µm)			No. of kranz cells
			I°	II°	III°	I°	II°	III°	I°	II°	III°	
22	*Iseilema laxum*	333.34x416.67 ±24.38	23±3	12±2	15±4	35.45x24.54 ±7.19	16.25x18.18 ±4.17	10.91x13.18±2.74	8.18x5.68 ±3.27	4.17x3.75±1.38	3.18x3.86 ±1.75	absent
23	*Ophiuros exaltatus*	480x545±38.17	34±6	26±3	79±9	22.78x18.34 ±5.28	17.5x17±3.97	3.82x4.12± 1.82	6.12x4.67 ±1.36	5x3.5±2.74	1.76x0.88 ±0.63	7±2
24	*Rottboellia exaltata*	367.28x227.18 ±24.37	37±5	20±4	25±5	24.37x21.25 ±3.17	8.27x10.17± 3.19	7.83x8.69± 3.71	5x5±1.42	2.12x2.69±0.27	2.17x2.61 ±1.22	absent
25	*Saccharum spontanum*	305x355±21.79	28±4	20±1	10±2	17.5x25±5.72	15.03x15.04 ±3.16	7.69x4.62± 1.92	6.63x4.72 ±1.25	5.38x4.54±1.87	1.35x1.54 ±0.17	absent
26	*Sehima ischaemoides*	203.57x214.28 ±18.36	17±2	32±5	21±7	17.39x25.22 ±4.28	8.26x7.93±2.71	5.19x7.41± 2.71	7.17x7.39 ±3.46	3.04x3.27±1.63	2.96x2.59 ±0.84	absent
27	*Sehima nervosum*	257.41x259.26 ±24.63	23±6	14±4	12±3	21.74x20.22 ±6.26	17.08x21.25 ±3.71	3.94x5.76± 1.52	6.74x5±2.17	4.79x4.17±2.78	1.82x1.97 ±0.41	absent
28	*Sehima sulcatum*	127.27x102.27 ±11.72	14±5	11±2	10±4	11.67x13.94 ±2.78	6.34x8.34±2.19	4.27x4.07± 1.18	3.48±3.34 ±1.86	2.59x2.83±0.93	1.84x1.84 ±0.g72	absent
29	*Sorghum halepense*	1765x1877.5±32.78	21±6	24±2	30±3	19.13x25.22 ±5.27	17.27x21.82 ±4.87	4.55x4.31± 1.64	8.04x7.83 ±2.78	6.82x6.36±2.71	4.71x5.17 ±2.93	absent
30	*Thelepogn elegans*	500x550±16.62	24±3	18±2	15±4	16.67x21.43 ±3.17	7.67x10±2.73	6.82x5.93± 2.23	7.38x5.71 ±1.83	3.34x3.57±1.73	2.83x2.64 ±0.38	absent
31	*Themeda cymbaria*	269.23x369.23 ±31.73	26±7	18±4	20±2	20x19.58±2.73	8.28x5.84±2.74	6.86x10.29 ±1.37	7.29x5.84 ±2.37	3.17x2.68±1.98	3.14x3.14 ±1.64	absent
32	*Themeda laxa*	275x318.75±25.38	32±4	19±2	-	25x24.17±8.78	9.63x11.36± 3.18	-	8.56x6.12 ±2.18	3.63x2.95±1.28	-	absent
33	*Themeda triandra*	305x362±11.28	36±5	25±3	24±6	19.77x27.5 ±7.21	13.46x16.15 ±4.26	8.27x8.92± 2.81	9.5x10.5± 3.27	6.92x5.19±2.72	2.05x2.48 ±0.83	absent
34	*Themeda*	390.91x363.64	32±7	24±2	22±5	24.71x24.71	12.95x16.36	9.5x10.5±3	7.65x6.17	5.45x4.55±2	2.5x3±1.0	absent

Sr No.	Name of plant	Cross section area (µm)	Number of Vascular bundles			Size of Vascular bundles (µm)			Size of metaxylem (µm)			No. of kranz cells
			I°	II°	III°	I°	II°	III°	I°	II°	III°	
	quadrivalvis	±25.81				±6.17	±3.19	.47	±2.91	.37	2	
35	*Triplopogon ramosissimus*	1050.14x1108.16±5.28	25±7	16±4	28±3	58.34x91.08±2.73	50.34x51.63±0.83	33.45x29.35±0.21	10.21x11.16±1.73	9.29x9.18±0.40	5.04x5.94±0.63	absent
36	*Vetivaria zizanioides*	1133.34x1483.34±34.16	60±7	25±4	23±3	36.12x27.78±8.15	13.89x16.67±4.18	8.34x8.34±4.28	16.67x13.89±55.18	5.56x8.34±2.81	2.78x2.78±1.27	absent
Tribe: Paniceae												
37	*Alloteropsis cimicina*	159.13x153.13±16.28	16±4	9±2	12±1	10.56x15±2.91	13.34x16.67±3.18	4.5x6.5±1.24	4.73x5.56±1.71	6.12x5.27±2.56	1.5x2±0.95	absent
38	*Brachiaria distachya*	141.17x170.59±32.34	12±2	7±1	8±3	15.45x21.36±2.15	8.57x13.39±3.71	5.88x7.35±1.62	5.45x6.14±1.36	3.57x4.11±1.26	2.94x2.94±1.02	absent
39	*Brachiaria eruciformis*	112.5x137.5±22.08	15±6	11±2	9±2	14.09x17.27±2.17	8x10±1.27	3.34x4.17±1.34	4.54x5.90±2.04	3.34x3.34±1.09	2.08x1.67±0.46	absent
40	*Brachiaria ramose*	340.91x572.73±32.72	60±7	22±2	27±5	26.67x22.78±5.16	11.25x11.56±2.18	7.69x11.54±3.18	6.39x5.56±2.10	3.46x3.46±1.72	2.97x2.81±1.04	absent
41	*Brachiaria reptans*	167.86x164.28±21.91	23±4	12±3	21±2	15.24x17.14±3.16	10.68x9.88±3.16	7.69x5±1.26	4.76x4.76±1.76	3.09x3.08±0.64	2.5x2.95±1.05	9±2
42	*Cenchrus biflorus*	165x480±14.86	53±3	28±1	34±5	23.18x18.18±7.16	11.5x14.5±2.18	5.56x7.78±1.72	6.82x5.91±2.17	3.5x3.5±1.86	1.67x2.08±0.13	absent
43	*Cenchrus ciliaris*	600x591.67±47.61	48±9	20±4	24±2	36.67x28±6.17	18.63x15.91±4.76	15.2x13.6±5.15	6.34x7.34±2.17	5.45x4.09±1.72	3.6x2.8±1.62	absent
44	*Cenchrus setigerus*	333.34x311.12±16.24	23±4	19±6	17±3	28.18x32.73±4.16	10.88x13.82±3.28	4.68x4.37±1.62	6.36x7.27±2.06	4.12x3.53±2.7	2.5x2.81±0.61	7±3
45	*Digitaria ciliaris*	320x305±21.63	24±5	15±3	30±2	21.54x23.85±6.18	9.47x11.58±3.71	6.15x5.72±2.16	6.92x6.92±1.52	2.63x4.74±1.53	2.21x3.52±0.35	absent
46	*Digitaria*	258.34x294.26	13±3	12±4	-	43.75x40±6	16.67x25.34	-	9.63x11.1	6x7.34±1.72	-	absent

Sr No.	Name of plant	Cross section area (µm)	Number of Vascular bundles			Size of Vascular bundles (µm)			Size of metaxylem (µm)			No. of kranz cells
			I°	II°	III°	I°	II°	III°	I°	II°	III°	
	granularis	±13.24				.16	±4.14		3±3.71			
47	*Digitaria longiflora*	409.09x463.64 ±72.22	8±2	7±3	7±2	36x30±9.26	16.24x21.29 ±3.28	3x3.67±1.6 2	9x8±2.16	2.5x2.67±0. 53	1x1±0.03	absent
48	*Digitaria stricta*	250x308.34±24 .25	21±5	17±2	18±4	9.56x11.36 ±3.16	5x5.67±1.25	2x4±0.34	4.09x3.64 ±1.25	2x2±0.83	1x1±0.04	absent
49	*Echinochloa colonum*	1123.08x1184. 62±82.63	28±6	20±4	24±3	24.17x31.67 ±7.25	20.56x25.56 ±6.24	14x11.5±4. 26	11.67x20. 84±5.72	8.89x6.67±3 .72	5.5x5.5±2. 62	absent
50	*Echinochloa crusgalli*	1584.61x1638. 46±69.18	83±2 5	41±1 1	40±7	14.64x14.29 ±3.12	0.09x9.55±3. 17	4.09x3.64± 2.13	4.28x2.5± 1.52	3.64x2.73±1 .85	1.36x1.14 ±0.46	absent
51	*Echinochloa stagnina*	1050x1163±62. 58	24±9	14±5	16±3	29.17x25±7 .14	23.34x25±5. 12	8.34x12.5± 3.62	6.67x7.08 ±2.15	6.25x6.25±2 .51	4.17x4.17 ±1.88	absent
52	*Eremopogon foveolatus*	1210x1560±10 2.13	24±5	16±5	20±3	26.12x16.24 ±6.15	21.92x16.15 ±7.36	7x14±3.16	5.77x5±2. 61	5.01x4.89±2 .61	4.38x3.50 ±2.17	absent
53	*Eriochloa procera*	261.90x304.76 ±36.41	20±3	15±4	17±3	12.72x16.82 ±4.52	7.73x11.36± 3.17	6.07x8.03± 2.76	5.45x4.09 ±2.75	2.27x4.09±1 .35	2.68x2.5± 0.72	absent
54	*Oplismenus burmannii*	173.34x193.34 ±36.29	14±3	15±3	12±1	14.34x13.34 ±5.26	12.34x11.34 ±4.26	4x5±2.16	5x3.5±2.1 6	3.34x2.79±1 .16	2.25x1.5± 1.51	absent
55	*Oplismenus compositus*	214.28x257.14 ±37.34	15±2	23±5	-	12.5x14.75 ±3.71	5.22x6.52±2. 53	-	6x6±1.73	2.61x2.06±0 .83	-	absent
56	*Panicum antidotale*	480x1146.67±6 2.25	48±1 0	23±6	64±1 2	19.55x20.91 ±7.21	10x12.61±4. 14	6.67x10±3. 61	5.91x5.45 ±2.53	4.35x3.48±1 .72	3.34x3.34 ±1.62	absent
57	*Panicum maximum*	533.34x438.09 ±36.26	36±8	22±5	28±3	22.5x23.5± 7.25	8.69x16.95± 2.47	5.16x4.17± 2.13	6x6.5±2.1 4	4.35x5.22±1 .46	3.02x2.96 ±1.93	absent
58	*Panicum miliaceum*	315.38±323.07 ±25.16	32±6	24±3	22±4	19.68x23.22 ±5.27	17.23x19.45 ±6.16	6.07x9.28± 2.72	7.74x7.39 ±2.68	6.67x6.12±2 .17	3.21x2.86 ±1.28	absent

Sr No.	Name of plant	Cross section area (µm)	Number of Vascular bundles			Size of Vascular bundles (µm)			Size of metaxylem (µm)			No. of kranz cells
			I°	II°	III°	I°	II°	III°	I°	II°	III°	
59	*Panicum trypheron*	316.67x308.34 ±51.56	20±6	14±4	24±6	15.94x19.69 ±6.17	8.34x12.5±3. 17	6.39x10±2. 15	5.94x5.94 ±2.17	4.17x4.17±1 .54	3.62x3.05 ±1.13	11±4
60	*Paspalidium flavidum*	361.90x280.95 ±47.25	32±6	24±6	14±3	15.43x16.08 ±3.16	11.78x19.28 ±3.26	3.13x3.13± 1.25	4.78x4.35 ±1.53	3.57x4.64±1 .26	2.08x2.75 ±0.7vb4	6±2
61	*Paspalidium geminatum*	1080.64x1677. 42	28±4	24±3	12±3	18.21x18.39 ±4.15	10.78x11.56 ±2.36	4.27x4.03± 1.82	6.07x5±2. 64	2.18x2.5±0. 73	1.64x1.82 ±0.28	absent
62	*Paspalum scrobiculatum*	275x362.5±13. 54	17±3	15±4	16±4	18.75x15.63 ±3.27	17.08x21.04 ±3.65	6.34x8.34± 2.56	6.25x5±2. 63	6.25x4.68±2 .38	3x2.67±1. 36	absent
63	*Pennisetum setosum*	742.23x1151.1 3±92.36	67±8	19±3	18±4	31.43x27.85 ±8.62	13.46x17.69 ±4.28	8.12x12.5± 3.28	9.28x8.57 ±3.45	5.19x4.61±2 .78	3.75x3.75 ±1.62	absent
64	*Setaria glauca*	777.79x1100±1 04.26	26±3	14±2	12±2	22.5x29.37 ±6.37	21.36x26.36 ±5.89	15x17±4.7 2	9.09x5±2. 73	8.75x8.13±2 .67	6.5x5.75± 2.63	absent
65	*Setaria tomentosa*	263.64x290.90 ±14.52	16±3	11±2	13±2	20.38x13.07 ±5.28	12.67x15±3. 52	5.23x6.36± 2.45	5.77x5±2. 74	3.67x4.34±1 .67	1.59x1.82 ±0.51	absent
66	*Setaria verticillata*	241.67x325±21 .68	14±3	16±3	12±3	16.43x18.21 ±4.27	9.26x10.27± 3.79	6.11x6.67± 2.74	4.64x5.36 ±2.47	3.47x3.97±1 .29	2.23x2.23 ±0.96	absent
Group: Pooideae												
Tribe: Isachneae												
67	*Isachne globosa*	268.18x431.82 ±16.29	29±7	18±3	20±5	20.84x25.42 ±6.42	11.25x13.75 ±4.82	8.37x8.75± 2.38	8.34x7.5± 2.43	5.63x4.38±2 .67	2.75x2.98 ±0.65	6±2
Tribe: Aristideae												
68	*Aristida adscensionis*	225.92x229.63 ±15.38	17±2	15±3	12±2	13.57x12.86 ±4.89	8.28x9.14±2. 19	3.28x3.81± 1.34	5.71x4.28 ±2.78	3.71x2.86±1 .03	1.85x1.84 ±0.06	6±2
69	*Aristida funiculata*	196.37x198.32 21.38	9±1	10±3	10±2	11.25x15±3 .16	5.71x8.57±2. 46	3.44x6.25± 1.37	5.31x4.69 ±2.67	2.32x2.14±0 .84	1.88x1.88 ±0.52	6±2

Sr No.	Name of plant	Cross section area (µm)	Number of Vascular bundles			Size of Vascular bundles (µm)			Size of metaxylem (µm)			No. of kranz cells
			I°	II°	III°	I°	II°	III°	I°	II°	III°	
Tribe: Perotideae												
70	*Perotis indica*	98.54x47.81±9.24	10±2	11±2	13±3	12.5x16.67 ±3.74	10.36x11.73 ±2.46	7.92x10.42 ±1.53	5x4.58±2.46	3.46x3.06±1.34	2.5x2.08± 0.85	8±3
Tribe: Chlorideae												
71	*Chloris barbata*	129.54x118.18 ±32.64	17±3	19±2	24±3	25x10.71±6.63	12.78x17.22 ±3.46	3.67x2.33± 1.63	7.86x10±2.63	5x6.11±2.39	1.67x1.67 ±0.25	7±2
72	*Chloris montana*	171.44x145.24 ±17.37	30±6	14±3	26±3	20x15.45±4.17	9.25x10.15± 3.89	6.67x7.34± 2.43	5x3.18±	3.36x3.89±1.37	1.67x1.34 ±0.93	6±2
73	*Chloris virgata*	130x157.5±26.27	12±3	8±2	10±3	13.72x14.26 ±2.36	7.63x8.68±2.16	5x4.37±1.25	5x2.63±1.25	2.5x2.5±0.68	1.46x1.71 ±0.48	6±2
74	*Cynadon dactylon*	277.27x265.09 ±41.26	27±4	16±3	48±5	14.58x13.75 ±2.18	9.09x12.73± 3.17	6.34x6.82± 2.37	5x4.17±2.37	4.09x4.09±1.38	1.53x1.38 ±0.92	7±2
75	*Melanocenchris jaequemontii*	115.79x126.32 ±36.26	19±3	11±2	-	10x10.59±3.16	7.81x10.31	-	4.06x3.13 ±1.36	3.53x2.94±1.37	-	absent
76	*Oropetium villosulum*	116x136±17.28	10±2	8±2	19±4	13x12±4.17	7.78x10±2.19	3.70x5.18± 1.27	3x2.67±1.32	2.23x2.23±0.95	0.74x1.12 ±0.39	10±3
77	*Sachoenefeldia gracilis*	47.62x73.81±11.43	11±2	14±3	-	14.28x15±4.27	6.04x6.25±2.17	-	6.04x6.25 ±2.67	5x5±1.94±2.18	-	absent
78	*Tetrapogon tenellus*	239.28x271.43 ±32.46	32±8	14±4	22±3	19.55x25.45 ±5.28	13.5x14.5±3.17	7.86x11.78 ±2.16	5.91x5±2.48	4x5.5±1.83	3.21x3.21 ±0.82	5±1
79	*Tetrapogon villosus*	131.82x168.18 ±27.46	22±3	12±3	26±4	10.36x6.43 ±2.17	8.64x11.36± 3.12	4.62x6.15± 2.15	3.18x2.73 ±1.28	2.86x1.43±0.62	1.15x1.15 ±0.38	4±1
Tribe: Eragrosteae												
80	*Acrachne Racemosa*	86.96x93.48±13.70	18±3	10±1	11±2	11.67x12.92 ±1.38	8.75x9.58±2.61	5.83x5±2.15	2.5x2.5±0.93	1.25x1.25±0.46	0.84x0.84 ±0.04	absent

Sr No.	Name of plant	Cross section area (µm)	Number of Vascular bundles			Size of Vascular bundles (µm)			Size of metaxylem (µm)			No. of kranz cells
			I°	II°	III°	I°	II°	III°	I°	II°	III°	
81	*Dactyloctenium aegyptium*	294.45x433.34 ±18.64	28±6	24±3	30±5	18.64x17.5 ±3.26	10.52x14.83 ±3.17	5.77x6.15± 2.62	4.54x4.54 ±1.73	4.14x3.62±2 .18	2.31x1.92 ±0.92	10±2
82	*Dactyloctenium sindicus*	242.31x226.92 ±38.57	12±1	14±2	24±2	17.39x22.61 ±4.27	4.23x8.46±2. 37	2.18x2.61± 0.26	4.56x5.65 ±1.86	1.35x1.73±0 .43	1.17±1.05 ±0.04	6±2
83	*Desmostachya bipinnata*	326.67x240±21 .80	22±5	20±2	-	11.67x11.67 ±1.84	10x6.67±2.1 6	-	4.27x4.25 ±2.46	2.92x3.75±1 .35	-	absent
84	*Dinebra retroflexa*	423.07x346.15 ±36.18	26±4	20±3	30±2	17.5x11.67 ±2.87	5.42x6.67±1. 73	3.17x3.17± 1.25	3.75x2.92 ±1.02	1.67x1.67±0 .29	1.27x1.25 ±0.76	absent
85	*Eleusine indica*	78.94x71.05±6. 26	15±2	10±2	18±3	8.34x7.5±2. 17	8.24x7.94±3. 17	5.17x4.83± 1.56	2.08x2.5± 0.36	1.76x1.91±0 .18	1.55x1.38 ±0.27	7±2
86	*Eragrostiella bachyphylla*	121.25x142.5± 10.27	12±1	10±2	18±2	9.52x13.57 ±1.56	8.89x11.12± 2.18	4.27x4.18± 1.78	3.09x3.57 ±1.87	1.85x2.59±0 .53	1.28x1.45 ±0.15	6±2
87	*Eragrostiella bifaria*	120x112.5±34. 72	13±4	14±2	14±2	14.85x13.64 ±2.78	7.69x13.46± 1.77	4.17x4.86± 1.07	4.09x4.24 ±1.67	1.92x1.73±0 .63	1.38x1.25 ±0.32	6±1
88	*Eragrostis cilianensis*	138.46x203.85 ±25.78	20±2	16±2	32±3	13.75x14.58 ±4.28	10.84x13.34 ±1.54	4.75x5.5±1 .69	3.96x3.75 ±1.42	3.34x2.92±1 .65	1.75x1.75 ±0.21	5±2
89	*Eragrostis ciliaris*	168x118.18±11 .75	24±5	30±2	31±4	11.12x11.81 ±3.32	6.76x6.32±2. 17	5.6x5.4±2. 18	4.17x3.47 ±2.21	3.53x3.24±1 .54	2.4x2.8±0. 54	4±1
90	*Eragrostis japonica*	160.87x201.35 ±48.63	30±2	27±4	44±6	17.31x13.08 ±3.87	7.69x6.35±2. 89	3.39x3.57± 1.66	6.73x4.62 ±1.89	2.5x2.12±0. 83	1.61x1.07 ±0.58	5±2
91	*Eragrostis nutans*	150x127.27±24 .18	26±2	28±3	29±2	16.82x11.36 ±3.65	11.92x13.46 ±2.18	3.48x4.06± 1.86	4.32x3.41 ±1.29	4.23x3.46±1 .37	1.52x1.06 ±0.78	5±1
92	*Eragrostis pilosa*	241.28x222.24 ±38.20	30±5	21±2	24±1	15.42x21.67 ±3.81	14.76x18.09 ±2.37	7.5x6.5±1. 39	6.25x6.25 ±1.36	4.76x4.29±2 .61	1.5x1.75± 0.83	7±2
93	*Eragrostis*	163.64x209.09	22±4	18±2	14±2	11.78x13.04	8.32x8.96±2.	4.32x4.86±	4.29x3.93	1.62x1.22±0	1.08x1.17	absent

Sr No.	Name of plant	Cross section area (µm)	Number of Vascular bundles			Size of Vascular bundles (µm)			Size of metaxylem (µm)			No. of kranz cells
			I°	II°	III°	I°	II°	III°	I°	II°	III°	
	tenella	±25.98				±3.17	41	1.53	±0.93	.48	±0.48	
94	*Eragrostis tremula*	175x193.75±21.29	25±3	23±3	27±5	11.43x12.5±3.17	7.93x7.86±2.18	4.45x4.45±0.83	2.5x2.5±0.64	1.97x1.94±0.54	1.25x1.39±0.28	absent
95	*Eragrostis unioloides*	168.75x159.38±14.75	16±3	10±3	19±3	17.08x17.92±4.18	5.86x5.52±2.18	5x6.56±1.34	4.58x5±1.45	1.72x1.55±0.53	1.25x1.56±0.48	7±2
96	*Eragrostis viscosa*	150x145±13.65	17±2	15±3	16±2	11.56x9.69±1.48	8.82x8.82±2.68	5.43x5.92±1.54	3.44x2.5±1.87	3.24x3.08±1.03	1.43x1.71±0.04	5±1
Tribe: Sporoboleae												
97	*Sporobolus coromardelianus*	97.72x118.18±24.53	15±1	12±2	14±2	12.5x13.34±3.17	9.45x11.38±2.68	7.04x7.27±1.13	3.34x3.34±1.79	2.78x3.89±1.86	2.27x2.27±0.81	6±2
98	*Sporobolus diander*	117.5x120±25.17	16±3	18±2	-	22.5x22.3±4.96	17.65x20.17±5.28	-	10x10±3.18	5.29x6.47±2.18	-	absent
99	*Sporobolus indicus*	216.67x220.84±25.18	17±4	15±2	24±3	20x14.45±3.17	11.25x13.34±3.15	3.5x5.67±1.78	4.45x4.17±1.59	2.92x3.75±0.83	1.34x1.17±0.07	absent
Tribe: Zoysieae												
100	*Tragrus biflorus*	115.96x119.5±9.54	20±4	9±2	18±3	26x27±6.28	14x16±5.17	5.28x7.69±2.17	10x8±3.97	6x7±2.16	2.31x2.31±0.61	absent

Discussion

Distribution of the vascular bundles in the culm varied. Vascular bundles were distributed among the cortical and hypodermal region. I°IVB and II°IVB were distributed in cortical region and III°PVB were generally present in hypodermal region.Vascular bundle distribution is a strength property of the internode (Sulthani, 1989). Increased number of vascular bundle's might be accompanied by increment in the greater number and density of sclerenchyma and conducting cells thereby increasing the strength properties of the internodes (Mohmod *et al.,* 1992). Number of vascular bundles vary from species to species. *Coix-lachryma jobi* had maximum number of I°IVB (68) and II°IVB (36) while *Ophiuros exaltatus* showed maximum of III°PVB (79) among the studied species.

Grosser and Liese (1972) noted considerable variation in the appearance of the vascular bundles within a single culm species of bamboo. Grosser and Liese (1971) describes four types of vascular bundles in different bamboo species. Hypodermal vascular bundles are smaller in size reported in many monocotyledons species (Grosser and Liese, 1971; Hossain 2011; Joarder and sima, 2011). The center vascular bundles i.e. which were near to the pith, were larger in sizes and outer ones were smaller in size. A wide range of vascular bundles area has been reported in cogon grass ecotypes (Homeed *et al.,* 2009). According to Liese (1985), in bamboos smaller vascular bundles are denser in distribution than that of bigger ones resulting in the higher density and mechanical strength for the outer zone than both inner and middle. Among the 100 studied species *Triplopogon ramosissimus* showed maximum size of all vascular bundles (58.34x91.08±2.73 (µm) I°IVB, 50.34x51.63±0.83 (µm) II°IVB, 33.45x29.35±0.21 (µm) III°PVB). Quantitative data shows a wide standard error in the size of the vascular bundles which is an indication of existence of differences between plants with in a sample. High variation in measurements of anatomical traits has been reported in different ecotypes of cogon grass (Hameed et al., 2009). Polygenic controlled rice and wheat exhibits high variation grown under different environmental conditions (Joarder, 1980; sima, 2010). Hossain (2010) noted strong environmental effects on the expression of anatomical traits and each estimate is attached with high standard error in wild sugarcane.

Peripheral vascular bundles being completely encircled by thick walled sclerenchymatous, bundle sheath, indicats an anatomical adaptation for tolerating drought and harsh environment (Matumura and Nokajima, 1988). Species like *Panicum miliaceum, Panicum trypheron, Paspalum scorbiculatum, Setaria sp.,Melanocenchris jaquimontii, Chionachnae koenigii* showed pheriperal vascular bundles were covered by sclerenchymatous cells while species like *Pennisetum setosum,Dinebra, Eragrostiella, Chrysopogon, Cymbopogon, Dicanthium* showed pheripheral vascular bundles totally embedded within sclerenchymatous tissue.

Sometimes few vascular bundles did not develop into full vascular bundles (i.e. with xylem and phloem), they had only phloem cap and more tissues which were surrounded by fibrous cell. This is an adaptation for efficient phloem transport to undergo and rhizome for reseve (Sima *et al.,* 2015).

In cross section, vessel diameter increased significantly from outer to inner. Vascular bundles an observation which is in accordance with noticed by that authors Liese (1985); Hishman et al. (2006) and Wang et al. (2011). The metaxylem vessels wide in the inner and middle zones, a feature attributed to the fact that these zones are mainly functioned for water and nutrient transportation while in outer/pheripheral zone incomplete developed vascular vessel was observed (Huong x y, 2015). Vessel diameter of I°IVB are more than the other vascular bundles while III°PVB showed less diameter. Among the studied species, metaxylem of I°IVB of *Vetiveria zinzanoides* (16.67x13.89±5.18 (µm)) showed maximum size. *Triplopogon ramosissimus* showed maximum vessel diameter (9.29x9.19±0.40 (µm)) of II°IVB among the studied species. Likewise, *Setaria glauca* showed high vessel diameter (6.5x5.75±2.63) of III°PVB.

In ground tissue, cell size increases from the outer to the inner layers (Grosser, 1970; Parameswaran and Liese, 1981) a similar feature noticed in all the studied species.

Presence of Schizo-lysigeny to lysogenous arenchyma in culm is normal feature observed in *Cynodon dactylon, Eremochloa ophiuroides, Hemarthria altissima* and *Miscanthus sacchariflorus* (Sangster, 1985; Seago *et al.,* 2005; Jung *et al.,* 2008; Yang *et al.,* 2011). In the present study *Cynodon dactylon,* did not show air cavities but the pith region was hollow. *Vetivaria zinzanoides, Paspalidium geminatum* shows air cavities in cortical region. *Aristida adscensionis* did not show any cavity but parenchyma cells below hypodermis region are large in very big size and elongated. These consecutively formed air spaces (Kawai *et al.,* 1998) which obviously stored and transported oxygen to organs in hypoxic environments (Justin and Armstong, 1987; Vartapetian and Jackson, 1997; Colmer, 2003; Armstrong and Armstrong, 2006).

Kranz anatomy is observed only in species like *Eragrostis, Dinebra, Cenchrus setigerus, Dactyloctenium sps., Tragus biflors, Perotis indica, Tetrapogon sp.,* etc. Kranz layer shows prominently distinct rounded cells in *Arundinella* (Sanchez et al., 1989) a similar feature observed in the present study in species like *Chloris montana, Tetrapogon sps., Tragus biflorus, Paspalidium flavidum, Sporobolus dianer, Aristida adscenionis, Ischanae globosa,* etc. The cells are thickened and contained specialized distinct large chloroplasts embedded in distinctly larger chlorenchyma cells. They are not part of vascular tissue and therefore cannot be considered as degenerate intercalary vascular bundles (Brown, 1977). Instead they are seen to be long, isolated kranz cell columns not physically connected to the vascular bundles but presumably functionally linked at regular intervals by vascular strands. The occurrence of kranz anatomy in both culms and leaves in noteworthy, because grass species with kranz leaf anatomy do not necessarily exhibit kranz structure in the culm as well (Sanchez, unpublished). Kranz arc, radial cholrenchyma, culm outline and chloroplast shape and position, are some of the culm anatomical features suggested to be useful for inferring phylogenies (Siqueiros and Herrera, 1996). Four different types of kranz arc were

observed viz. straight, half circle, horse shoe shaped, circular in the studied species. *Eragrostis viscosa, Eragrostis ciliaris, Tetraoogon tenellus, Tragus biflorus* showed straight type of kranz arc, *Sporobolus indicus, Chloris montana, Dactyloctenium sindicus, Tetrapogon villosus, Dactyloctenium aegyptium, Cenchrus setigerus* showed half circle shaped kranz arc, while species like *Aristida funiculata, Perotis indica* showed horse shoe shaped kranz arc and only *Ophiuros exaltatus* showed circular shaped kranz arc. Two types of chloroplast arrangements were present: centripetal and centrifugal. Species like *Eragrostis viscosa, Sporobolus sp., Tetrapogon sp., Dactyloctenium sp., Eragrostiella bachyaphylla, Sporobolus coromandelianus, Dinebra* showed centrifugal type of chloroplast while species like *Eragrostis ciliaris, Chloris sps., Tragus biflorus* showed centripetal type of choloroplast.

Based on the characteristic features a dichotomous key for the studied species has been prepared.

1. Presence of Kranz cells.....**2**
1. Absence of Kranz cells.....**39**
2. Elongated/ round shaped epidermal cell.....**3**
2. Barrel/ rectangular/ square shaped epidermal cell.....**11**
3. Square to trapezoid kranz cell shape…….. ***Eragrostis cilianensis***
3. Round to oval kranz cell shape….....**4**
4. Sclrenchyma in form of girder..... **5**
4. Sclrenchyma in form of unicylinder..... **6**
5. Kranz arc shape is half circle…… ***Ishcaemum pilosum***
5. Kranz arc shape is horse shoe…… ***Perotis indica***
6. Circular shaped Kranz arc.....***Ophiuros exaltatus***
6. Half circle shaped Kranz arc.....**7**
7. Type D sclerenchyma.....***Desmostachya bipinnata***
7. Type E sclerenchyma.....**8**
8. Elongated shaped epidermal cell.....**9**
8. Round shaped epidermal cell.....**10**
9. Horse shoe shaped in transection.....***Panicum trypheron***
9. Triangular shaped in trnscection..... ***Cynodon dactylon***
10. Type B I°IVB..... ***Eriochloa procera***
10. Type H I°IVB.....***Cenchrus setigerus***
11. Round to oval shaped Kranz cell.....**12**
11. Square to trapezoid shaped Kranz cell.....**19**
12. Straight shaped Kranz arc.....**13**
12. Half circle shaped Kranz arc.....**15**
13. Sclerenchyma presents in form of girder.....***Dactyloctenium scindicus***
13. Unicylindrical type of sclerenchyma.....**14**

14. Centripetal type of chroloplast.....***Eragrostis ciliaris***
14. Centrifugal type of chloroplast.....***Eragrostis viscosa***
15. Centripetal type of chloroplast.....***Chloris barbata***
15. Centrifugal type of chloroplast.....**16**
16. Unicylindrical form of sclerenchyma.....***Eragrostis uniolodies***
16. Sclerenchyma present in the form of girder.....**17**
17. Type B I°IVB present..... ***Sporobolus cormardelianus***
17. Type B I°IVB present.....**18**
18. Oblong shaped in transection, type E sclerenchyma present…….
……...***Eragrostiella bachyphylla***
18. Round shaped in transection, type B sclerenchyma present… ***Eragrostiella bifaria***
19. Horseshoe shaped Kranz arc.....***Aristida funiculata***
19. Half circle shaped Kranz arc.....**20**
20. Rectangular shaped epidermal cell.....***Paspalidium flavidum***
20. Barrel shaped/ square shaped epidermal cells.....**21**
21. Centripetal type of chloroplast.....**22**
21. Centrifugal type of chloroplast.....**24**
22. Square shaped epidermal cell.....***Chloris montana***
22. Barrel shaped epidermal cell.....**23**
23. Round shaped in outline.....***Tragus biflorus***
23. Horseshoe shape in outline.....***Brachiaria reptans***
24. Sclerenchyma present in form of bicylindrical type.....***Ischaemum rugosum***
24. Sclerenchyma present in the form of unicylindrical /girder.....**25**
25. Sclerenchyma present in the form of girder.....**26**
25. Sclerenchyma present in form of unicylindrical type.....**29**
26. Oval shaped vascular bundle.....**27**
26. Triangular diamond shaped vascular bundle.....**28**
27. Elliptical shaped of I°IVB, cross section size 78.94x71.05±6.25....***Eleusine indica***
27. Oval shaped of I°IVB, Cross section size 239.28x271±32.46…….
……...***Tetrapogon tenellus***
28. Hollow internode…….....***Tetrapogon villosus***
28. Solid internode…….....***Dactyloctenium aegyptium***
29. Square shaped epidermal cells.....**30**
29. Barrel shaped epidermal cells.....**32**
30. Type E sclerenchyma present.....***Sporobolus indicus***
30. Type D sclerenchyma present.....**31**
31. Epidermal cells covered with thick cuticle including tangential wall……
…..….....***Oropetium villosulum***
31. Epidermal cell covered with thick cuticle penetrating between epidermal cell……

…..…….. ……..*Chloris virgata*
32. Type E sclerenchyma present.....**33**
32. Type D sclerenchyma present.....**35**
32. Cordate shape in cross section.....*Isachne globosa*
32. Round/ oblong shape in cross section.....**34**
34. Diamond shaped vascular bundle.....*Acrachne racemosa*
34. Elliptical shaped vascular bundle.....*Dinebra retroflexa*
35. Hollow pith region.....**36**
35. Parenchymatous pith region.....**37**
36. Type E I˚IVBs present…….....*Aristida adscensionis*
36. Type B I˚IVBs present.....*Eragrostris pilosa*
37. Round shaped in cross section.....*Sporobolus diander*
37. Oblong to oval shaped in cross section.....**38**
38. Elliptical in transection…….....*Ischaemum indicus*
38. Heart shaped in transection.....*Ischaemum molle*
39. Sclerenchyma present in form of girder.....**40**
39. Sclerenchyma present in form of cylinder.....**50**
40. Type C sclerenchyma present.....*Arthraxon lanceolatus*
40. Type D/E sclerenchyma present.....**41**
41. Type E sclerenchyma present.....**42**
41. Type D sclerenchyma present.....**43**
42. Barrel shaped epidermal cell.....*Oplismenus burmanii*
42. Square shaped epidermal cells.....*Triplopogon ramosissimus*
43. Elongated/ round shaped epidermal cell.....**44**
43. Barrel shaped epidermal cells.....**45**
44. Elongated shaped epidermal cells.....*Apluda mutica*
44. Round shaped epidermal cells.....*Cenchrus ciliaris*
45. Hollow pith region.....**46**
45. Parenchymatous pith region.....**48**
46. Oval shaped vascular bundle.....*Eragrostis temula*
46. Triangular diamond shaped vascular bundle.....**47**
47. Obovate shaped I°IVB with size is 258.34x294.26±13.24 µm……..
……*Digitaria granularis*
47. Elliptical shaped I°IVB with size is 409.09x463.64±72.22 µm……..….
……*Digitaria longiflora*
48. Small sized with tapering base, epidermal cells, tangential wall covered with cuticle.....*Setaria verticillata*
48. Flat cells with thin cuticle.....**49**
49. Round shaped in transection with size is 127.2x102.27±11.72 µm……...

…….***Sehima sulcatum***
49. Oval shaped in transection with size is 214.28x257.14±37.34 µm.....
……..***Oplismenus composites***
50. Sclerenchyma present in form of bicylindrical.....**51**
50. Sclerenchyma present in form of unicylindrical.....**55**
51. Barrel shaped epidermal cell.....**52**
51. Barrel shaped epidermal cell.....**53**
52. Only type B scelerenchyma present.....***Bothriochloa pertusa***
52. Type B and type E sclerecnhyma present.....***Imperata cylindrica***
53. Oval shaped vascular bundle.....***Heteropogon ritchiei***
53. Diamond shaped vascular bundle.....**54**
54. 10-12 layeres of sclerenchyma present in hypodermis.....***Cymbopogon martini***
54. 1-2 layeres of sclerenchyma present in hypodermis.....***Echinochloa stagnina***
55. Type A sclerenchyma present.....***Chrysopogon fulvus***
55. Type B/D/E sclerenchyma present.....**56**
56. Type B sclerenchyma present.....**57**
56. Type D/E sclerenchyma present.....**65**
57. Rectangular shaped epidermal cell.....***Pennisetum setosum***
57. Barrel shaped and square or round shaped epidermal cells.....**58**
58. Round shaped epidermal cell.....***Panicum miliaceum***
58. Barrel/ round shaped epidermal cell.....**59**
59. Square shaped epidermal cells.....**60**
59. Barrel shaped epidermal cells.....**61**
60. Vertically oval shaped II˚ IVB.....***Chionachne koengii***
60. Inverted triangular shaped II˚ IVB .....
…..……..…..***Heteropogon contortus* var.*genuinus* sub var. *hispidissmus***
61. Oblong shaped in cross section **62**
61. Round to oval shaped in cross section.....**63**
62. Angular parenchymatous ground tissue.....***Hackelochloa granularis***
62. Round shaped parenchymatous ground tissue.....***Cenchrus biflorus***
63. Barrel shaped- V shaped epidermal cells, cross section size in1155.56x1444.45±47.28 µm…….....***Heteropogon triticeus***
63. Barrel shaped- IV shaped epidermal cells, Cross section size in between 185-280x195-230 µm……..**64**
64. Inverted triangular shaped I˚IVB.....***Sehima ischaemoides***
64. Triangular diamond shaped I˚IVB.....***Sehima nervosum***
65. Type D sclerenchyma present.....**66**
65. Type E sclerenchyma present.....**86**
66. Round Shaped epidermal cell.....***Paspalidium geminatum***

66. Barrel/ rectangular/square/elongated shaped epidermal cell.....**67**
67. Square shaped epidermal cell.....**68**
67. Barrel/ rectangular/ elongated shaped epidermal cell.....**70**
68. Triangle diamond shaped vascular bundle.....***Isilema laxum***
68. Diamond shaped vascular bundle.....**69**
69. Type B I˚IVB.....***Vetivaria zinzanoides***
69. Type I I˚IVB.....***Themeda laxa***
70. Elongated shaped epidermal cell.....**71**
70. Barrel/ rectangular shaped epidermal cells.....**74**
71. Hollow pith region.....**72**
71. Parenchymatous pith region.....**73**
72. Type- B sclerenchyma present, number of III˚PVBs is 22±5 ……..……
……*Themeda quadrivalvis*
72. Type- D sclerenchyma present, number of III˚PVBs is 64±12.....
……..*Panicum antidotale*
73. Angular parenchymatous ground tissue.....***Rottboellia exaltata***
73. Round to oval shaped parenchymatous ground tissue.....***Thelepogon elegans***
74. Barrel shaped epidermal cells.....**75**
74. Rectangular shaped epidermal cells.....**81**
75. Parenchymatous pith region.....**76**
75. Hollow pith region.....**77**
76. Irregular shaped simple parenchymatous ground tissue.....***Setaria tomentosa***
76. Round shaped with thick walled parenchymatous ground tissue……
…….....***Capillidpedium hugelii***
77. Horseshoe shaped in cross section.....***Eragrostis japonica***
77. Round/ oblong shaped in cross section.....**78**
78. Oblong shaped in cross section.....***Paspalum scorbiculatum***
78. Round shaped in cross section.....**79**
79. Triangular diamond shaped I˚IVBs.....***Echinochloa colona***
79. Simple diamond shaped I˚IVBs.....**80**
80. Barrel shaped-III type of epidermal cells, cross section size in 320x 305± 21.63 µm..…….....***Digitaria ciliaris***
80. Barrel shaped-V type of epidermal cells, cross section size is 163.64x 209.09±25.98 µm..…….....***Eragrostis tenella***
81. Hollow pith region.....**82**
81. Parenchymatous pith region.....**83**
82. Oval in transection, number of I˚IVBs is 16±4.....***Alloteropsis cimicina***
82. Round in transection, number of I˚IVBs is 36±8.....***Panicum maximum***
83. Small, flat epidermal cell with thin cuticle.....***Coix lachryma jobi***

83. Big sized epidermal cell with cuticle.....**84**
84. Triangular diamond shaped I˚IVB.....***Saccharum spontanum***
84. Oval shaped I˚IVB.....**85**
85. Rectangular shaped –I of epidermal cells..... ***Sorghum halepense***
85. Rectangular shaped –III of epidermal cells..... ***Echinochloa crusgalli***
86. Square shaped epidermal cell.....***Themeda cymbaria***
86. Barrel/ rectangular shaped epidermal cell.....**87**
87. Rectangular shaped epidermal cell.....**88**
87. Barrel shaped epidermal cell.....**93**
88. Hollow pith region.....**89**
88. Parenchymatous pith region.....**90**
89. Outline undulating.....***Brachiaria distachya***
89. Outline is smooth.....***Brachiaria ramosa***
90. III˚ PVBs absent.....***Melanocenchris jaequemontii***
90. III˚ PVBs present.....**91**
91. Oval shaped I˚IVB.....***Themeda triandra***
91. Diamond shaped I˚IVB.....**92**
92. Diamond shaped II°IVB, cross section size is 253.72x241.67±27.56µm…….
……...***Dicanthium annulatum***
92. Round shaped II°IVB, cross section size is 527.2x613.23±61.78µm……
……...***Dicanthium caricosum***
93. Hollow pith region.....**94**
93. Parenchymatous pith region.....**97**
94. Oblong shaped cross section.....***Andropogon plumis***
94. Round to oval shaped cross section.....**95**
95. 'U' shaped scutellum..... ***Eragrostis nutans***
95. 'V' shaped scutellum…….....**96**
96. Type D pericarp present……..... ***Digitaria stricta***
96. Type B pericarp present.....***Brachiaria eruciformis***
97. III°PVB absent……..…… ***Schoenefeldia gracilis***
97. III°PVB present……..**98**
98. Oblong shaped II˚IVB.....……..……...…..…… ***Setaria glauca***
98. Round shaped II˚IVB.....**99**
99. Oval shaped I°IVB…..... ***Heteropogon contortus* var. *contortus* sub.var. *typicus***
99. Elliptical shaped I°IVB ……..... ***Eremopogon foveolatus***

3.3. Leaf anatomy

GENERAL MONOCOT LEAF ANATOMY:

Monocotyledonous leaves are commonly isobilateral with adaxial and abaxial surface of leaf having similar anatomical arrangements of leaf tissue and mesophyll being hardly differentiated into palisade and spongy parenchyma cells.

Epidermis

The epidermis is generally uniseriate or sometimes multiseriate, and composed of more or less oval cells with cuticle on outer walls. The upper epidermis generally possesses motor cells or bulliform cells. These cells help in rolling down of leaf in order to avoid excessive loss of water when the wind velocity is high. A major characteristic feature in grass leaves are silica deposition in various morphological forms. Stomata are evenly distributed on both the surfaces of epidermal layer.

Mesophyll

Isobilateral leaf mesophyll cells do not show differentiation into palisade and spongy parenchyma and thus the tissue are composed of mainly isodiametric cells with intercellular spaces (mostly spongy type). Chloroplasts are abundantly present in these cells.

Conducting strand

Vascular bundles are collateral and closed type as found in dorsiventral leaf but they are arranged in parallel series. These vascular bundles are of monomorphic or dimorphic (smaller and larger size) in nature. When dimorphic, the larger ones are fewer in number. Generally the vascular bundle contain xylem on the upper side and phloem on the lower side surrounded by parenchymatous cells known as bundle sheath cells. The bundle sheath cells contain plastids with starch grains. These plastids present in the bundle sheath cells lack grana or poor in grana but possess the machinery to fix the carbon dioxide with the help of enzyme RUBISCO (Ribulose-1, 5-bisphosphate carboxylase/oxygenase) and thus consequently forms starch. Absence of grana makes plastid nongreen and eventually the bundle sheath colourless. On the other hand, the mesophyll cells also have plastids with well-developed grana that generates high amount of ATP and NADPH (assimilatory power) and have special enzyme phosphoenol pyruvate carboxylase (PEPcase) that can capture the CO_2 very efficiently from the atmosphere and send trapped CO_2 and assimilatory power to bundle sheath cells for fixation.

Grass leaf anatomy

As the leaves have a parallel venation, grass leaf can be divided into two major parts i.e. midrib and leaf blade. The leaf blade region which comprises of two epidermis with mesophyll tissue in between them within which vascular bundles are arranged parallely. In midrib region, two epidermis and vascular bundles present in parenchymatous and chlorenchymatous cells. Terminologies in the present study used to describe the leaves of different grass species are in accordance to Ellis (1976). Only the types observed in the present study has been included from the description key proposed by Ellis (1976).

Outline of the lamina in transverse section

The lamina of most grass leaves in transverse section is flattened, and it may or may not have a conspicuous keel or midrib. Leaves of some grasses have well defined midribs. When a midrib is present it generally projects more prominently from the abaxial than from the adaxial surface and then constitutes a keel. In an individual leaf the midrib or keel usually becomes progressively larger towards the base of the lamina. When a midrib or keel is described as being conspicuous, moderately conspicuous or not conspicuous, it refers to sections taken in the half way position which was adopted as a standard. The portion of the lamina on either side of the midrib is relatively thin, and the lamina frequently becomes still thinner towards the margins or may again be thicker and they are frequently well supported by sclerenchyma.

The outline of open leaf lamina can be mainly categorized into four, based on their shape: (I). Expanded, (II). V shaped, (III). U shaped, (IV). Inrolled. The three categories have been further categorised by taking into consideration features like angle of arms, shape of arms, symmetry of two halves, nature of folding, degree of folding, etc.

Outline of lamina for open leaves:

Categorisations of the outline are as follows:

I. Expanded: Lamina is flattended, a line with connecting both margins and the median bundle straight:

The nature of leaf blade varies and it may be

1. Flat, even or straight (Fig. 109 A, B)
2. Undulating gently (Fig. 109 C)
3. Distinctly wavy or undulating
    a. Corrugated leaf i.e. waves rounded (Fig. 109 D)
    b. Pleated leaf i.e. waves pointed or angled (Fig. 109 E)

II. V-shaped: Two halves of the lamina folded towards each other on either side of the midrib i.e. a line connecting both margins with the median bundle angled at the median bundle:

Further it has been categorised on the basis of the following three characters:

A: Angel formed by the two arms of the lamina at the midrib

1. Narrow; closed V i.e. less than 45° to each other (Fig. 109 F)
2. Standard V i.e. between 45° and 90° to each other (Fig. 109 G)
3. Broad, open V i.e. more than 90° to each other (Fig. 109 H)
4. Wide, very open V i.e. almost 180°; presence of projecting keel gives appearance of V-shaped (Fig. 109 I)

B: Shape of arms of the lamina:

1. Straight (Fig. 109 J)

2. Outwardly bowed; concave (Fig. 109)
3. Outwardly curving; convex (Fig. 109 K)
4. Outline heart shaped (Fig. 109 L)
5. Distinctly wavy or undulating with rounded wave i.e. corrugated leaf (Fig. 109 M)
6. Irregularly wavy or bent ((Fig. 109 N)

C: Symmetry of two halves of the lamina

1. Symmetrical on either side of the median vascular bundle (Fig.109J)
2. Two halves asymmetrical on either side of the median vascular bundle (Fig. 109 N)

III. U shaped: Two halves of the lamina curved upwards on either side of the midrib or with a prominent rounded keel i.e. no definite angle formed with the midrib Shape of the U formed is tall, narrow i.e. vertically elongated (Fig. 109 O)

IV. Inrolled: Lamina rolled inwards the adaxial surface

Nature of rolling may be:

1. Convolute; inrolled from one margin only; margins wrapped around each other (Fig. 110 A)
2. Involute; inrolled from both margins (Fig. 110 B)

Ribs and furrows on the leaf surface

The adaxial surface of the leaf may be either flat or longitudinally ribbed, the height of ribs varying in different species. The ribs are separated from one another by wide or narrow grooves. Ribs are generally characteristic of and more fully developed on, the adaxial than the abaxial surface, but abaxial ribs also occur, and in some grasses the adaxial and abaxial grooves opposite each other, the leaf in transverse section has the appearance of a number of almost circular areas each enclosed by a pair of opposed ribs and having a vascular bundle at the centre, adjacent circles being connected to one another by much narrower portions of the lamina where the grooves are situated.

The characterisations of ribs and furrows present on the leaf surface have been categorized into the different types. Characteristic features included are the presence and absence of furrows and further the depth of the ribs and furrows. Accordingly the studied species could be categorized into the following types:

Two major categories based on the presence or absences are

I. No ribs and furrows or ribs and furrows are absent

II. Ribs and furrows present. This is further categorized on the basis of its presence on adaxial/abaxial surface or on both surfaces. Also further it is divided on the basis of the depth of the furrows. Depth of the furrows have been considered in comparison to the leaf thickness i.e. the depth of the larger ribs in the central region of

the lamina between the margin and the median vascular bundle regarded as leaf thickness.

The shape of the ribs showed variation so the shape of the ribs as seen in transverse section has been included. Variations have been observed in the distribution of the different ribs in association with the vascular bundles as given below:

I. Ribs are distributed over all the vascular bundles

II. Ribs are not being associated necessarily with vascular bundles. The elevation of the ribs may be similar over all the vascular bundles or they may be of varying size.

Taking into consideration the above mentioned features three major categories are further divided as follows:

I. No ribs or furrows present on either surface i.e. lamina surface straight or only slightly undulating with no regular pattern associated with the vascular bundles (Fig. 110 C)

II. Adaxial ribs and furrows present

Further categorized on basis of deapth, shape and distribution of furrows

A: Depth of adaxial furrows in comparison to the leaf thickness i.e. the depth of the larger ribs in the central region of the lamina between the margin and the median vascular bundle regarded as leaf thickness

1. Slight, shallow furrows i.e. less than a quarter of the leaf thickness (Fig. 110 D)
2. Medium furrows i.e. a quarter to one half the leaf thicknesses (Fig. 110 E)
3. Deep furrows i.e. more than one half the leaf thickness (Fig. 110 F)

B: Shape of adaxial furrows

1. Wide, open furrow i.e. obtuse angle formed by furrow sides at base (Fig.110 G)
2. Narrow furrow i.e. sides of furrow almost vertical:
    a. In form of cleft (Fig. 110 H)
    b. Base fairly broad but sides steep (Fig. 110 I)

C: Distribution of adaxial furrows (important for acicular leaves)

1. Furrows between all vascular bundles (Fig. 110 H)
2. Furrows between 1st and 2nd order vascular bundles i.e. present over 3rd order vascular bundles (Fig. 110 I)
3. Deepest furrow on either side of the median vascular bundle (Fig. 110 J)

D: Shape of adaxial ribs as seen in transection

1. Rounded with obtuse ribs and apex rounded:
    a. Situated over the vascular bundles (Fig. 110 K)
2. Flat-topped with square ribs and apex flattened

a. Sides rounded with flat top (Fig. 110 I)

3. Triangular ribs with apex pointed:

a. One vascular bundle in each rib (Fig. 110 L)

b. Grooved at apex (Fig. 110 M)

4. Massive ribs i.e. very large usually with bases narrow in relation to upper parts of rib: Rounded apices (Fig. 110 J)

E: Distribution of different ribs in association with the vascular bundles:

1. Ribs present over all vascular bundles

a. Similar ribs over all vascular bundles (Fig. 110 H)

b. Ribs over 1st and 2nd order vascular bundles larger than those over the 3rd order vascular bundles (Fig. 110 F)

2. Ribs not associated with all vascular bundles

a. Ribs present only over 1st and 2nd order vascular bundles (Fig. 110 E)

III. Abaxial ribs and furrows present or absent

A: Abaxial rib absent:

1. Surface smooth or with few undulations not regularly associated with the vascular bundles (Fig. 110 C)

2. Grooves present on abaxial surface

a. Opposite larger vascular bundles (Fig. 110 N)

b. Between vascular bundles; often shallow (Fig. 110 O)

c. Groove on either side of midrib (Fig. 110 R)

B: Ribs present on abaxial surface

1. Size of abaxial ribs

a. Taller than the adaxial ribs (Fig. 110 P)

b. Same size as adaxial ribs i.e. section resembles a string of beads; moniliform (Fig. 110 Q)

c. Smaller than adaxial ribs (Fig. 110 H)

d. Slight undulation associated with vascular bundles (Fig.110 G)

2. Distribution of abaxial ribs

a. Present opposite all vascular bundles (Fig. 110 G, S)

3. Composition of abaxial ribs

a. Composed of girder or strand of sclerenchyma in contact with the epidermis (Fig. 110 S, T)

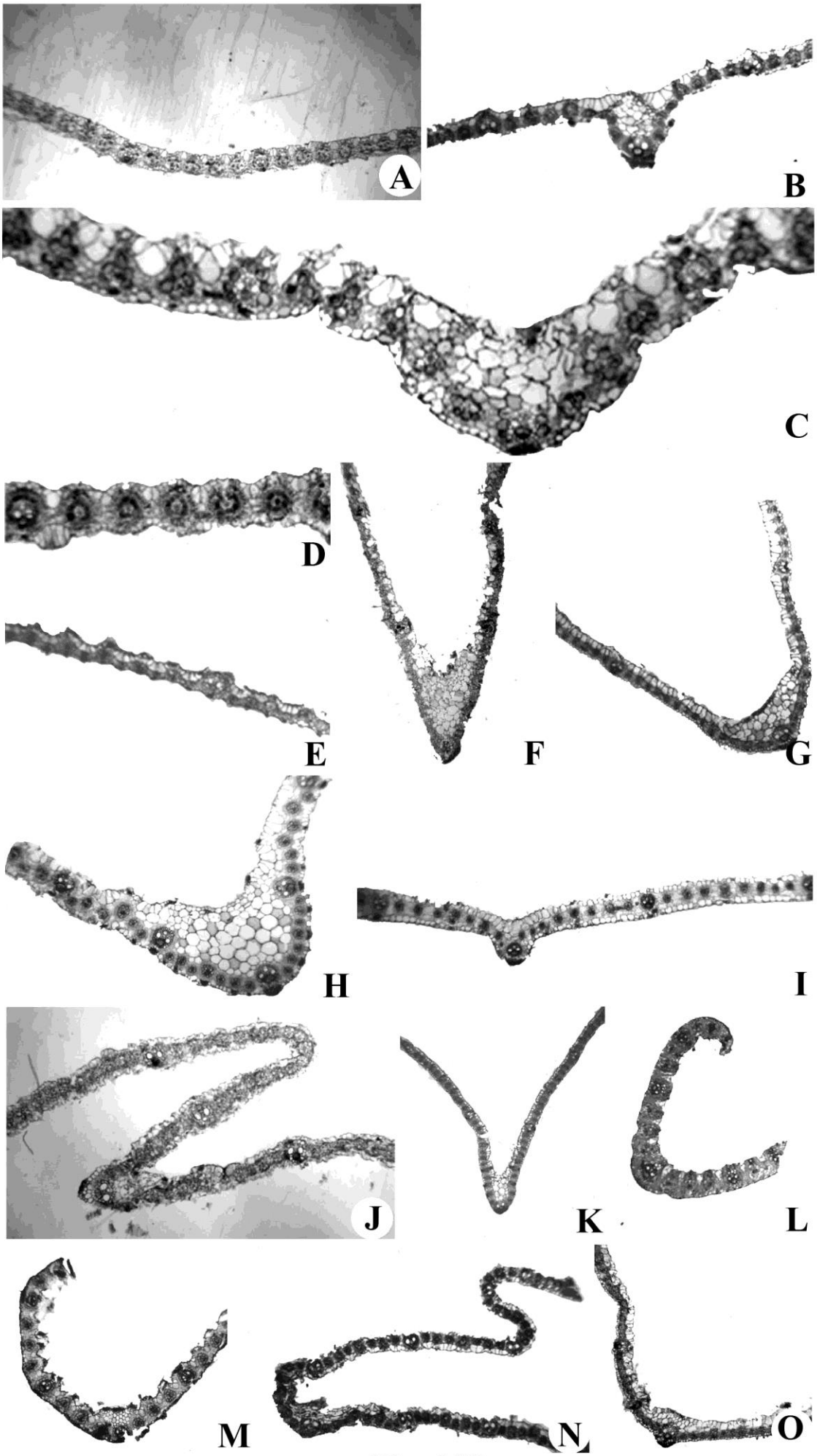


Fig. 109

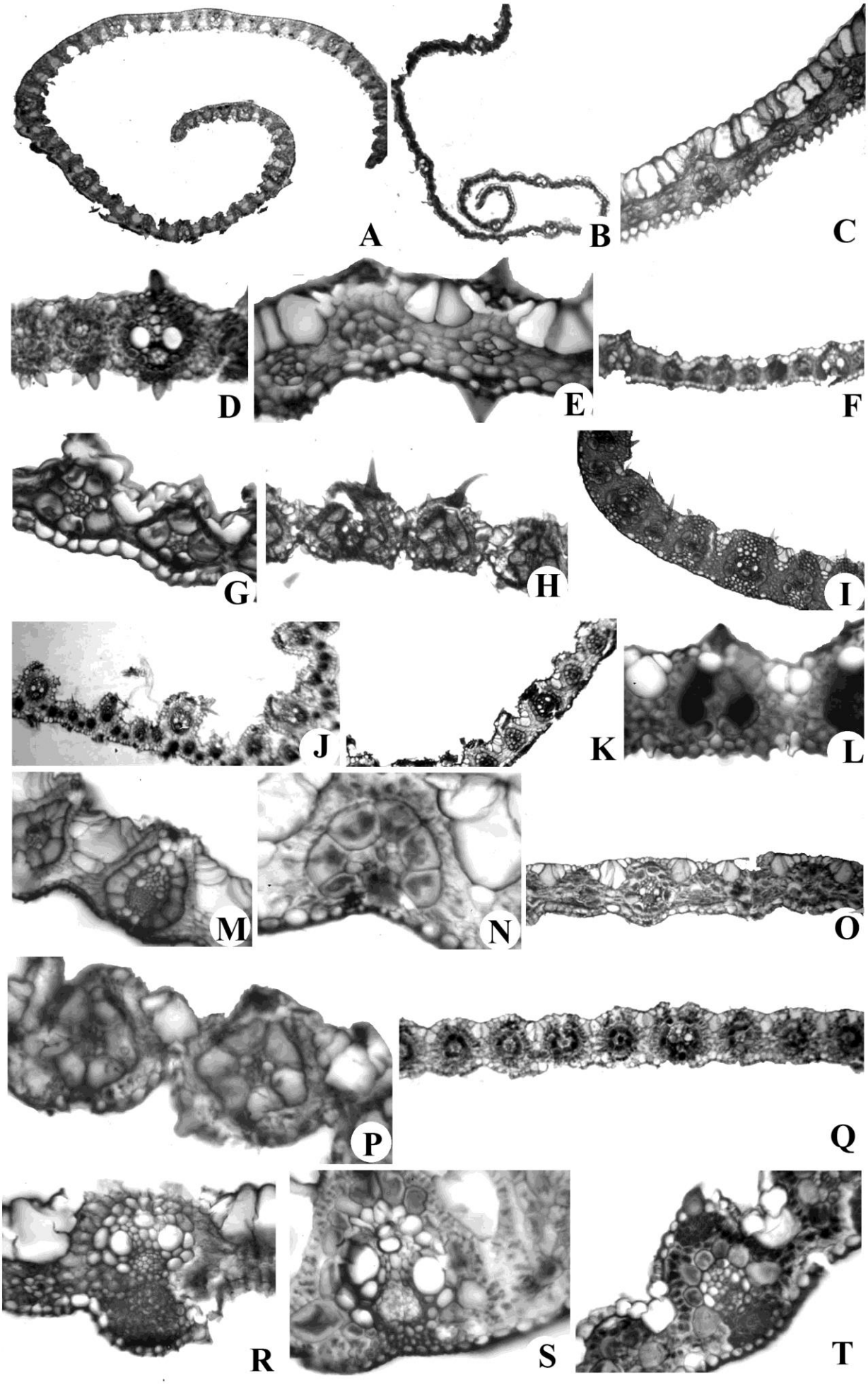


Fig. 110

Median vascular bundle, midrib and keel structure

Grass leaves show difference in their midrib shape and arrangements of first order vascular bundles/ median vascular bundles. Numbers of vascular bundles are also different. Keel is longitudinal rib present on leaf. When parenchyma or bulliform cells are developed in association with the median bundle or bundles, the whole structure, often incorporating many bundles, is termed a keel. Keel and midrib are distinguished by the presence or absence of parenchyma associated with the median vascular bundle. It is termed a 'midrib' if the median bundle is solitary, structurally distinct and without associated parenchyma and a 'keel' if parenchyma or bulliform cells are associated with the median bundles. Thus one or many vascular bundles may be incorporated in a keel unless there is a marked thickening in relation to the rest of the lamina. The number of vascular bundles in a keel is in general, roughly proportional to the size of the keel. The number of vascular bundles present in the keel shows difference from one to many so this feature has been included for observation and categorisation. Shape of keel in transverse section, sclerenchyma and air lacunae associated with the keel are some of the other features considered. Accordingly the classification is as follows:

I. Median bundle only present. The entire or more than half the blade width sectioned and no structurally distinct midrib is distinguishable (Fig. 113 A)

II. Midrib bundle only present and is distinguishable from other first order vascular bundles; no associated parenchyma developed i.e. keel inconspicuous:

A. Projection of midrib varies

1. Projects abaxially

a. Sclerenchyma causes projection (Fig. 111 B)

b. Projection due to position or size of bundle (Fig. 111 C)

2. Projection inconspicuous or marked; not projecting abaxially only:

a. Blade expanded or slightly inrolled (Fig. 111 D)

b. Lamina V-shaped but no parenchyma at angle (Fig. 111 E)

c. Acicular or terete leaves; parenchyma may be developed but no specifically in association with the midrib (Fig. 111 F)

III. Keel developed; colourless parenchyma and/or bulliform cells associated with the median bundle; sclerenchyma development may also occur

A: Number of vascular bundles comprising keel; in V-shaped leaves, if there is no thickening in the keel area the median bundle is considered to constitute the keel

1. One vascular bundle comprising the keel
    a. Parenchyma of small, rounded cells surrounding or immediately adaxial to the median bundle (Fig. 111 G)
    b. Bulliform cells in adaxial epidermis above median bundle which makes the,
        - Leaf expanded, flat or slightly in rolled (Fig. 111 D)
        - Leaf V-shaped with
            - Bulliform cells penetrating into leaf on either side of median bundle forming an inverted 'V' (Fig. 111 D)
            - Bulliform cells elongated and arranged in U above median bundle (Fig. 111 H)
            - Elongated bulliform cells in 'U' as well as layers of elongated parenchyma cells (Fig. 111 I)
2. Three vascular bundles present in keel
    a. Adaxial groove present (Fig. 111 J)
    b. Adaxial groove absent (Fig. 111 K)
3. Many vascular bundles present in keel with all vascular bundles abaxially arranged. The median bundle may or may not be prominent.
        - Median bundle indistinguishable from other 1st order bundles
            - One 1st order bundle and smaller bundles comprise keel (Fig. 111 L)
            - Three 1st order bundles and other smaller bundles comprise keel (Fig. 111 O)
        - Median bundle structurally distinct (size, bundle sheath) from other 1st order bundles
            - Large median bundle and other 3rd and 2nd order bundles only in keel (Fig. 111 G)

- Normal 1st order bundles present in addition to the median bundle

B. Shape of keel in transverse section. Three categories:

1. Not really distinct from leaf outline (Fig. 111 A)
2. V-shaped, pointed or inverted triangular keel
    a. Leaf V-shaped with V-shaped keel (Fig. 111 E)
    b. Leaf V-shaped with inverted triangle-shaped keel (Fig. 111 L)
    c. Leaf expanded with inverted triangular or pointed keel (Fig.111 I)
3. Rounded or semicircular keel; leaf not necessarily U-shaped
    a. U-shaped keel; slightly thicker than rest of lamina (Fig. 111 H)
    b. U-shaped keel; much thicker than rest of lamina (Fig. 111 J)
    c. Rounded or semicircular kell i.e. adaxial side of the keel flat (Fig. 112 O)
    d. Rounded keel with raised, flattened adaxial side (Fig. 111 M)
    e. Rounded keel with single, central adaxial groove (Fig. 111 I)

C. Sclerenchyma associated with the keel on adaxial and abaxial surface

1. Adaxial sclerenchyma
    a. Strands in subepidermal layers (Fig. 111 O)
    b. Strands fused forming a hypodermal band (Fig. 111 G)
2. Abaxial sclerenchyma
    a. Most bundles with abaxial strands (Fig. 111 J)
    b. Most bundles with abaxial girders (Fig. 111 N)
    c. Central or solitary bundle with anchor-shaped girder (Fig. 111 P)

D: Air spaces or lacunae incorporated in the keel; definite lacunae present or enlarged parenchyma cells of keel breaking down: One air-space in keel (Fig. 111 Q)

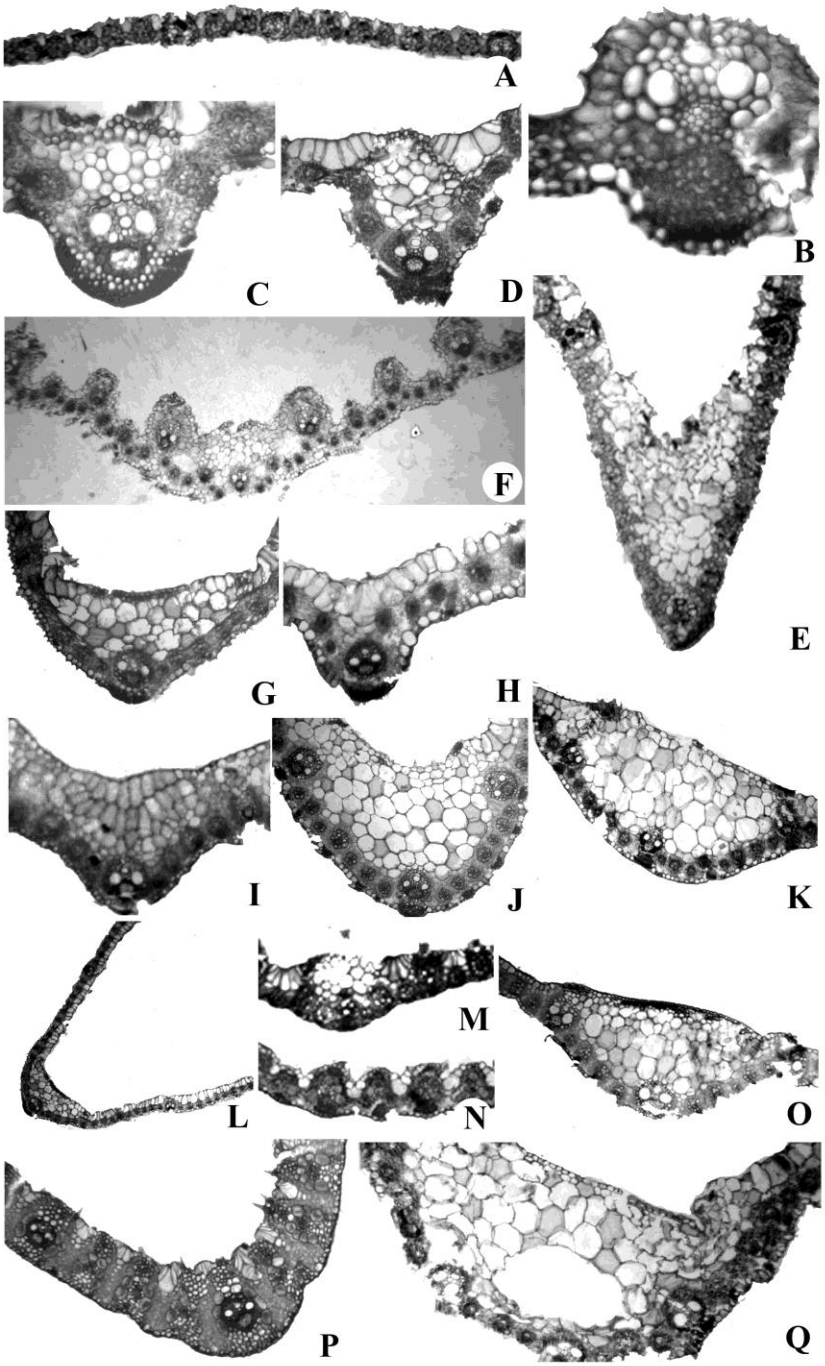


Fig. 111

Vascular bundles

The vascular bundles, apart from those in the midrib, are generally arranged in a single row, and they are embedded more or less in the middle of the mesophyll, although they may be closer to the abaxial or adaxial surface in different species. The vascular bundles are of different sizes, and it is usual to find bundles of different sizes or orders not only in different species, but also within a single leaf. The bundles are arranged in such a way that those of different orders alternate with one another. Vascular bundles are of 1st order, 2nd order and 3rd order, the arrangement varieing.

Arrangement of vascular bundles:

I. Number: Number of first order vascular bundles varies. Accordingly total number of 1st order bundles in half the width of the lamina; includes the median vascular bundle and the variation can be categorised as follows:

A. One 1st order vascular bundle in blade section i.e. median bundle
B. Two 1st order vascular bundles in half lamina i.e. 3 in entire blade
C. Three 1st order vascular bundles in half lamina i.e. 5 in entire blade
D. Four 1st order vascular bundles in half lamina i.e. 7 in entire blade
E. Five 1st order vascular bundles in half lamina i.e. 9 in entire blade
F. Six 1st order vascular bundles in half lamina i.e. 11 in entire blade
G. Seven 1st order vascular bundles in half lamina i.e. 13 in entire blade
H. Eight 1st order vascular bundles in half lamina i.e. 15 in entire blade
I. Nine 1st order vascular bundles in half lamina i.e. 17 in entire blade
J . Ten or more 1st order vascular bundles in half lamina

II. Arrangement and alternation of different orders of vascular bundles along width of blade varies. The part of lamina between the margin and the midrib has been observed to determine the arrangement and alternation of the different order bundles.

A. Variable from median bundle to margin; no regular pattern discernible i.e. there was no regular pattern in which the different order vascular bundles were arranged.
    1. Progressively fewer 1st and more 3rd order bundles towards the margin
    2. Progressively more 1st and fewer 2nd and 3rd order bundles toward the margin
    3. Arrangement near margin differs from remainder
B. Regular arrangement from median bundle to margin i.e. the different order vascular bundles were arranged in a specific pattern as described below:
    1. Number of 3rd order bundles between consecutive 2nd or 1st order bundles at a position halfway to margin
        a. 3rd order bundles between consecutive larger bundles absent

b. One 3rd order bundle between consecutive larger bundles

c. Two 3rd order bundles between consecutive larger bundles

d. Three 3rd order bundles between consecutive larger bundles

e. Four 3rd order bundles between consecutive larger bundles

f. Five 3rd order bundles between consecutive larger bundles

g. Six 3rd order bundles between consecutive larger bundles

h. Seven 3rd order bundles between consecutive larger bundles

i. Eight 3rd order bundles between consecutive larger bundles

j. Nine 3rd order bundles between consecutive larger bundles

k. Ten or more 3rd order bundles between consecutive larger bundles

2. Number of 2nd order bundles between consecutive 1st order bundles

a. 2nd order bundles between consecutive 1st order bundles absent

b. One 2nd order bundle between consecutive 1st order bundles

c. Two 2nd order bundles between consecutive 1st order bundles

d. Three 2nd order bundles between consecutive 1st order bundles

e. Four 2nd order bundles between consecutive 1st order bundles

f. Five or more 2nd order bundles between consecutive 1st order bundles

III. Position of vascular bundles within the leaf blade. The position of the vascular bundles may be oriented in the centre, adaxial or abaxial side of the leaf blade in transaction.

A. Same level of positioning for all bundles of different orders:

1. All bundles situated in the centre of the blade (Fig. 112 A)
2. All bundles situated closer to the abaxial surface (Fig. 112 B)
3. All bundles situated closer to the adaxial surface (Fig. 112 C)

B. Different levels of positioning for bundles of different orders:

1. 1st order bundles central and 3rd order bundles abaxial (Fig. 112 D)
2. 3rd order bundles central and 1st order bundles displaced adaxially in ribs (Fig. 112 E)

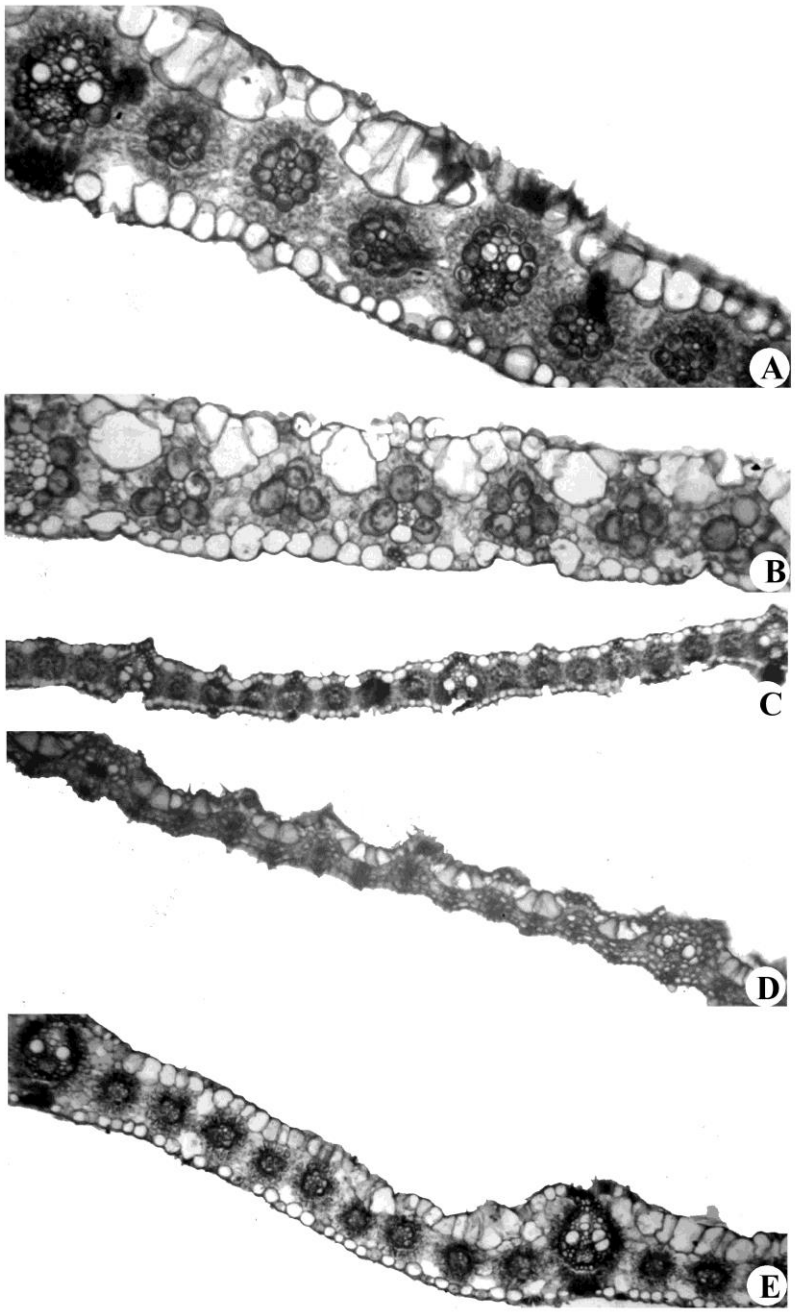


Fig. 112

All the above features were mainly based on the morphological appearance of the tissue system. Further characterization of the leaf blade has been done on the basis of the anatomical features of the different layers of tissue.

Epidermis

Epidermis is outer most layer which is covered by cuticle. Adaxial and abaxial shows different shaped epidermal cells. In between epidermal cells silica and stomata are also seen. Grass leaves also have specialized cells which are known as bulliform cells. They are large, bubble-shaped cells occuring in groups. These cells are present on the adaxial surface of the leaf. They are generally present near the mid vein. These cells are large, empty and colourless.

Description of the epidermal layer in the present study includes all the different types of cells i.e. epidermis, bulliform and prickles present in this layer. Characteristic features of bulliform cells have been considered followed by the epidermal cells. Adaxial and abaxial epidermal layers and their associated cells have been categorized separately. Abaxaial surface of the epidermis is homogenous and made of same type of cells.

Adaxial and abaxial epidermis of the leaf; cells of the upper and lower epidermis considered separately and the adaxial epidermis is fully described before commencing with the abaxial epidermis:

I. Cells of adaxial epidermis

II. Cells of abaxial epidermis

Bulliform cells

Colourless cells forming part of the epidermis but differing from the remaining epidermal cells by being markedly larger and inflated. Characteristically they are large and are restricted to groups often intimately associated with colourless cells but all gradations are found. Thus small solitary bulliform cells may be present or the epidermis may be comprised primarily of large, rounded and inflated cells.

Mainly bulliform cells present on the adaxial surface of leaf blade, but few species have bulliform cells on abaxial surface also. Nine major categories could be identified and are as follows:

I. Bulliform cells are absent in epidermis; consists of small cells; often thickened epidermal cells (Fig. 113 A)

II. Most part of epidermis made up of bulliform cells; not arranged in regular groups; epidermal cells rounded and inflated the same size or slightly larger than the cells of the bundle sheath

A. Almost all the epidermal cells are inflated (Fig. 113 B)

B. Isolated large and inflated cells interrupted with irregular small groups of cells. The irregular group of cells may be located.

1. On sides of deep furrows (Fig. 113 C) or
2. Not in furrows but on the flat surface. This feature is noted usually in leaves with flat surfaces (Fig. 113 D)

III. Groups of bulliform cells present in epidermis which are well-defined and regular; distinct from normal epidermal cells. They may be

A. Small bulliform cells; not conspicuously larger than the normal epidermal cells which is
    1. Not associated with colourless cells or
    2. Closely associated with colourless cells; indistinct (Fig. 113 E)

B. Extensive groups of large, inflated bulliform cells extending over one or many vascular bundles. It may or may not be associated with colourless parenchyma.
    1. Not associated with colourless parenchyma. Distribution and size of the cells vary.
        a. Distribution of extensive bulliform groups
            - Present throughout the epidermis; may be slightly reduced opposite the larger bundles (Fig. 113 F)
            - Present in most of the epidermis but not present opposite the first order bundles and usually reduced over the second order bundles (Fig. 113 G)
        b. Size of constituent cells; taken in areas opposite the third order bundles
            - Occupy less than 1/4 of the leaf thickness (Fig. 113 H)
            - Occupy more than 1/4 of the leaf thickness
    2. Associated with colourless parenchyma cells together with which it forms a zone of colourless cells above or below the chlorenchyma; may be disrupted over the first order bundles
        a. Colourless zone comprises more than ½ of the leaf thickness
        b. Colourless zone comprises less than ½ of the leaf thickness

IV. Restricted groups of large, inflated bulliform cells (Zea type) having parallel-sided cells i.e. inner tangential wall same length or only slightly shorter than the outer tangential wall:
    A. Bulliform cells projecting above the level of the epidermis. Few bulliform cells form cushion cells of macro hairs (Fig. 113 I)
    B. Bulliform cells in level with the general epidermal surface (Fig. 113 J)

V. Restricted groups of tall and narrow bulliform cells which are not inflated and having parallel-sided cells or with outer tangential wall slightly shorter than the inner wall. The lateral walls are long and straight (Fig. 113 K)

VI. Fan-shaped groups bulliform cells each cell of the group is with outer tangential wall shorter than inner tangential wall; median cell of group appreciably larger than the remaining cells of the group
    A. Bulliform cells situated at bases of furrows (Fig. 113 L)
    B. Not found at bases of furrows as it is present in leaves without furrows; some cells parallel-sided (Fig. 113 M)

VII. Resemble fan-shaped due to central cell of the bulliform group being larger and of a different shape than the rest which may be small by comparison; not necessarily with shorter inner tangential walls, it has been designated **(Sporobolus type)**. The shape and size of the central cell varies.

A. Shape of central cell of the group which is always narrow at epidermis and often recurved or straight at area of contact with lateral bulliform cells of group:

1. Inflated, rounded; short area of contact with lateral cells (Fig. 113 N)
2. Inflated, fan-shaped (Fig. 113 O)
3. Narrower than deep; shield-shaped (Fig. 113 P)
4. Elongated with parallel sides (Fig. 113 Q)
5. Elongated rather pointed base; diamond-shaped (Fig. 113 R)

B. Size of central cell

1. Relatively small; not much larger than bundle sheath parenchyma (Fig. 113 S)
2. Occupy ¼-½ of the leaf thickness (Fig. 113 T)
3. Occupy more than ½ of the leaf thickness (Fig. 113 U)

VIII. Narrow groups of bulliform cells and intimately associated large colourless parenchyma cells penetrating deep into the mesophyll; the contact with the adaxial epidermis made by the bulliform cell superficial **(Arundo type)** (Fig. 114 A)

IX. Bulliform cells and closely associated colourless cells forming an extensive column or girder extending from the base of an adaxial furrow deep into leaf

A. Nature of column or girder

1. Column uni-seriate (Fig. 114 B)
2. Column bi-seriate (Fig. 114 C)
3. Column multi-seriate

B. Position of column

1. Extends from base of furrow to abaxial epidermis (Fig. 114 B)
2. Extends from base of furrow towards a vascular bundle

Typical epidermal cells and appendages

Includes all epidermal structures as seen in transverse section excluding the bulliform cells which has been described in the above section. Characteristic features of the cuticle, macro-hairs, prickles and papillae as seen in transverse section has also been incorporated.

I. Cuticle and thickening of epidermal cell walls:

A. Outer tangential wall of the epidermal cells

1. Outer walls not thickened and with a very thin cuticle (Fig. 114 D)
2. Outer walls slightly thickened or with a thin cuticle (Fig. 114 E)
3. Outer walls thickened and covered by a distinct, thick cuticle continuous over the epidermal cells. The thickness of cuticle varies.

a. Cuticle and cell wall equal to or greater than the depth of the average epidermal cells (Fig. 114 F)

b. Cuticle and cell wall less than the depth of the average epidermal cells (Fig. 114 G)

4. Outer tangential wall of each epidermal cell thickened individually:

a. Outer wall occupies half or more of the depth of the cells (Fig. 114 H)

b. Outer wall occupies less than half of the depth of the cells (Fig. 114 I)

c. Irregular; cells of different sizes comprise the epidermis (Fig. 114 J)

B. Thickening of radial and inner tangential walls of epidermal cells

1. All walls of epidermal cells thickened

2. Only outer wall thickened

3. No walls thickened

II. Macro-hairs as seen in transverse section and nature of hair bases are categorised as:

A. No macro-hairs visible

B. Superficial bases i.e. not sunken into the leaf or embedded between inflated bulliform cells: epidermal cells not modified to form cushion cells associated with the base of the hair

a. Swollen base not much larger than and situated between normal epidermal cells; included here are probably some elongated prickle hairs:

- Hair short and thick (Fig. 114 K)

b. Constriction above bulbous base embedded in normal epidermal cells

- Hair thickened and stiff (Fig. 114 L)

III. Sunken bases i.e. sunken in leaf or embedded between large, inflated epidermal cells or bulliform cells

A. Constriction above bulbous base embedded between large epidermal cells

1. Size and shape of hairs

a. Hairs slender but relatively short (Fig. 114 M)

b. Hairs thick and short (Fig. 114 N)

c. Hairs long and very slender (Fig. 114 O)

2. Nature of bulliform or epidermal cells surrounding base

a. Unraised bulliform cell groups (Fig. 114 P)

B. Base bulbous and not constricted; embedded between bulliform cells

IV. Prickles and Hooks as seen in transverse section

A. No hooks or prickles visible

B. Small hooks present in the epidermis; usually located in intercostal areas:

1. With short, curved barbs (Fig. 114 P)
2. With straight, pointed and slender barbs:
    a. Present between typical epidermal cells (Fig. 114 Q)
    b. Present between inflated bulliform-like cells (Fig. 114 R)

C. Thickened prickles present in epidermis; usually located opposite the vascular bundles

1. Pointed broad prickle; base not bulbous
2. Small with short barb (Fig. 115 A)

V. Papillae on the epidermal cells as seen in transverse section

A. Shape of outer tangential wall of the epidermal cells

1. Outer walls of epidermal cells not arched to any marked degree; flattened (Fig. 115 B)
2. Outer walls of epidermal cells arched but not papillose (Fig. 115 C)
3. Arching of outer wall exaggerated; papillose; inflated papillae as wide as epidermal cells
    a. Thin-walled wide papillae scattered throughout the epidermis (Fig. 115 D)
    b. Entire or major part of epidermis composed of thin-walled wide papillae (Fig. 115 E)
4. Papillae wide; as wide as or slightly narrower than epidermal cells; not inflated and thin-walled: Distal, outer wall markedly thickened (Fig. 115 F)
5. Papillae narrower than the epidermal cells
    a. Size of papillae
        - Relatively broad but not much more than half the width of the epidermal cells (Fig. 115 G)
        - Much less than half the width of the cell (Fig. 115 H)

The following two types of papillae have not been described by Ellis, but were observed in the present study.

- Long, as wide as cell (Fig. 115 J)
- Long, balloon or similar to Ω shaped (Fig. 115 K)

b. Number per cell as seen in transverse section:

- One per cell (Fig. 115 I)
- Bifurcate; two per cell (Fig. 115 G)

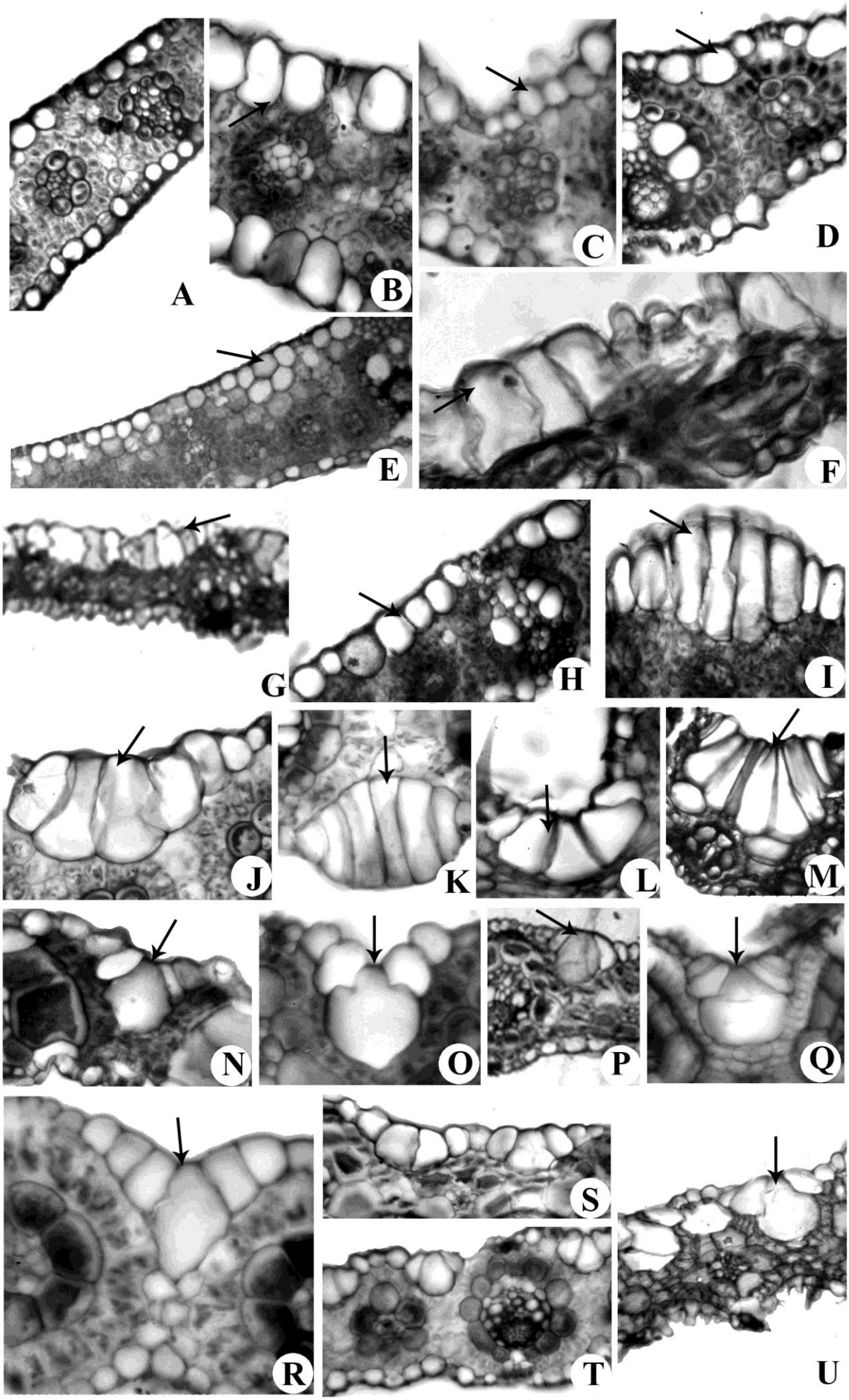


Fig. 113

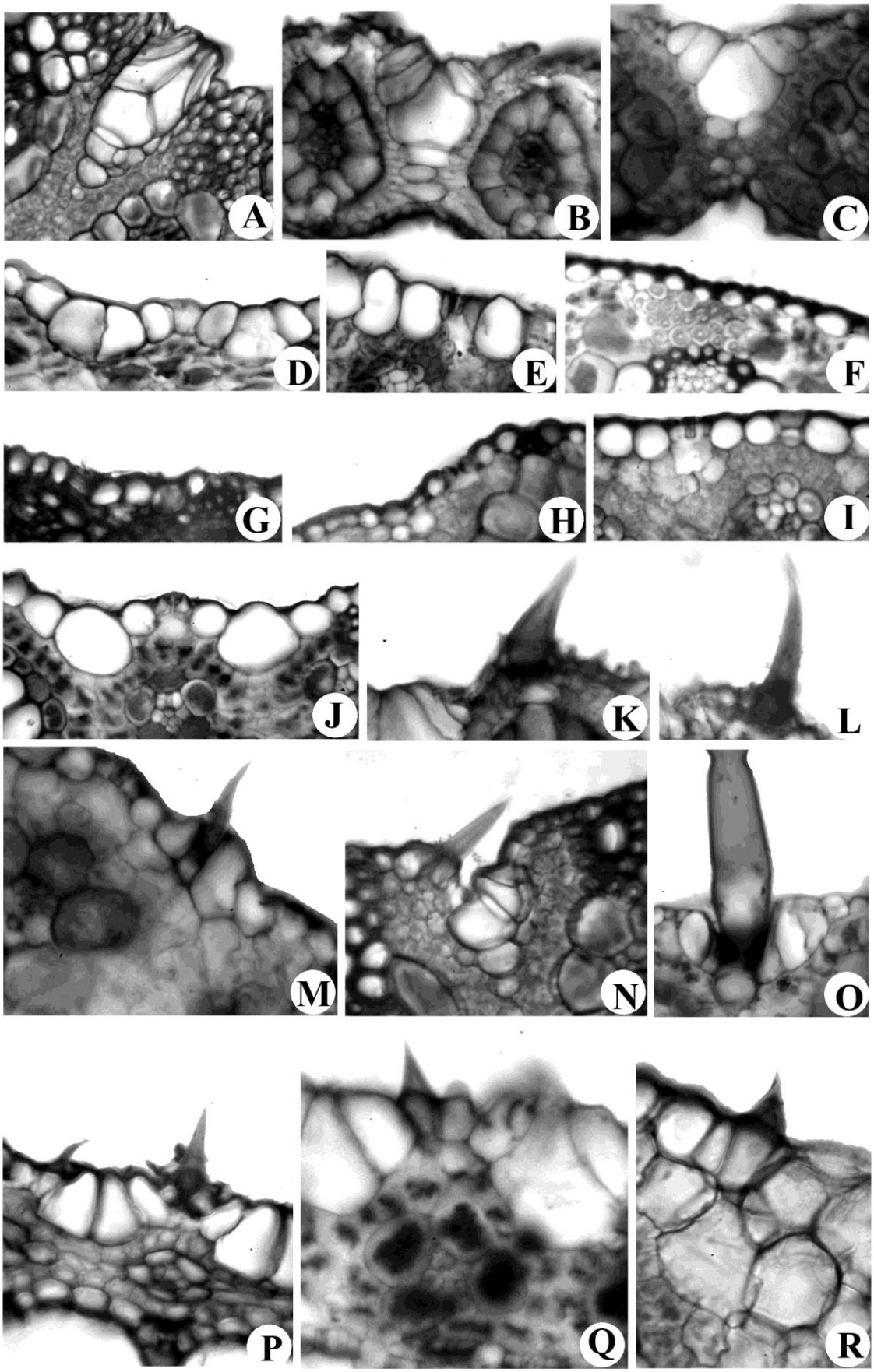


Fig. 114

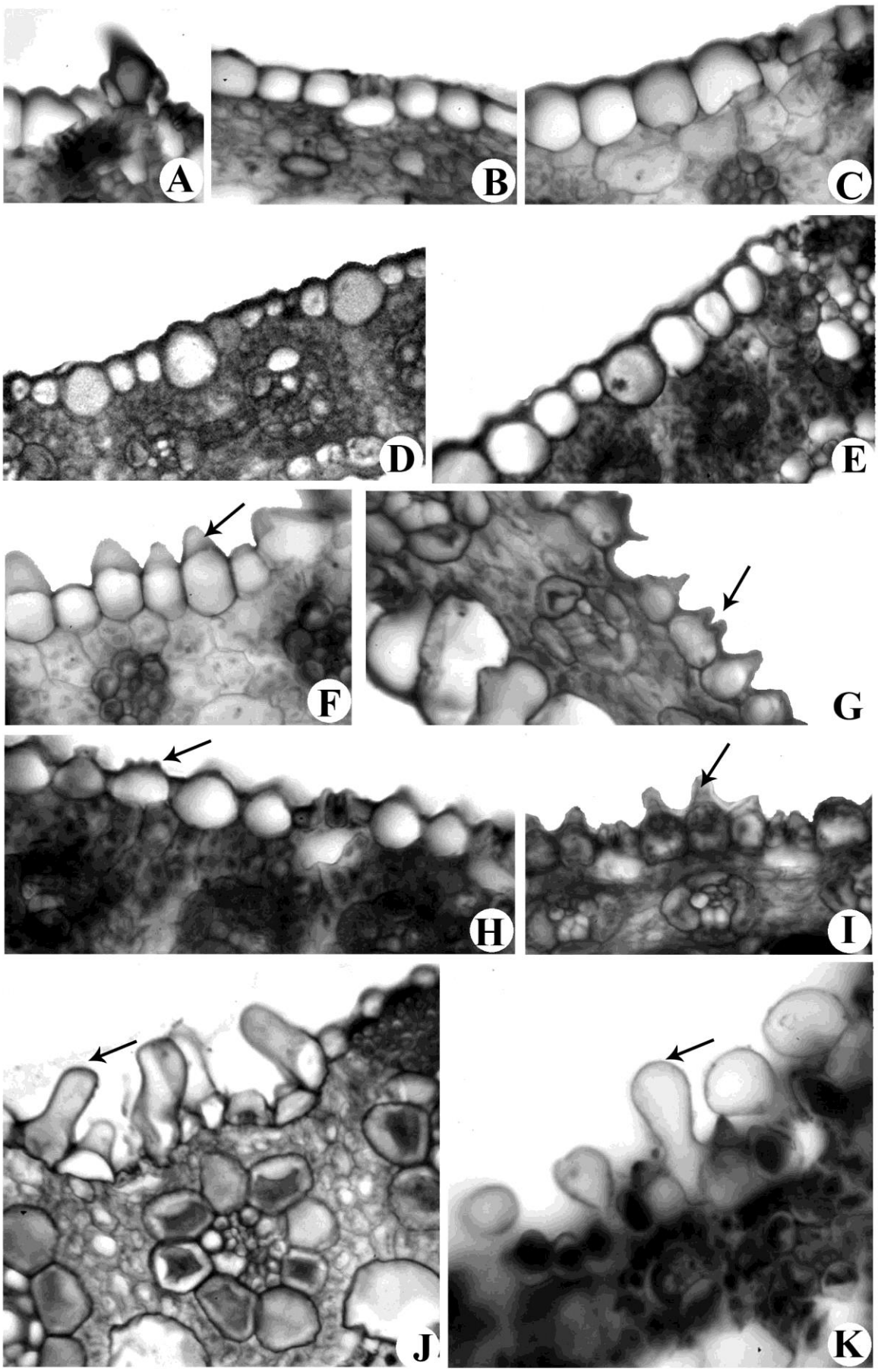


Fig. 115

Mesophyll

Mesophyll is present between the adaxial and the abaxial epidermis occupying all the space in the leaf not occupied by the vascular bundles, bundle sheath and sclerenchyma. It consists of chlorenchyma, but in some it is often partly composed of translucent cells, which are arranged in different patterns which appear to depend on the affinities of the grasses concerned. The chlorenchyma and translucent cells occupy all of the space in the leaf that is not taken up by the sclerenchyma or the vascular bundles and their surrounding sheaths. There is no differentiation of mesophyll into palisade and spongy was observed among studied species. Based on the arrangement of the cholrenchyma cells, mesophyll can be classified into two major categories: (1) panicoid i.e. radiate chlorenchyma (2) festucoid i.e. non radiate chlorenchyma.

Chlorenchyma

All the tissue containing chloroplasts excepting the parenchyma bundle sheath which may or may not contain chloroplasts is described under bundle sheaths. It does not include the ground tissue between the adaxial and abaxial epidermides especially if any translucent cells without chloroplasts are present. Chlorenchyma may be-

I. Radiate i.e chlorenchyma radially arranged around the vascular bundles which are often close together (panicoid). It may be interrupted by sclerenchyma girders and thus divided into two groups on either side of the vascular bundle

A. Number of layers of chlorenchyma cells arranged around the bundles may be

1. Single layer of cells which may be
    a. Tabular (Fig. 116 A)
    b. Isodiametric (Fig. 116 B)
2. Two layers of radiating cells (Fig. 116 C)
3. Numerous layers of radiating cells; cells long and narrow\Isachne type (Fig. 116 D)

B. Extent of radiating cells around bundles varies and may be

1. Radiating cells completely surrounding bundles (Fig. 116 A)
2. Interrupted above bundles by sclerenchyma or colourless parenchyma girders (Fig. 116 E)
3. Interrupted below bundles by sclerenchyma or colourless parenchyma girders (Fig. 116 F)
4. Reduced to two strips of chlorenchyma by large girders or colourless parenchyma (Fig. 116 G)

C. Relationships of successive radiating mesophyll groups to each other could be categorised as:

1. Separated by bulliform and colourless cell groups

a. Completely divided; colourless cells continuous to abaxial epidermis (Fig. 116 G)

b. Adaxially divided; colourless cells in adaxial half of leaf (Fig. 116 A)

2. Separated by irregular chlorenchyma and intercellular air-spaces (Fig. 116 B)

3. Radiating cells of successive bundles adjoin one another

II. Indistinctly or incompletely radiating chlorenchyma i.e. inteimediate between radiate type and that not arranged in a definite pattern:

A. Continuous between bundles (Fig. 116 C)

B. Chlorenchyma divided by groups of colourless cells; tending to be radiate (Fig. 116 D)

III. Irregular chlorenchyma i.e.chlorenchyma does not radiate or arranged in a definite pattern; vascular bundles are usually widely spaced (festucoid)

A. Vertical arrangement of chlorenchyma in the mesophyll between successive vascular bundles

1. Occupying the major or entire area between the adaxial and abaxial epidermides

a. All cells of the chlorenchyma similar; homogenous

- Regular small cells; isodiametric; tightly packed (Fig.116 E)
- Irregular; cells of different size and shape; often with intercellular air-spaces

b. Cells pallisade-like in the adaxial chlorenchyma (Fig. 116 F)

c. Chlorenchyma cells adjoining the bundles larger

2. Occupying the lower abaxial half of the leaf thickness

3. Occupying the lower abaxial third of the leaf thickness

4. Confined to small patches surrounding abaxial and adaxial grooves which contain stomata

B. Horizontal arrangement of chlorenchyma in the mesophyll between successive vascular bundles

1. Continuous between bundles

a. Strap-shaped; horizontally elongated; bundles widely spaced (Fig. 116 G)

b. Tall and narrow groups; bundles close together (Fig. 116 I)

c. U-shaped; occupying the sides and bases of furrows or around bulliform cell groups (Fig. 116 H)

2. Mesophyll groups divided by colourless cell groups

IV. Arm cells present or comprise chlorenchyma with walls invaginated

A. Invaginations extend almost to opposite wall; cells divided into compartments

B. Invaginations relatively short

V. Lacunae or air spaces present in mesophyll

A. Extent of lacunae

1. Between all or most adjacent vascular bundles
2. Continuous air spaces above third order bundles (Fig. 116 J)

B. Aerenchyma associated with the lacunae

1. Distinct lacunae bounded by compact mesophyll with no aerenchyma traversing the lacunae
2. Lacunae distinct but traversed by colourless aerenchyma cell chains
3. Irregularly defined air spaces in diffuse mesophyll with many intercellular spaces and chlorophyll-bearing aerenchyma; often subtending the stomata
4. Stellate cells representing a diaphragm interspersed by sclerotic strands present

Colourless cells

Translucent cells constituting the remaining cells in the zones between successive vascular bundles, excluding the chlorenchyma, the sclerenchyma and the bulliform cells. They vary in size and may be larger or smaller than the bulliform cells but are always without chlorenchyma and never part of the epidermis i.e. not in contact with the surface.

I. Absent, no colourless cells present

II. Well defined groups of colourless cells present

A. Closely associated with inflated bulliform cells or groups

1. Size of colourless cells
    a. Smaller than bulliform cells; uninflated; often same size as chlorencyma cells
    b. Similar in size or shape to bulliform cells; inflated (Fig. 116 G)
2. Width of extension of bulliform cell group; composed of colourless cells
    a. Narrower than bulliform cell group (Fig. 116 B)
    b. Same width as bulliform cell group
3. Number of extensions from each bulliform cell group
    a. 1 extension from each group (Fig. 116 D)
    b. 2 extensions from each group; one on either side of the vascular bundle (Fig. 113 M)

4. Extent of intrusion into the mesophyll by colourless cells:
    a. Girders extend to the opposite epidermis (Fig. 116 H)
    b. Strands not extending to the opposite epidermis (Fig. 116 I)
    c. Band occupying the adaxial half of the leaf composed of colourless cells

B. Not closely associated with large bulliform cells
1. Origin at the base of furrows:
    a. Girder-like extension to the opposite epidermis between the bundles
    b. Girder-like extensions to the bundle sheath or towards the bundle sheath
2. Origin on flat epidermis or with slight furrows
    a. Girder-like extension extends to the opposite epidermis
        - Column of girder only uni- or bi-seriate
        - Girder multi-seriate
    b. Girder of colourless cells does not extend to the opposite epidermis

III. III defined groups of smallish colourless cells; not associated with large or well defined bulliform groups; usually adaxial:
A. Adaxial half of leaf consisting entirely of colourless cells
B. Abaxial half of leaf consisting mainly of colourless cells
C. Present on adaxial side of small vascular bundles only
D. Form arches over third order bundles and extend to the abaxial epidermis
E. Abaxial irregular groups; may be associated with sclerenchyma strands

Description of individual cells:

I. Structure of colourless cells:
A. Inflated, large parenchyma cells; resemble bulliform cells in size and shape
B. Smaller, thin-walled parenchyma cells; rounded in shape
1. Cells regular in size and shape; tissue uniform in appearance
2. Cells irregular in size and shape; tissue irregular in appearance

II. Thick-walled parenchyma or collenchyma cells

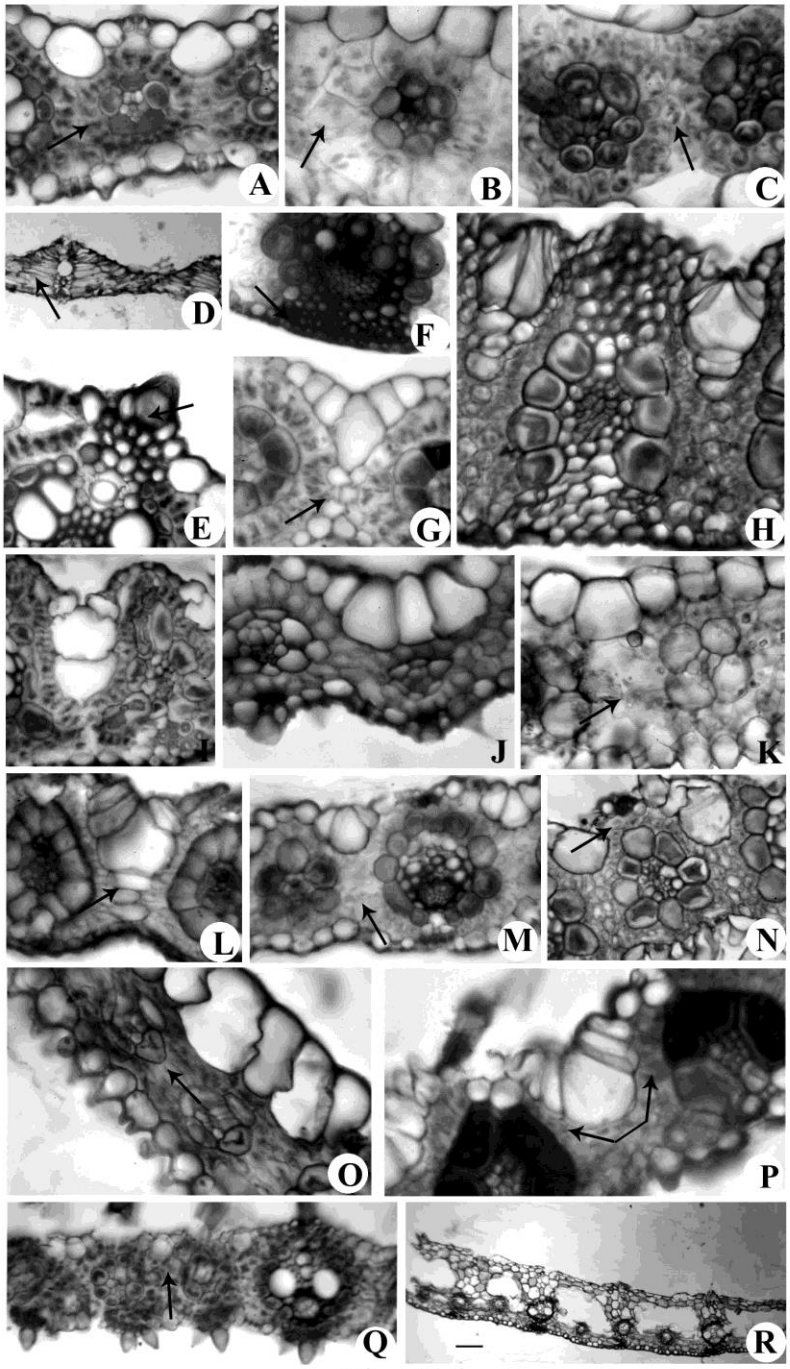


Fig. 116

Vascular bundles:

Vascular bundles are commonly more or less circular or elliptical in outline, but sometimes it may be angular. Present study shows the grass species comprising of third, second and first order vascular bundles. When the shapes of the vascular bundles are described it includes the shape formed by the cells within the bundle sheath.

Description of vascular bundle:

I. Third order vascular bundles: They are usually very small bundles often with xylem and phloem indistinguishable and consisting of only a few lignified cells and a few phloem elements; when the third order vascular bundles are not obviously smaller than basic type bundles then they are often distinguishable by the absence of sclerenchyma strands and/or the presence of bulliform cell groups adaxially

A. Absence of third order vascular bundles

B. Shape of third order bundles in transection

1. Round in outline; usually with many small parenchyma sheath cells
    a. Circular in outline (Fig. 117 A)
    b. Elliptical; vertically elongated (Fig. 117 B)
2. Angular in outline
    a. Square-shape or pentagonal i.e. surrounded by a sheath of 4 or 5 large parenchyma cells (Fig. 117 C)
    b. Hexagonal or octagonal i.e. surrounded by 6 or more relatively small parenchyma cells (Fig. 117 D)
    c. More or less triangular in outline with 9-10 small bundle sheath cells (Fig. 117 E)
    d. Vertically elongated; tall and narrow (Fig. 117 F)

C. Nature of vascular tissue of third order bundles

1. Xylem and phloem groups distinguishable (Fig. 117 B)
2. Vascular tissue consists of only a few indistinguishable vascular elements (Fig. 117 C)

II. Second order vascular bundles: xylem and phloem easily distinguishable; bundles usually fairly large, often of similar size to the first order bundles; no conspicuously large metaxylem vessels or lysigenous cavities present; sclerenchyma arrangement usually the same as for first order bundles

A. Second order bundles absent

B. Shape of second order bundles present

1. Rounded in outline; usually with many small parenchyma sheath cells
    a. Circular in outline (Fig. 118 R)
    b. Elliptical; vertically elongated (Fig. 118 S)
2. Angular in outline; parenchyma sheath of relatively few large cells; inner mestome sheath may also be present
    a. Hexagonal or octagonal (Fig. 117 I)
    b. Triangular in shape; often rather large (Fig. 117 J)

III. First order or Basic type vascular bundles: The vascular bundle has a large metaxylem vessel present on either side of protoxylem elements, lysigenous cavity commonly present and is associated with sclerenchymatous girders or strands. Based on the characteristic features of the different cells of the vascular bundles the following categories were observed.

A. Shape of first order bundles in section

1. Circular or round in outline (Fig. 117 K)
2. Elliptical; vertically elongated (Fig. 117 L)
3. Egg-shaped; broadest side adaxial (Fig. 117 M)

B. Relationship of phloem cells and the vascular fibres:

1. Phloem adjoins the inner or parenchyma sheath (Fig. 117 L)
2. Phloem completely surrounded by thick-walled fibres (Fig. 117 K)
3. Phloem divided by intrusion of small fibres resulting in sclerosed phloem (Fig. 117 N)

C. Nature of lysigenous cavity and protoxylem

1. Lysigenous cavity and enlarged protoxylem vessel present (Fig. 117 O)
2. Lysigenous cavity but no protoxylem vessel presents (Fig. 117 L)
3. Enlarged protoxylem vessel present but no lysigenous cavity (Fig.117 M)
4. No lysigenous cavity or protoxylem vessel presents (Fig. 117 P)

D. Size of metaxylem vessels in relation to parenchyma sheath cells in transection

1. Narrow vessels; parenchyma sheath cells wider than vessels (Fig. 117 Q)
2. Wide vessels i.e. vessels with width equal to or slightly greater than parenchyma sheath cells (Fig. 117 L)
3. Very wide vessels i.e. width of vessels very much more than that of parenchyma sheath cells (Fig. 117 O)

E. Shape of metaxylem vessels as seen in transection

1. Angular in transection (Fig. 117 L, M)
2. Circular in transection (Fig. 117 N, O)

IV. Median/midrib vascular bundles: Based on the characteristic features of the cells of the band comprising the median bundle and their shape. The further categories have been presented as follows:

A. Shape

1. Obovate (Fig. 118 A)
2. Inverted triangular (Fig. 118 B)
3. Egg (Fig. 118 C)
4. Oval (Fig. 118 D-F)
5. Round (Fig. 118 G-K)

B. Phloem cells relationship with vascular fibers

1. Phloem adjoins the inner or parenchyma sheath (Fig. 118 D)
2. Phloem complete surrounded by thick walled fibers (Fig. 118 A, G)

C. Nature of lysigenous cavity and protoxylem:

1. Lysigenous cavity and enlarged protoxylem vessel present (Fig. 118 D)
2. Lysigenous cavity but no protoxylem vessel present (Fig. 118 G)
3. Enlarged protoxylem vessel present but no lysigenous cavity (Fig. 118 J)

D. Size of metaxylem vessels in relation to parenchyma sheath cells in cross section:

1. Narrow vessels i.e. parenchyma sheath cells wider than vessels (Fig. 118 E, F)
2. Wide vessel i.e. vessels with width equal to or slightly greater than parenchyma sheath cells (Fig. 118 A, C)
3. Very wide vessels i.e. width of vessels very much more than that of parenchyma sheath cells (Fig. 118 J)

Vascular bundle sheath

Bundle sheath may or may not be present around vascular bundles. Almost all vascular bundles surrounded, either completely or partly, by one or more bundle sheath layers, each sheath consisting of a single layer of cells. The outer sheath, when two are present, or the single sheath where there is but one, generally consists of parenchymatous cells with thin, or not more than slightly thickened walls. The cells of inner sheath are nearly always smaller in diameter and with thicker walls than those of the outer sheaths. In general, single sheaths are characteristic of the panicoid and double sheaths of the festucoid grasses. Structure of the sheaths surrounding the different orders of vascular bundles shows variations. Characters istics included are shape of bundle sheath, extent of bundle sheath, composition of extension, size of cells comprising sheath, shape of cells. It is categorised as given below.

I. Bundle sheaths surrounding the vascular bundles absent

II. Outer or single parenchymatous bundle sheath. It includes vascular bundles with single and those with double sheaths

A. Shape of bundle sheath

1. Sheath round, circular (Fig. 117 A, G, K)
2. Sheath elliptical, vertically elongated (Fig. 117 N)
3. Sheath triangular with adaxial apex (Fig. 117 E, J)
4. Sheath horse-shoe shaped (Fig. 117 P)

B. Extent of bundle sheath around the vascular bundle

1. Sheath complete; completely surrounding the bundle (Fig. 117 C)
2. Sheath incomplete interrupted by sclerenchymatous girders of various sizes

a. Adaxial interruption

- Slight interruption caused by a narrow girder of 1 - 3 fibres wide (Fig. 118 A)
- Wide interruption caused by broad girder of more than 3 fibres wide or by colourless parenchyma (Fig. 118 A)

b. Abaxial interruption

- Slight interruption caused by a narrow girder of 1 - 3 fibres wide (Fig. 117 Q, 119 G)
- Wide interruption caused by broad girder of more than 3 fibres wide or by colourless parenchyma (Fig. 117 M, P)

III. Extensions of the bundle sheath, comprising of parenchyma cells associated with the sheaths and not part of the bulliform groups. The parenchyma cells extend to adjacent sclerenchyma girders or strands or to the epidermis

A. Extensions of the bundle sheath absent (Fig. 118 M)

B. Nature of the extensions

1. Adaxial extension of the bundle sheath
   a. Narrow extension
      - Uni-seriate; consisting of one column of cells
      - Bi-seriate; consisting of two columns of cells
   b. Broad extension; tri-or multi-seriate (Fig. 118 N)
2. Abaxial extension of the bundle sheath: broad extension; tri- or multi-seriate (Fig. 118 O)

C. Composition of the extensions

1. Consist of large, thin-walled colourless cells; the same size or bigger than sheath cells (Fig. 118 T)
2. Consist of relatively small, thin-walled colourless cells; smaller than the sheath cells (Fig. 118 P)
3. Consist of thickened parenchyma cells (Fig. 118 Q)
4. Consist of colourless cells gradually decreasing in size as walls increase in thickness and eventually merge into the sclerenchyma strand (Fig. 118 R)

D. Extent of the extensions of the bundle sheath

1. Extend to and in contact with the epidermis or an inconspicuous sclerenchyma strand (1-4 fibres) (Fig. 118 R)
2. Extend to conspicuous sclerenchyma strand (Fig. 118 S)
3. Extend to sclerenchyma strand almost extending to the bundle sheath (Fig. 114 C)
4. Extend to colourless subepidermal parenchyma (Fig. 118 T)

IV. Number of cells comprising the bundle sheath

A. Four parenchyma cells comprise the sheath

B. Five parenchyma cells comprise the sheath

C. Six parenchyma cells comprise the sheath

D. Seven parenchyma cells comprise the sheath

E. Eight parenchyma cells comprise the sheath

F. Nine parenchyma cells comprise the sheath

G. Ten parenchyma cells comprise the sheath

H. Eleven parenchyma cells comprise the sheath

I. Twelve parenchyma cells comprise the sheath

J. Thirteen parenchyma cells comprise the sheath
K. Fourteen parenchyma cells comprise the sheath
L. Fifteen or more parenchyma cells comprise the sheath

V. Structure of the parenchyma sheath cells: cells of each order of vascular bundle considered separately and all cell types included

A. Not well differentiated from the chlorenchyma cells
B. Distinct from chlorenchyma cells:

1. Shape of cells comprising sheath; includes all shapes relevant for each order of vascular bundle:
   a. Inflated, round, circular (Fig. 117 G)
   b. Radial walls straight; tangential walls inflated (Fig. 117 C)
   c. Radial and outer tangential walls straight; inner tangential wall inflated (Fig. 117 D)
   d. Radial and inner tangential walls straight; outer tangential wall inflated; fan-shaped (Fig. 117 E)
   e. Cells elliptical; elongated; often rather irregular (Fig. 118 P)
2. Arrangement of cells of different shapes comprising the bundle sheath
   a. All cells similar in shape (Fig. 117 H)
   b. Two enlarged elongated cells abaxially situated
      - Adjoining girder of sclerenchyma (Fig. 117 P)
      - Normal parenchyma sheath cells between the elongated cells (Fig. 117 L)
   d. Cells at adaxial side of sheath elongated vertically; elliptical (Fig. 118 D)
3. Size of cells comprising sheath
   a. Cells of sheath similar in size
      - Large and inflated; generally larger than mesophyll cells; conspicuous (Fig. 118 E)
      - Not markedly larger than the mesophyll cells; conspicuous (Fig. 118 D)
      - Cells smaller than the mesophyll cells; inconspicuous (Fig. 118 C)
      - Cells smaller than the inner bundle sheath cells
      - Cells small; resemble cells of a mestome sheath i.e. thickened walls often especially the inner tangential walls; parenchyma sheath apparently absent
   b. Cells of sheath of various sizes
      - Cells of different sizes comprise sheath; irregular (Fig. 118 O)
      - Gradation in size with largest cells adaxially situated (Fig. 118 H)
      - Gradation in size with largest cells abaxially situated (Fig. 118 P)

- Gradation with smallest cells in the centre; abaxial and adaxial cells larger (Fig. 118 I)
- Gradation with largest cells in the centre on each side (Fig. 118 K)

4. Chloroplast structure of the bundle sheath cells
    a. Translucent; sheath cells without chloroplasts
    b. With small chloroplasts; not distinct from chloroplasts of the chlorenchyma
    c. With large, specialised chloroplasts
        - Chloroplasts fill entire cell lumen (Fig. 118 E)
        - Chloroplasts concentrated near the outer tangential wall (Fig. 117 L)
        - Chloroplasts concentrated near the inner tangential wall (Fig. 117 N)
        - Chloroplasts centrally situated (Fig. 117 O)

Inner or Mestome bundle sheath or endodermis:

Bundle sheath in many grass specis are made up of two layers in which case the inner layer is designated as 'mestome', it is only applicable when two sheaths are present; often difficult to distinguish from fibrous ground tissue of the vascular bundle; in contact with the metaxylem i.e. if metaxylem vessels in contact with parenchyma sheath then there is no inner bundle sheath:

I. Extent of sheath

A. No inner sheath present (Fig. 118 H)
B. Sheath complete; completely surrounding the xylem and phloem (Fig. 118 F)
C. Sheath incomplete due to interruptions of sclerenchyma girders:
    1. Adaxial interruption (Fig. 118 C)
    2. Abaxial interruption (Fig. 118 E)
D. Sheath reduced; intermediate type; interruptions not due to sclerenchyma girders: adaxial; opposite xylem only (Fig. 118 T)

II. Structure of cells of inner bundle sheath in region adjacent to phloem; cells of each order of vascular bundle considered separately

A. Relatively large with inner tangential and radial walls thickened (Fig. 118 D)
B. Small, with uniformly thickened walls:
    1. Walls heavily thickened; lumen small (Fig. 118 E)
    2. Walls not conspicuously thickened (Fig. 118 F)
C. Larger than outer bundle sheath; parenchymatous; with chloroplasts
D. Adaxially situated cells larger than lateral cells of the sheath (Fig. 118 D)

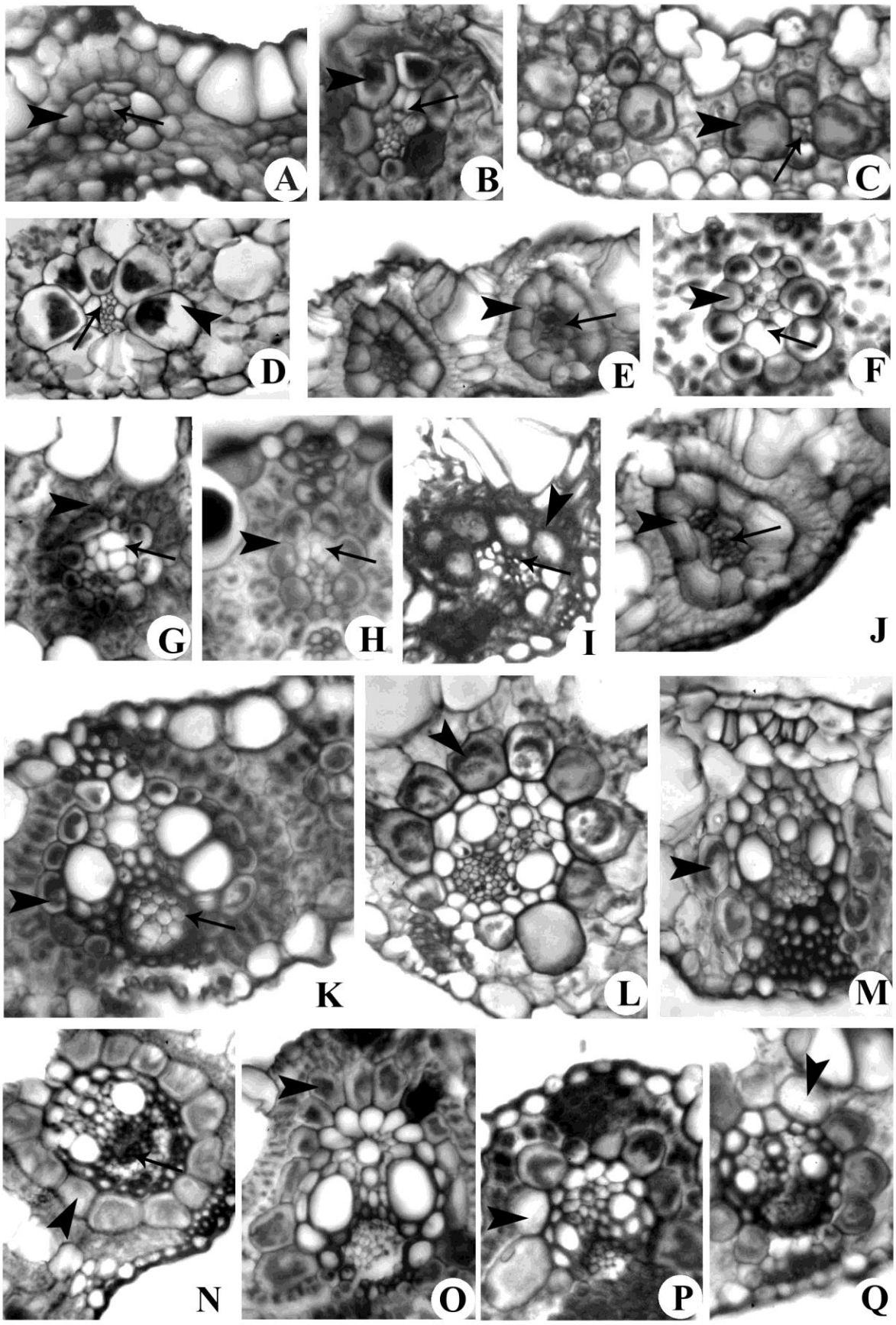


Fig. 117

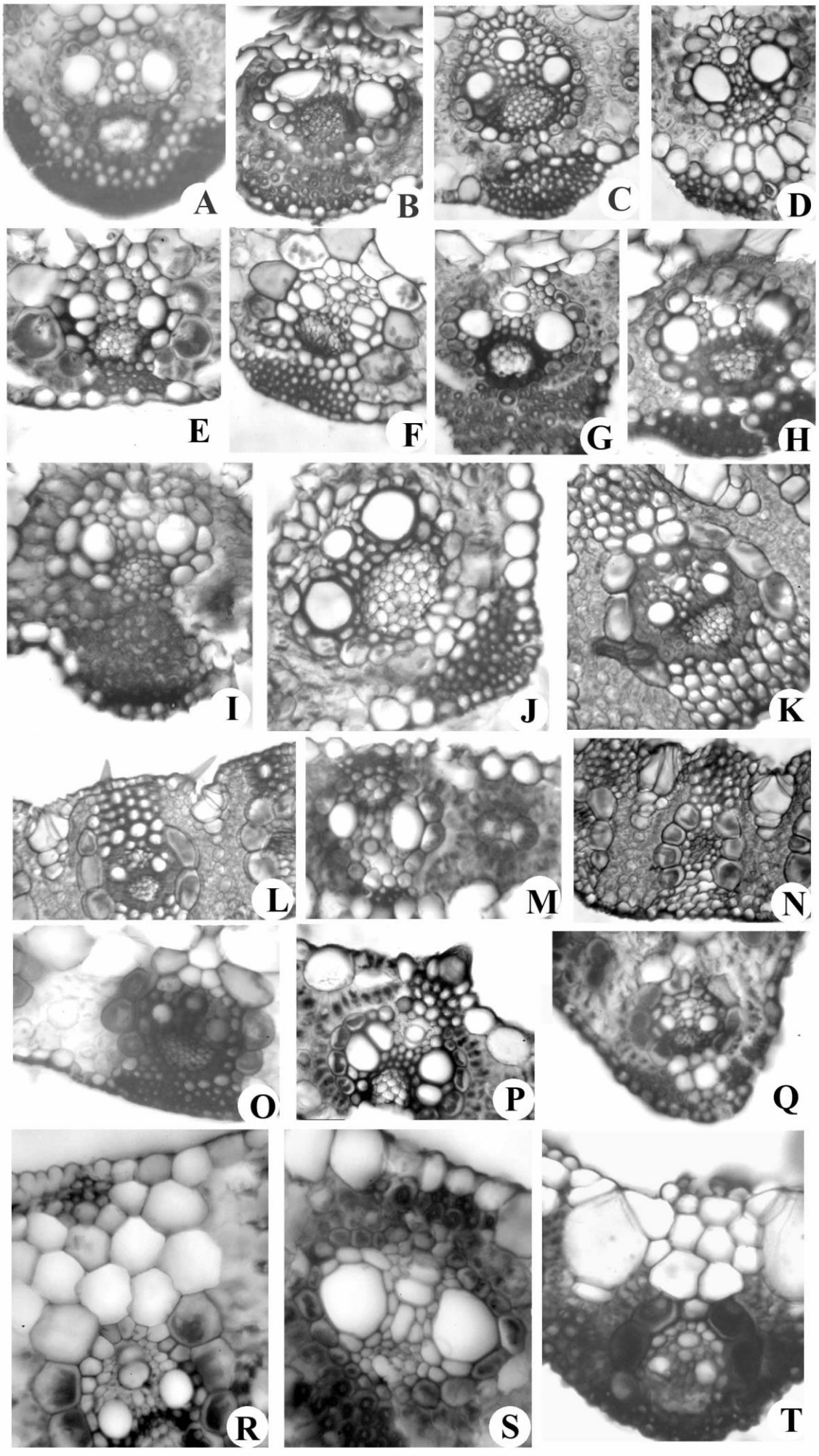


Fig. 118

Sclerenchyma

In grass leaf, support is provided by fibrous and other types of thick walled cells that collectively constitute the sclerenchyma. This is in the form of subepidermal longitudinal strands or girders which follow the course of the vascular bundles. In some species sclerenchyma appear as islands of lignified tissue lying above and below or on one side only, of each vascular bundle, it known as strands. Sometimes it appears as girders extending from either or each epidermis to the bundle sheath, and is known as girdered.

Adaxial sclerenchyma; sclerenchyma located and associated above the vascular bundles:

I. Adaxial sclerenchyma absent (Fig. 119 A)

II. Sclerenchymatous strand present: It is not in contact with the bundle sheath and is separated by parenchyma or mesophyll from sheath

A. Minute strand consisting of only a few subepidermal fibers (Fig. 119 B)

B. Small strand; inconspicuous; epidermal cells unaltered over the strand

1. Shallow, forming a strip; only 2-4 fibers deep; subepidermal (Fig.119 C)
2. Narrow; only 2 - 4 fibers wide (Fig. 119 D)

C. Well-developed conspicuous strand. Epidermal cells over strand usually small and thick-walled

1. As deep as wide as seen in tansection
2. Wider than deep as seen in transection; in form of band
    a. Arched; follows the shape of the adaxial rib (Fig. 119 E)
    b. Straight, horizontal band

III. Sclerenchymatous girder present. The girder is in contact with, or interrupts the bundle sheath

A. Very small girder; inconspicuous; epidermal cells usually unaltered over girder (Fig. 119 F)

B. Small girder; epidermal cells over the girder usually small and thick-walled

1. Small thin subepidermal strip (Fig. 119 H)
2. Narrow; deeper than wide
3. As deep as wide as seen in transection; equidimensional (Fig. 119 G)

C. Well-developed girder; conspicuous; epidermal cells over girder small and thickened

1. The girder is relatively wide and deep band; as wide or wider than the vascular bundle
    a. Arched; follows the shape of the adaxial rib (Fig. 119 I)
    b. Straight; horizontal band (Fig. 119 J)
    c. Narrowing towards bundle (Fig. 119 K)
2. Relatively narrow and deep girder; narrower than the vascular bundle (Fig. 119 A)

3. The girder is T-shaped with the horizontal band of 'T' connected to bundle or bundle sheath by a vertical sclerenchymatous band of the stem
    a. Stem is short i.e. it is shorter than the horizontal band of 'T'
    b. Stem is relatively long; as long as or longer than horizontal band of 'T'
4. Inversely anchor-shaped; arched band follows shape of adaxial rib:
    a. Stem short and sturdy; more than tri-seriate
    b. Stem long or tall and sturdy; more than tri-seriate
    c. Stem short and thin or narrow; 1 - 3 seriate
    d. Stem long or tall and thin or narrow; 1 - 3 seriate

Iv. Girder extends from bundle sheath to bulliform or colourless cells; not to epidermis

A. Fibers interrupt the cells of the single or outer bundle sheath (Fig. 119 K)

B. Fibers in contact with the cells of the single or outer bundle sheath (Fig. 119 J)

Abaxial sclerenchyma; sclerenchyma found below the vascular bundles

I. Abaxial sclerenchyma absent (Fig. 119 A)

II. Sclerenchymatous strand present; not in contact with the bundle sheath; separated by parenchyma or mesophyll from sheath:

A. Minute strand consisting of only a few subepidermal fibers (Fig. 119 C)

B. Small strand; inconspicuous; epidermal cells unaltered under the strand:
    1. Shallow, forming a strip; only 2-4 fibres deep; subepidermal (Fig.119 B)
    2. Narrow but fairly deep; only 2 - 4 fibres wide
    3. As deep as wide as seen in transection (Fig. 120 C)

C. Well-developed strand; conspicuous; epidermal cells under strand usually small and thick-walled
    1. As deep as wide as seen in transection
    2. Wider than deep as seen in transection; in form of a band:
        a. Arched, follows the shape of the abaxial rib
        b. Straight, horizontal band

III. Sclerenchymatous girder present. The girder is in contact with, or interrupts the bundle sheath

A. Very small girder; inconspicuous; epidermal cells usually unaltered under girder (Fig. 113 N)

B. Small girder; epidermal cells under the girder usually small and thick-walled
    1. Small, thin subepidermal strip (Fig. 120 D)
    2. Narrow, deeper than wide
    3. As deep as wide as seen in transection; equidimensional

C. Well-developed girder; conspicuous; epidermal cells under the girder usually small and thickened

1. Relatively wide and deep band; as wide or wider than the vascular bundle
    a. Arched, follow the shape of the abaxial rib (Fig. 120 E)
    b. Straight, horizontal band (Fig. 119 K)
    c. Narrowing towards bundle; triangular or trapezoidal (Fig.119 G)
2. Relatively narrow and deep girder; narrower than the vascular bundle
3. Inverted T-shaped; horizontal band connected to bundle or bundle sheath by stem
    a. Stem is short i.e. it is shorter than the horizontal band of 'T' (Fig. 120 F)
    b. Stem is relatively long; as long as or longer than horizontal band of 'T'
4. Anchor-shaped; arched band follows shape of abaxial rib
    a. Stem short and sturdy; more than tri-seriate (Fig. 120 A)
    b. Stem long or tall and sturdy; more than tri-seriate (Fig. 120 E)
    c. Stem short and thin or narrow; 1 - 3 seriate
    d. Stem long or tall and thin or narrow; 1 - 3 seriate
5. Continous or almost continuous abaxial hypodermal band

D. Girder extends from bundle sheath to bulliform or colourless cells; not to the epidermis

1. Fibers interrupt the cells of the single or outer bundle sheath (Fig.120 A)
2. Fibers in contact with the cells of the single or outer bundle sheath

Sclerenchyma between bundles:

These are supernumary strands not associated with the vascular bundles but situated intermediate between them, usually beneath the abaxial epidermis opposite the bulliform cell groups or furrows. The supernumary strands excludes sclerenchyma at the leaf margin and of the keel or midrib.

I. Sclerenchyma is absent between the vascular bundles

II. Abaxial strands of sclerenchymatous fibres:

A. Opposite adaxial furrows with or without bulliform cells

B. Opposite bulliform cell groups not associated with furrows

III. Hypodermal band: Sclerenchyma is arranged in the form of more or less continuous abaxial band

A. Extensions of girder or strand groups

B. Hypodermal layer continuous

Sclerenchyma in leaf margin:

This includes all mechanical tissue situated in, or directly associated with the margin of the lamina. It may incorporate or fuse with the ultimate, the penultimate or other lateral bundles. The margin of the leaf may remain straight or is sometimes curved. Also the marginal tip in cross section when viewed has different shape in different species. Also many of the species have leaf margin capped with sclerenchyma.

I. Sclerenchyma absent in the margin

II. Cap of sclerenchyma at the margin which is not in contact with the lateral bundle. It can be further categorised into:

A. Size of the sclerenchymatous cap

1. Very small; consists of a couple fibers (Fig. 120 H)
2. Relatively small; less than the width of a third order vascular bundle (Fig. 120 J)
3. Well-developed; wider than third order vascular bundles (Fig. 120 K)

B. Shape of sclerenchymatous cap

1. Rounded cap (Fig. 120 L)
2. Pointed cap (Fig. 120 K)
3. Narrow, very pointed projection (Fig. 120 H)
4. Crescent-shaped cap; sclerenchyma extends shortly along both abaxial and adaxial side of leaf
5. Curved in shape with sclerenchyma extending along adaxial side of the leaf (Fig. 120 M)
6. Curved in shape with sclerenchyma extending along abaxial side of the leaf

C. Epidermal cells at margin

1. Not fibrous; thin-walled or outer walls thickened; distinct from fibers (Fig. 120 N)
2. Small, fibrous; thickened on all walls; similar to fibers in transection (Fig. 120 O)

D. Angular prickles of margin

1. Enlarged bases present in margin
2. No prickle bases visible in margin

E. Nature of junction with mesophyll and remainder of lamina

1. Adjoins normal mesophyll cells
2. Specialised enlarged parenchyma cells near cap or ultimate bundle
3. Lateral intercellular canal near margin; lysigenous duct not associated with the bundle

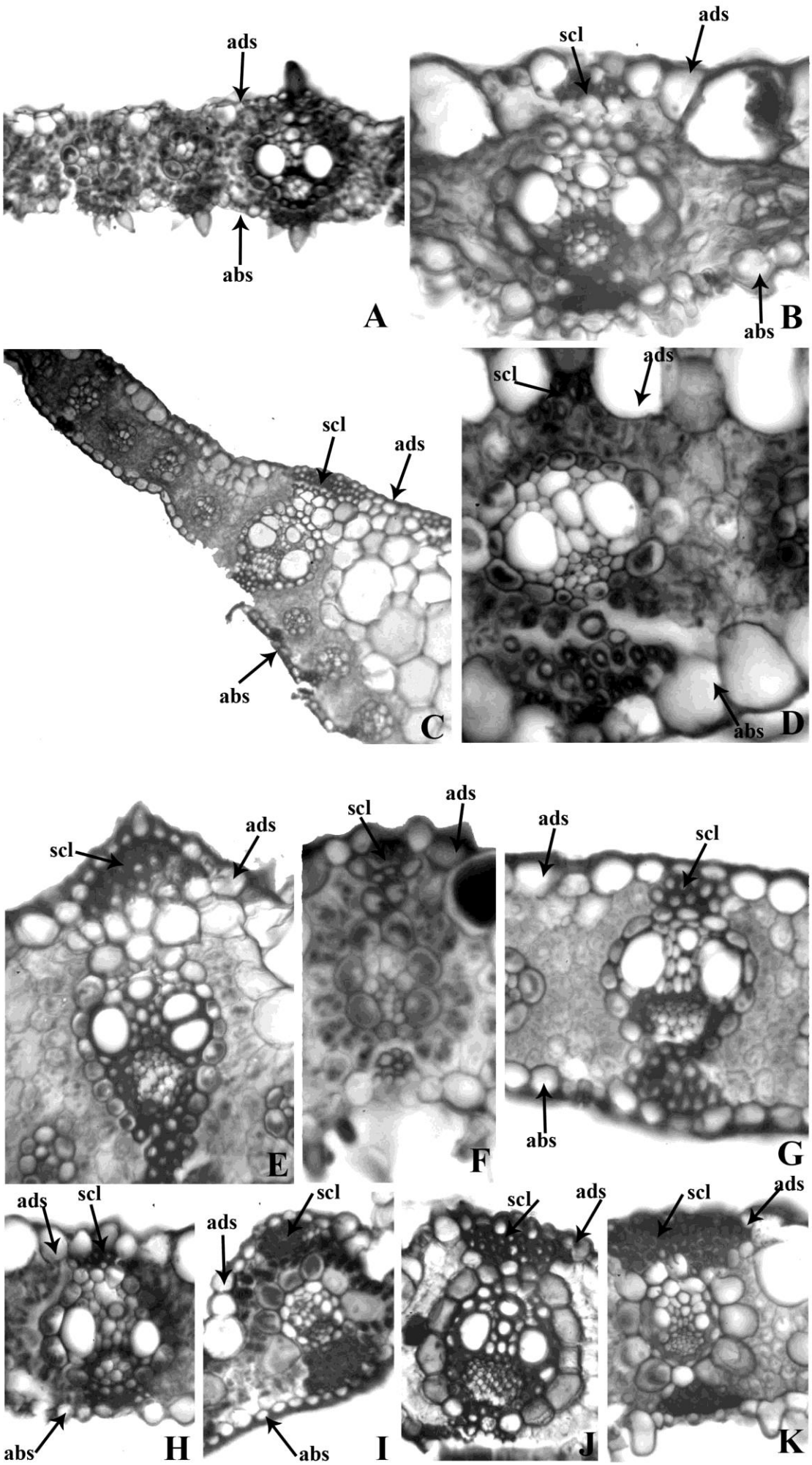

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Fig. 119

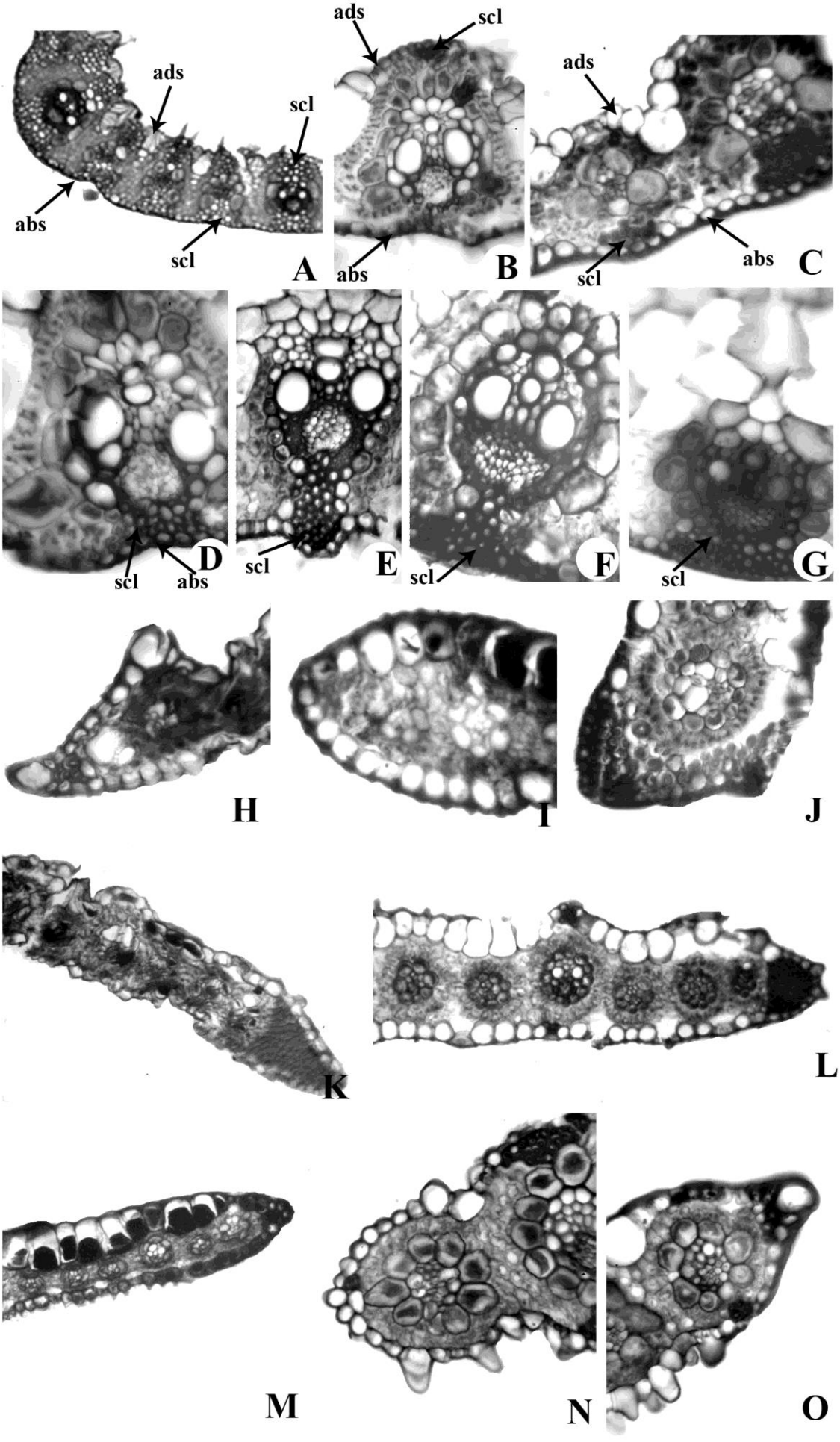
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Fig. 120

LEAF SHEATH ANATOMY

Characteristic features of leaf sheath cells are similar to the leaf lamina cells upto some extent. It showed adaxial and abaxial epidermis, in between them ground tissue is present in which the vascular bundles were arranged. Vascular bundles were distributed towards the abaxial surface. Most of the characters like outline of leaf sheath, vascular bundle arrangement, vascular bundle structure, vascular bundle sheath structure are similar with the structure of leaf lamina. But leaf lamina shows bulliform cells, papillae structure on epidermal cell, macrohairs, prickles, chlorenchymatous cells, colourless cells which are not present in leaf sheath transection.

Outline of leaf sheath

Outline of leaf sheath showed two types of shapes, either V shaped or round shaped. In both the types margin of the leaf sheath are overlapping. The degree of overlapping is variable. It may shows single or double inrolling. Categorization is as follows:

I: V-shaped: Where two halves of the leaf sheath folded towards inner side

A: Angle formed by the two arms of the lamina at the midrib is

1. Narrow i.e. closed 'V' i.e. less than 45° to each other (Fig. 121 A)
2. Standard 'V' i.e. between 45° and 90° to each other (Fig. 121 B)
3. Broad, open 'V' i.e. more than 90° to each other (Fig. 121 C)
4. Wide, very open 'V' i.e. almost 180°; presence of projecting keel gives appearance of V-shaped (Fig. 121 D)

B: Shape of arms of the lamina:

1. Straight (Fig. 121 C)
2. Outwardly bowed; concave (Fig. 121 E)
3. Outwardly curving; convex (Fig. 121 F)
4. Outline heart shaped (Fig. 121 G)
5. Distinctly wavy or undulating

II. U shaped (Fig. 121 H)

III. Round shaped where in leaf sheath is circular in outline and two halves of that overlapping each other

A. margins are inrolled, not overlapping (Fig. 121 I)

B. margins are inrolled, single overlapping (Fig. 121 J, K)

C. margins are inrolled, double overlapping (Fig. 121 L)

Longitudinal ribs and furrows

The longitudinal ribs and furrows may or may not be present. If they are present then it was observed only on abaxial surface. Adaxial surface never showed presence of ribs and furrows.

I. Ribs and furrows are absent

II. Abaxial ribs and furrows present: distribution of abaxial ribs varied

1. Present opposite 1st order vascular bundles only
2. Present opposite all vascular bundles

Vascular bundle arrangement

Vascular system is comprised of first order, second order and third order bundles similar to the leaf lamina. They showed different arrangements.

1. 1st order, 2nd order and 3rd order vascular bundle arranged sequentially one after other (Fig. 121 N)
2. Two consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle (Fig. 121 M)
3. Three consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle (Fig. 121 O)
4. One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle (Fig. 121 P)

Epidermis

Single layered epidermal cells are present. Adaxial epidermal cells are always flat, recantangular or barrel shaped and cuticle is absent. Abaxial epidermal cells are small, elongated or barrel shaped with thick cuticle. Other than this, there was no distinct difference observed. Papillae, bulliform cells, prickles are absent in leaf sheath.

Ground tissue

Parechymatous with air spaces. Four types of air spaces were observed:

1. Vertically oval shaped air cavities (Fig. 121 Q)
2. Horizontally oval shaped air cavities (Fig. 121 R)
3. Oval shaped, big, air cavity, very few cavities present (Fig. 121 T)
4. Round shaped air cavity (Fig. 121 S)

Vascular bundle

Vascular bundles are covered with bundle sheath and they contain phloem, metaxylem and protoxylem. Based on their shape and type of bundle sheath cells, they could be differentiated into following categories:

Description of vascular bundles:

I. Third order vascular bundles were usually very small bundles often with xylem and phloem indistinguishable and consisting of only a few lignified cells and a few phloem elements. When vascular bundle is not obviously smaller than basic type bundles it is often distinguishable by the absence of sclerenchyma strands and/or the presence of bulliform cell groups adaxially

A. Third order bundles absent in section

B. Shape of third order bundles in section:

1. Round in outline; usually with many small parenchyma sheath cells
   a. Circular to elliptical in outline (Fig. 122 A)
   b. Elliptical; vertically elongated (Fig. 122 B)
2. Angular in outline
   a.; Square-shape or pentagonal i.e. surrounded by a sheath of 4 or 5 large parenchyma cells

b. Hexagonal or octagonal i.e. surrounded by 6 or more relatively small parenchyma cells (Fig. 122 C, E)

c. Triangular in outline (Fig. 122 D)

d. Vertically elongated; tall and narrow

C. Nature of vascular tissue of third order bundles

1. Xylem and phloem groups distinguishable (Fig. 122 D)

2. Vascular tissue consists of only a few indistinguishable vascular elements (Fig. 122 A)

II. Second order vascular bundles: xylem and phloem easily distinguishable; bundles usually fairly large, often of similar size to the first order bundles; no conspicuously large metaxylem vessels or lysigenous cavities present; sclerenchyma arrangement usually the same as for first order bundles

A. Second order bundles absent in section

B. Shape of second order bundles in section:

1. Rounded in outline; usually with many small parenchyma sheath cells

a. Circular in outline (Fig. 122 F)

b. Elliptical; vertically elongated (Fig. 122 G, H)

2. Angular in outline; parenchyma sheath of relatively few large cells; inner mestome sheath may also be present

a. Hexagonal or octagonal (Fig. 122 I-K)

b. Triangular in shape; often rather large

III. First order or Basic type vascular bundles: large metaxylem vessel present on either side of protoxylem elements; lysigenous cavity commonly present; associated with sclerenchyma girders or strands

A. Shape of first order bundles in section

1. Circular or round in outline (Fig. 122 L)

2. Elliptical; vertically elongated (Fig. 122 N)

3. Egg-shaped; broadest side adaxial (Fig. 122 R)

B. Relationship of phloem to vascular fibres:

1. Phloem adjoins the inner or parenchyma sheath (Fig. 122 O)

2. Phloem completely surrounded by thick-walled fibres (Fig. 122 L)

C. Nature of lysigenous cavity and protoxylem

1. Lysigenous cavity and enlarged protoxylem vessel present (Fig. 122 P)

2. Lysigenous cavity but no protoxylem vessel present (Fig. 122 M)

3. No lysigenous cavity or protoxylem vessel present (Fig. 122 R)

D. Size of metaxylem vessels in relation to parenchyma sheath cells in transection

1. Narrow vessels i.e. parenchyma sheath cells wider than vessels (Fig. 122 R)

2. Wide vessels i.e. vessels with width equal to or slightly greater than parenchyma sheath cells (Fig. 122 N)
3. Very wide vessels i.e. width of vessels very much more than that of parenchyma sheath cells (Fig. 122 P)

E. Shape of metaxylem vessels as seen in T/S

1. Angular in transection (Fig. 122 N)
2. Circular in transection (Fig. 122 L)

Vascular bundle sheath

Structure of the sheaths surrounding the different orders of vascular bundles shows variations. Characters are included are shape of bundle sheath, extent of bundle sheath, composition of extension, size of cells comprising sheath, shape of cells. It is categorised as given below.

I. No bundle sheaths surrounding the vascular bundles

II. Outer or single bundle sheath: parenchyma sheath; includes vascular bundles with single and those with double sheaths

A. Shape of bundle sheath

1. Sheath round, circular (Fig. 122 L)
2. Sheath elliptical, vertically elongated (Fig. 122 N)
3. Sheath triangular with adaxial apex
4. Sheath horse-shoe (Fig. 122 J)

B. Extent of bundle sheath

1. Sheath complete; completely surrounding the bundle (Fig. 122M)
2. Sheath incomplete due to interruption of sclerenchyma girders of various sizes

a. Abaxial interruption

- Slight interruption caused by a narrow girder of 1 - 3 fibres wide (Fig. 122 I)
- Wide interruption caused by broad girder of more than 3

III. Number of cells comprising the bundle sheath

A. Four parenchyma cells comprise the sheath
B. Five parenchyma cells comprise the sheath
C. Six parenchyma cells comprise the sheath
D. Seven parenchyma cells comprise the sheath
E. Eight parenchyma cells comprise the sheath
F. Nine parenchyma cells comprise the sheath
G. Ten parenchyma cells comprise the sheath
H. Eleven parenchyma cells comprise the sheath
I. Twelve parenchyma cells comprise the sheath
J. Thirteen parenchyma cells comprise the sheath
K. Fourteen parenchyma cells comprise the sheath
L. Fifteen or more parenchyma cells comprise the sheath

IV. Structure of the parenchyma sheath cells; cells of each order of vascular bundle considered separately and all cell types included

A. Not well differentiated from the ground tissue

B. Distinct from ground tissue:

1. Shape of cells comprising sheath; include all shapes relevant for each order of vascular bundle:
    a. Inflated, round, circular (Fig. 122 P)
    b. Radial walls straight; tangential walls inflated (Fig. 122 N)
    c. Radial and outer tangential walls straight; inner tangential wall inflated
    d. Radial and inner tangential walls straight; outer tangential wall inflated; fan-shaped (Fig. 122 I)
    e. Cells elliptical; elongated; often rather irregular
2. Arrangement of cells of different shapes comprising the bundle sheath
    a. All cells similar in size (Fig. 117 N)
    b. Two enlarged elongated cells abaxially situated
        - Adjoining girder of sclerenchyma
        - Normal parenchyma sheath cells between the elongated cells
3. Size of cells comprising sheath
    a. Cells of sheath similar in size
        - Large and inflated; generally larger than ground tissue; conspicuous (Fig. 122 J)
        - Not markedly larger than the ground tissue; conspicuous (Fig. 122 N)
        - Cells smaller than the ground tissue; inconspicuous (Fig. 122 P)
    b. Cells of sheath of various sizes
        - Cells of different sizes comprise sheath; irregular
        - Gradation in size with largest cells adaxially situated (Fig. 122 N)
        - Gradation in size with largest cells abaxially situated
        - Gradation with smallest cells in the centre; abaxial and adaxial cells larger (Fig. 122 I)

Inner or Mestome bundle sheath or endodermis:

Bundle sheath in many grass species are made up of two layers in which case the inner layer is designated as ‘mestome’. It is only applicable when two sheaths are present and is often difficult to distinguish from fibrous ground tissue of the vascular bundle.

I. Extent of sheath

A. Inner sheath absent (Fig. 122 N)

B. Sheath complete; completely surrounding the xylem and phloem (Fig. 122 I)

C. Sheath incomplete due to interruptions of sclerenchyma girders:

1. Abaxial interruption (Fig. 122 K)

Sclerenchyma

In grass leaf sheath, sclerenchyma cells present only on abaxial surface. Adaxial surface and margin does not show sclerenchymatous cells.

Abaxial sclerenchyma; sclerenchyma found below the vascular bundles

I. Abaxial sclerenchyma absent (Fig. 119 A)

II. Strand present; sclerenchymatous not in contact with the bundle sheath; separated by parenchyma or mesophyll from sheath:

A. Minute strand consisting of only a few subepidermal fibers

B. Small strand; inconspicuous; epidermal cells unaltered under the strand:

1. Shallow, forming a strip; only 2-4 fibres deep; subepidermal (Fig.121 T)

C. Well-developed strand; conspicuous; epidermal cells under strand usually small and thick-walled

1. Wider than deep as seen in transection; in form of a band:

a. Arched, follows the shape of the abaxial rib (Fig. 122 M)

b. Straight, horizontal band (Fig. 122 N)

III. Girder present; sclerenchymatous in contact with, or interrupts the bundle sheath

A. Very small girder; inconspicuous; epidermal cells usually unaltered under girder (Fig. 122 L)

B. Small girder; epidermal cells under the girder usually small and thick-walled

1. Small, thin subepidermal strip (Fig. 122 I)

2. Narrow, deeper than wide (Fig. 122 J)

C. Well-developed girder; conspicuous; epidermal cells under the girder usually small and thickened

1. Relatively wide and deep band; as wide or wider than the vascular bundle

a. Arched, follow the shape of the abaxial rib (Fig. 122 R)

b. Straight, horizontal band (Fig. 122 K)

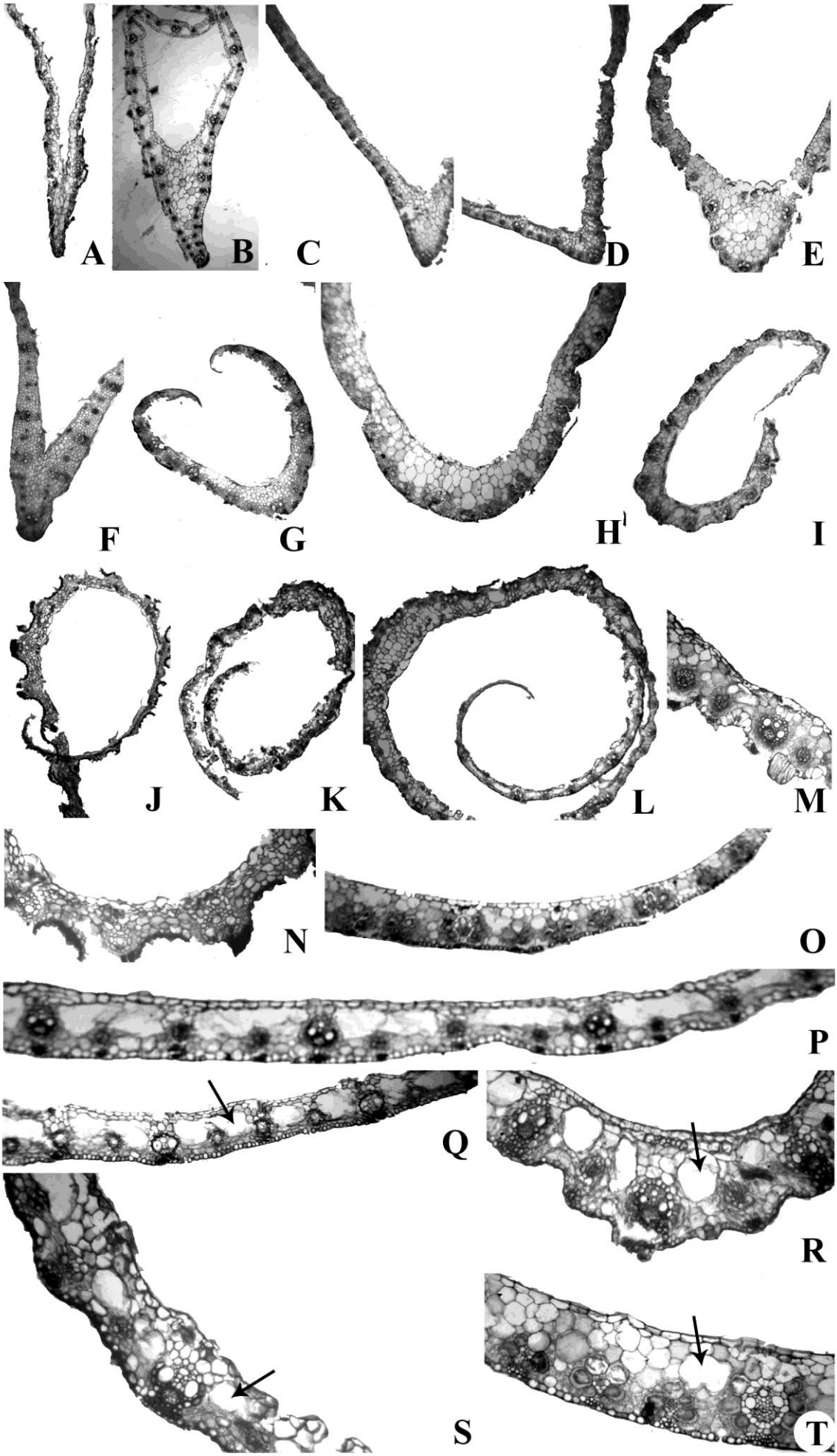

Fig. 121

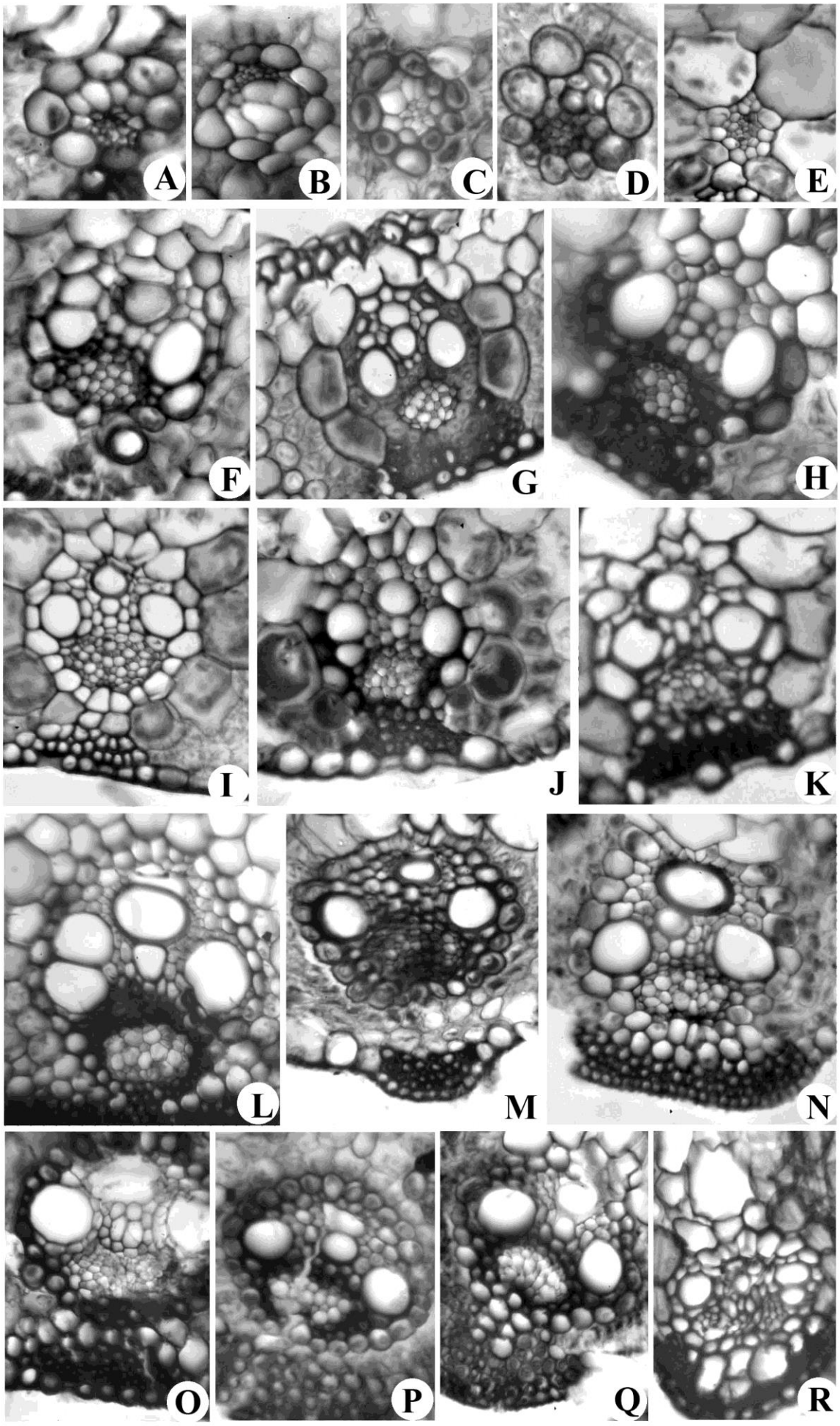

Fig. 122

LIGULE ANATOMY

Chaffy (1994) studied functional anatomy of ligules in different grass species. According to him, most of the ligules consisted of three layers: the mesophyll and two epidermal cell layers. Mesophyll in those ligules contained chloroplasts. Mesophyll layers may be one/two/up to eight cell layers in thickness.

Connection of the ligule between leaf blade and leaf sheath is at right angles to the longitudinal axis of leaf sheath. At the cut only the median part of the ligule connects to the leaf sheath tissue. The lateral parts are free and converge at the cut. Grasses either show vascularized ligule or non vascularized ligule.

From the studied species different connection of ligule between leaf blade and leaf sheath were observed, which are following:

Based on the shape of leafblade or leaf sheath, broadly it can be categorized into two:

I. "V" shaped

II. Round shaped

I. "V" shaped:

Type 1: Ligule attached to the lamina upto the half length of it and is free and sharp "V" shaped at the point of connection. (Fig. 123 A)

Type 2: Ligule attached to the lamina upto 1/3 length of it and than free, blunt, narrow, "V" shaped at the point of connection (Fig. 123 B)

Type 3: Ligule attached to the lamina more than half length of it and blunt "V" shaped at the connection point and narrow (Fig. 123 C)

Type 4: Ligule attached to the lamina till the ¾ than is free and blunt, broad "V" shaped at the connection (Fig. 123 D)

Type 5. Ligule attached less than half length of the lamina and at the connection point it is very broad, blunt "V" shaped (Fig. 123 E)

Type 6: Ligule attached to the lamina only ¼ portions and at connection point it was very broad almost like straight "V" shaped with small sharp angled (Fig. 123 F).

II: Round shaped:

Type 9: Ligule attached to the midrib region and little with lamina region, and at the connection it is broad round shaped (Fig. 123 I)

Type 8: Ligule attached to the half width of the leaf sheath region and it is round shaped at the connection point (Fig. 123 H)

Type 7: Ligule attached to the leaf sheath more than the half width and very broad round shaped at the connections point (Fig. 123 G)

Type 10: Ligule attached only to the midrib region and broad round shaped at connections point (Fig. 123 J)

Type 11: Ligule is attached to the midrib and few parts of lamina region because it is hairy ligule (Fig. 123 K).

Generally anatomically ligule shows adaxial and abaxial surface and between them mesophll cells, may be have chloroplast or not. Within these simple anatomical structures, few variations are observed in studied species.

Type 1: Single layered mesophlyll between adaxial and abaxial surfaces (Fig. 123 L)

Type 2: Two layered mesophlyll cells between adaxial and abaxial (Fig. 123 M)

Type 3: Three layered mesophlyll cells between adaxial and abaxial (Fig. 123 O)

Type 4: More than three layered mesophyll cells between adaxial and abaxial (Fig. 123 N)

Type 5: Two layered mesophyll cells between adaxial and abaxial surface but on abaxial surface few sclerenchyma cells present at regular interval (Fig. 123 P).

Type 6: Two layered mesophyll cells between adaxial and abaxial surfaces abxial surface almost covered with sclerenchyma cells (Fig. 123 Q)

Type 7: Single layered mesophlyll cells between adaxial and abaxial surfaces and at some places sclerenchyma cells present (Fig. 123 R)

Chaffy (1994) observed few cells which are round to oblong shaped with thickened wall and thickening was of lignin, so it considered as sclrenchyma cells of ligule.

Few species shows presences of prickles on the surfaces, specially those have hairy ligule. Among the studied species two type of prickle were observed

I. Thickened prickle, bulbous base, barbed (Fig. 123 S arrow)

II: Thickened prickle, bulbous base, sharp, pointed (Fig. 123 T arrow)

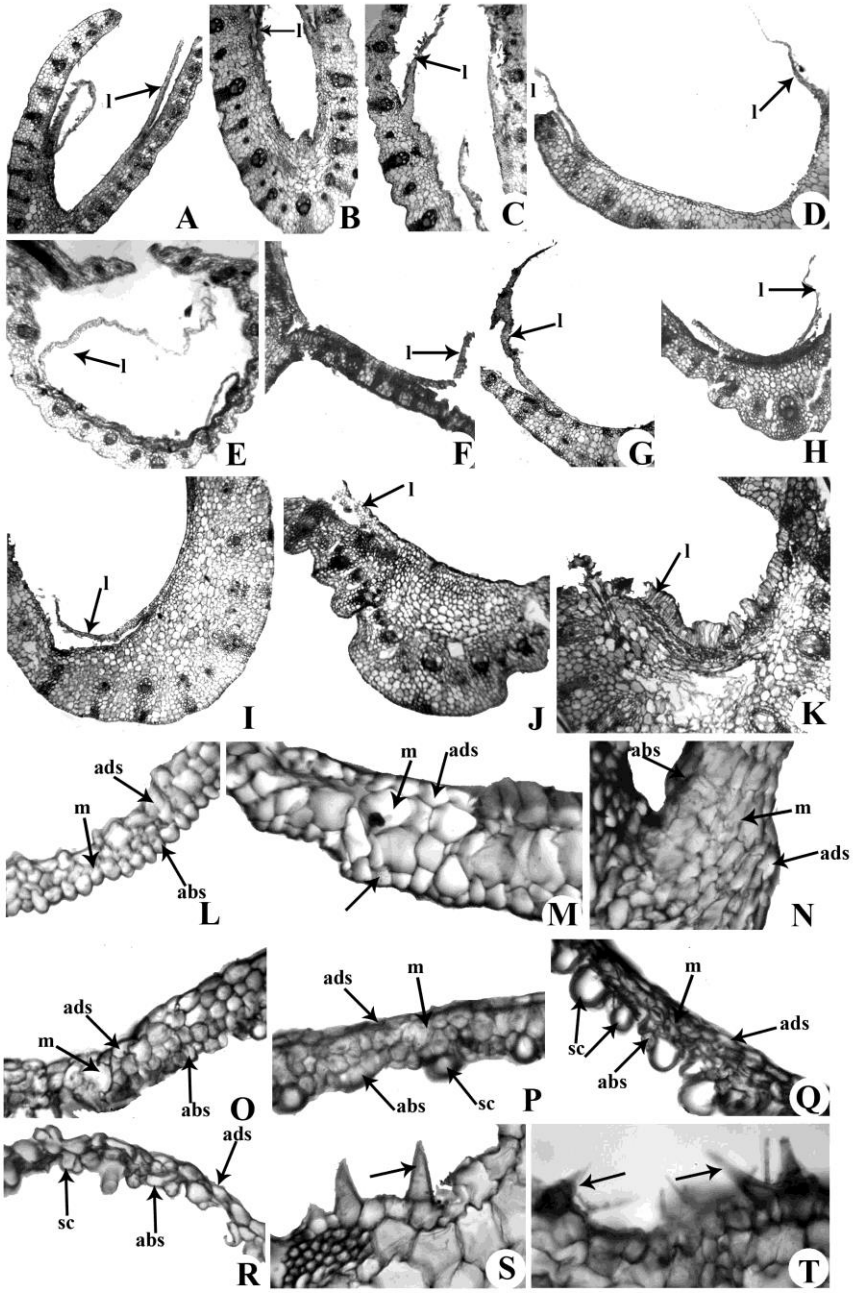

Fig. 123

CHARACTERISTIC FEATURES IN LEAVES OF THE DIFFERENT GRASS SPECIES:

The characteristic features noted in following different leaf parts i.e. leaf lamina, leaf sheath, ligule of the grass species have been described. Microphotographs depicting the features have been put up after the description of each species, individually. Description of genera with more than one species have been considered together. Variations in the characteristic features of the different species have been depicted in the given descriptions at athe appropriate points. Microphotographs of the species have been given separately. At the end of the species description of a single genera key to identify them are also provided. A dichotomous key differentiating the 100 species on the basis of leaf anatomical characters has been represented at the end of the discussion.

1. *Chionachne koenigii*

LEAF LAMINA: (Fig. 124 A-G)

Outline of the lamina: Expanded with flat, even leaf blade (Fig. A), ribs and furrows absent.

Keel is well developed, semicircular with an indistinguishable median vascular bundle, three 1st order vascular bundles and a small 3rd order vascular bundle arranged abaxially. Small, rounded parenchyma cells are present surrounding the median vascular bundle adaxially. Sclerenchyma present on abaxial surface of the keel is associated with vascular bundles in form of girders.

Epidermis: Adaxial epidermal surface has restricted group of large inflated bulliform cells of two different types (1) in level with epidermal surface (Fig. F, arrow) (2) projecting above the epidermal surface (Fig. G, arrow). Epidermal cells have thick cuticle. Prickles, macrohiars, hooks are absent.

Mesophyll: Indistinctly or incompletely radiating, small, isodiametric, Compactly homogenous chlorenchymatous cells occupying the major area between the adaxial and abaxial epidermides. Chlorenchyma cells are continuous strap shaped and elongated between bundles. Colourless cells absent.

Vascular bundles: Five 1st order vascular bundles regularly arranged from median bundle to the margin of in half lamina. Six 3rd order bundles between consecutive larger bundles and six 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and towards the abaxial surface.

3rd order vascular bundles: Square with Xylem and phloem groups distinguishable (Fig. F).

2nd order vascular bundles: Circular shaped (Fig. E).

1st order vascular bundles: (Fig. G).

Shape: Circular

Relationship of phloem cells and the vascular fibres: Phloem adjoins the inner or parenchyma sheath

Nature of lysigenous cavity and protoxylem: Enlarged protoxylem vessel present but no lysigenous cavity

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Very wide vessels

Shape of metaxylem vessels: Circular

Median vascular bundles: (Fig. D).

Shape: Circular

Relationship of phloem cells and the vascular fibres: Phloem adjoins the inner or parenchyma sheath

Nature of lysigenous cavity and protoxylem: Enlarged protoxylem vessel present but no lysigenous cavity

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: very wide vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. F, arrowhead).

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated; often rather irregular

2nd order vascular bundle's bundle sheath: (Fig. E, arrowhead).

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated; often rather irregular

Number of bundle sheath cell: 10

Nature of bundle sheath (either complete or incomplete): Incomplete, abaxially interrupted by sclerenchyma cells

Chloroplast position in bundle sheath cell: Chloroplast concentrated near the inner tangential wall

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. G).

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath incomplete, abaxially interrupted by 1-3 layers of sclerenchymatous fibers.

Extension of bundle sheath: Abaxial extension of the bundle sheath: broad extension; tri- or multi-seriate

Number of cells comprising the bundle sheath: 15-16 parenchyma cells

Bundle sheath cell shape: All cells are elliptical, elongated in shape. Chloroplast concentrated near the outer tangential wall of cell.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Absent

Abaxial sclerenchyma: Well developed girder, wider than deep (Fig. C, D, E arrow)

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming a well developed (Fig. B, arrow) rounded cap. Epidermal cells of margin are thin with outer thick tangential wall (Fig. B).

LEAF SHEATH ANATOMY (Fig. 124 H-K)

Outline of lamina: 'V' shaped, broad, outwardly bowed, margins are inrolled. Ribs and furrows absent (Fig. H).

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: barrel shaped with thick cuticle.Restricted groups of tall and narrow bulliform cells which are not inflated and having parallel-sided cells or with outer tangential wall slightly shorter than the inner wall (Fig. K).

Ground tissue: Parenchymatous ground tissue, vertically oval shaped air cavity present (Fig. H, arrow)

Vascular bundle:

Arrangement of vascular bundle: One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Circular with vascular tissue consisting of only few indistinguishable vascular elements

2nd order vascular bundle: Circular shaped

1st order vascular bundle: Circular with phloem adjoining the inner or parenchyma sheath, lysigenous cavity absent but protoxylem vessel present. Circular very wide metaxylem vessel elements (Fig. J).

Vascular bundle sheath: (Fig. J).

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath complete

Number of cells comprising the bundle sheath: 14-15 parenchyma cells

Bundle sheath cell shape: Different sized round, cells smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of vertical well developed strand on abaxial surface (Fig. I, arrow).

LIGULE ANATOMY (Fig. 124 L, M)

Shape: Ligule attached to the lamina more than half length of it, blunt narrow "V" shaped at the connection point (Fig. L, arrow).

Anatomy: Two layered mesophlyll cells between adaxial and abaxial epidermis.(Fig. M).

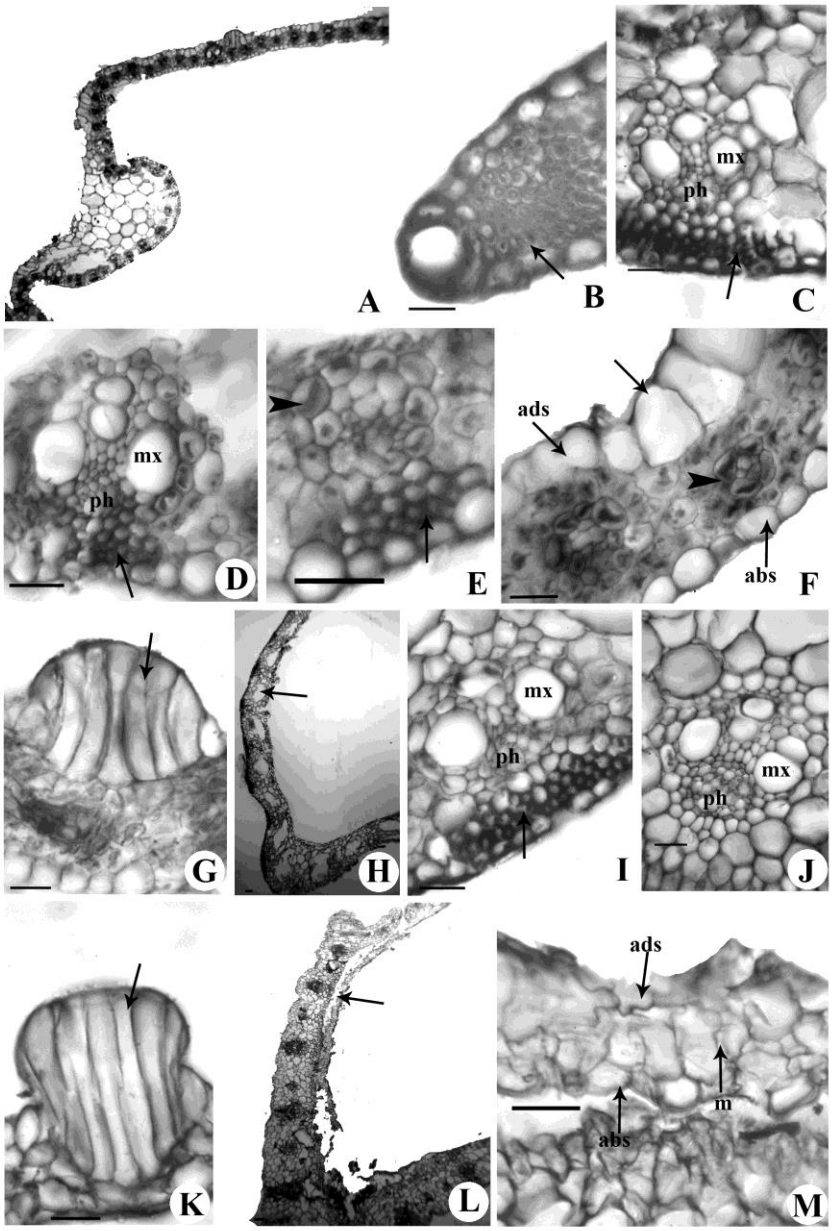

Fig. 124

2.*Coix lachryma-jobi*

LEAF LAMINA: (Fig. 125 A-H)

Outline of the lamina: Expanded with flat, even leaf blade (Fig. A), ribs and furrows absent.

Keel is well developed, semicircular with a indistinguishable median vascular bundle, four 1st order vascular bundles, small 2nd and 3rd order vascular bundle arranged abaxially and keel breaking down by one enlarged air space. Small, rounded parenchyma cells are present surrounding the vascular bundle adaxially.

Epidermis: Adaxial epidermal surface is majorly made up of by inflated, slightly thick walled bulliform cells and also few restricted group of bulliform cells (Fig. B, arrow) present which are slightly above the level of epidermal surface. Prickles, macrohiars, hooks are absent.

Mesophyll: Indistinctly or incompletely radiating, small, isodiametric, Compactly arranged homogenous chlorenchyma cells occupying the major area between the adaxial and abaxial epidermides. Chlorenchyma cells are continuous strap shaped and elongated between bundles. Colourless cells absent.

Vascular bundles: Nine 1st order vascular bundles regularly arranged from median bundle to marginal vascular bundle in half lamina. Six 3rd order bundles between consecutive larger bundles and two 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and towards the abaxial surface.

3rd order vascular bundles: Circular (Fig. D, arrow) and elliptical (Fig. E, arrow), vascular tissue consisting of only few indistinguishable vascular elements

2nd order vascular bundles: Circular (Fig. F, arrow).

1st order vascular bundles: (Fig. G).

Shape: Circular

Relationship of phloem cells and the vascular fibres: Phloem adjoins the inner or parenchyma sheath

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Very wide vessels

Shape of metaxylem vessels: Circular

Median vascular bundles: (Fig. H, arrow).

Shape: Circular

Relationship of phloem cells and the vascular fibres: Phloem adjoins the inner or parenchyma sheath

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Very wide vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. D, E).

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated; often rather irregular

2nd order vascular bundle's bundle sheath: (Fig. F)

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated; often rather irregular

Number of bundle sheath cell: 12-14

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplasts centrally situated

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. G).

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath complete

Extension of bundle sheath: Broad abaxial and narrow adaxial extension of the bundle sheath

Number of cells comprising the bundle sheath: 17-18 parenchyma cells

Bundle sheath cell shape: Elliptical, elongated cells. Chloroplasts centrally situated.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Minute strand consisting of only a few subepidermal fibers

Abaxial sclerenchyma: Well developed strand, wider than deep

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming a well developed pointed fibrous cap. Epidermal cells of margin are small, thick walled (Fig. C).

LEAF SHEATH ANATOMY (Fig. 125 I-L)

Outline of lamina: 'U' shaped. Minute ribs and furrows on abaxial surface present opposite to all vascular bundles (Fig. I).

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: square to barrel shaped with thick cuticle. Stomata present (Fig. K, arrow).

Ground tissue: Parenchymatous ground tissue, horizontally oval to square shaped air cavity present (Fig. J, arrow).

Vascular bundle:

Arrangement of vascular bundle: One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Circular with vascular tissue consisting of only few indistinguishable vascular elements (Fig. K).

2nd order vascular bundle: Circular

1st order vascular bundle: Circular with phloem adjoins the inner or parenchyma sheath, Lysigenous cavity and enlarged protoxylem vessel present. Circular wide metaxylem vessel element (Fig. L).

Vascular bundle sheath: (Fig. K, L arrow).

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath complete

Number of cells comprising the bundle sheath: 19-20 parenchyma cells

Bundle sheath cell shape: Different sized elliptical, elongated cells smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of straight horizontal well developed girder on abaxial surface.

LIGULE ANATOMY (Fig. 125 M, N)

Shape: Ligule attached to the half width of the leaf sheath region and it is round shaped at the connection point (Fig. M, arrow).

Anatomy: Two layered mesophyll cells between adaxial and abaxial epidermis (Fig. N).

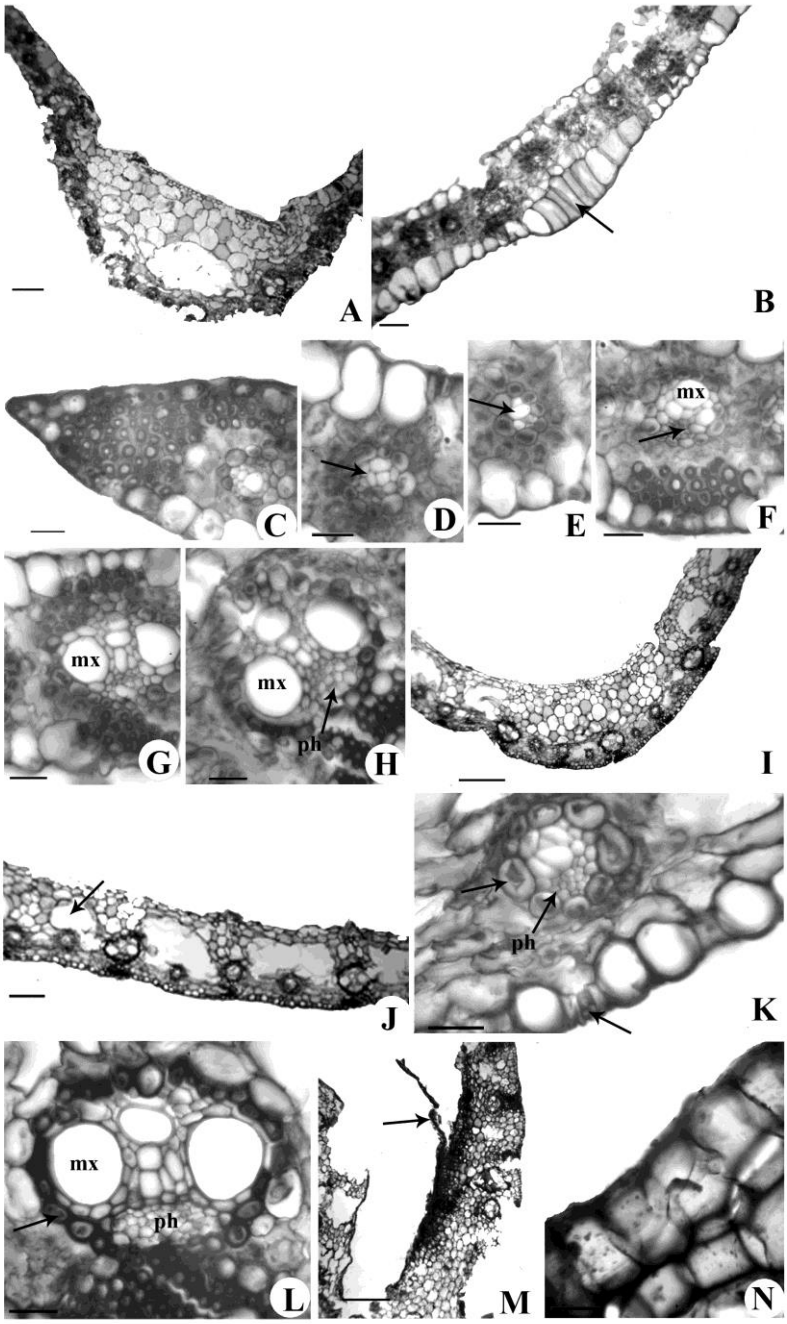

Fig. 125

3. *Andropogon pumilus*

LEAF LAMINA: (Fig. 126 A-E)

Outline of the lamina: Expanded with flat, even leaf blade (Fig. A). Ribs and furrows absent.

Keel is well developed, semicircular with single median bundle, two 3rd order vascular bundle arranged abaxially. Small, rounded parenchyma cells are present surrounding the median vascular bundle adaxially. Sclerenchyma present on abaxial surface of keel is associated with central bundle in form of small, anchor-shaped girder.

Epidermis: Adaxial epidermal surface with restricted fan shaped bulliform cells with larger, shield-shaped central cell (Fig. C, arrow). Bulliform cells occuping ¼-½ of the leaf thickness. Short, slender hairs are present (Fig. D, arrow). Prickles, hooks are absent.

Mesophyll: Radiate, single layered isodiametric chlorenchyma i.e. panicoid type, completely surrounding bundles and radiating cells of successive bundles adjoin one another. Colourless cells absent.

Vascular bundles: Two 1st order vascular bundles regularly arranged from median bundle to marginal bundle in half lamina. 4 3rd order bundles between consecutive larger bundles and 4 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally in leaf blade.

3rd order vascular bundles: Hexagonal with vascular tissue consisting of only few indistinguishable vascular elements (Fig. C).

2nd order vascular bundles: Hexagonal

1st order vascular bundles: (Fig. E).

Shape: Circular

Relationship of phloem cells and the vascular fibres: completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Median vascular bundles:

Shape: Round

Relationship of phloem cells and the vascular fibres: completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. C).

Shape: Elliptical

Shape of bundle sheath cell: Radial and outer tangential walls straight; inner tangential wall inflated

2nd order vascular bundle's bundle sheath:

Shape: Elliptical

Shape of bundle sheath cell: Radial and outer tangential walls straight; inner tangential wall inflated

Number of bundle sheath cell: 8-9

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: chloroplasts fill entire cell lumen

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. E, arrowhead).

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: absent

Number of cells comprising the bundle sheath: 11-12 parenchyma cells

Bundle sheath cell shape: Radial and outer tangential walls straight; inner tangential wall inflated. All cells similar in shape and similar sized as ground tissue. Chloroplasts fill entire cell lumen

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Absent

Abaxial sclerenchyma: Small, narrow strand but fairly deep; only 2 - 4 fibres wide

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very small pointed fibrous cap. Epidermal cells thin with outer thick tangential wall (Fig. B).

LEAF SHEATH ANATOMY (Fig. 126 F-I)

Outline of lamina: Broad 'V' shaped with inrolled margins and arms forms heart shape (Fig. F). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: barrel shaped with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavities.

Vascular bundle:

Arrangement of vascular bundle: One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Pentagonal shaped, Hexagonal, vascular tissue consists of only a few indistinguishable elements vascular (Fig. I).

2nd order vascular bundle: Circular shaped (Fig. H).

1st order vascular bundle: Circular with phloem adjoins the inner or parenchyma sheath, Lysigenous cavity and enlarged protoxylem vessel present, Circular wide metaxylemvessel elements (Fig. G).

Vascular bundle sheath: (Fig. G, H arrowhead).

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath incomplete, abaxailly interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 19-20 parenchyma cells

Bundle sheath cell shape: Elliptical, elongated cells often interrupted by normal parenchyma sheath cells. Cells smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of straight horizontal well developed girderon abaxial surface.

LIGULE ANATOMY (Fig. 126 J, K)

Shape: 'V' shaped, Ligule attached to the lamina till ¾ portion then is free and blunt, broad "V" shaped at the connection (Fig. J, arrow).

Anatomy: Single layered mesophyll cells between adaxial and abaxial epidermis (Fig. K).

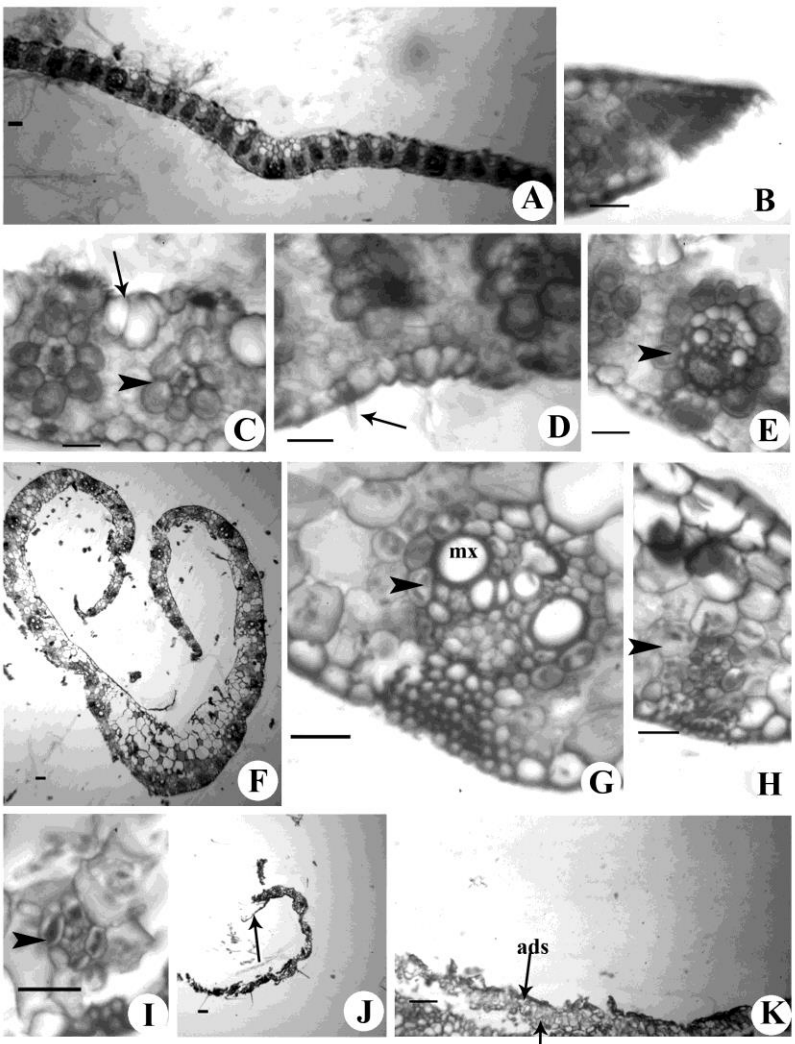

Fig. 126

4. *Apluda mutica*

LEAF LAMINA: (Fig. 127A-E)

Outline of the lamina: 'V' shaped (Fig. A) with wide angle having straight arms of lamina and two halves are symmetrical on either side of the median vascular bundle. Furrows and ribs present between all vascular bundles (Fig. B). Shallow and narrow furrows present on both the surface. Triangular shaped ribs present (Fig. B).

Keel is well developed, U shaped (Fig. C), slightly thicker than rest of lamina and projecting abaxially due to position and size of single median vascular bundle. Small, rounded parenchyma cells are present surrounding the median vascular bundle adaxially. Sclerenchyma present on adaxial surface in form of strands and on abaxial surface associated with vascular bundles in form of strands (Fig. C).

Epidermis: Adaxial epidermal has restricted group of large isolated and inflated bulliform cells present on sides of deep furrows interrupted with irregular small groups of epidermal cells which covered with thick cuticle (Fig. D). Hooks present (Fig. D, arrow). Short macrohairs present (Fig. D).

Mesophyll: Radiate, single layered isodiametric chlorenchyma completely surrounding bundles. Colourless cells absent (Fig. D).

Vascular bundles: Two 1st order vascular bundles regularly arrangement from median bundle to marginal budndle in half lamina. Eight-nine 3rd order bundles between consecutive larger bundles and Eight-nine 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centerally in leaf blade.

3rd order vascular bundles: Elliptical with vascular tissue consisting of only few indistinguishable vascular elements (Fig. E, arrow).

2nd order vascular bundles: Circular shaped

1st order vascular bundles:

Shape: Elliptical (Fig. D)

Relationship of phloem cells and the vascular fibres: Phloem adjoins the inner or parenchyma sheath

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Median vascular bundles: (Fig. C)

Shape: Obovate

Relationship of phloem cells and the vascular fibres: Phloem completely surrounded by thick-walled fibres

Nature of lysigenous cavity and protoxylem: Lysigenous cavity present, protoxylem vessel absent

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath:

Shape: Elliptical

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 7-8

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast concentrated near the outer tangential wall

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath:

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 14-15 parenchyma cells

Bundle sheath cell shape: All cells are elliptical, elongated in shape. Chloroplast concentrated near the outer tangential wall of cell.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Minute strand consisting of only a few subepidermal fibers

Abaxial sclerenchyma: Small, narrow strand but fairly deep; only 2-4 fibres wide

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very small rounded fibrous cap. Epidermal cells of margin are thin with outer thick tangential wall.

LEAF SHEATH ANATOMY (Fig. 127 F-H)

Outline of lamina: Round shaped. Ribs and furrows present opposite to 1st order vascular bundle on abaxial surface.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with vertically oval/oblong shaped air cavity present (Fig. F).

Vascular bundle:

Arrangement of vascular bundle: One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Circular shaped, vascular tissue consists of only a few indistinguishable vascular elements

2nd order vascular bundle: Circular shaped (Fig. G)

1st order vascular bundle: Circular with phloem completely surrounded by thick walled fibers, lysigenous cavity and enlarged protoxylem vessel present. Circular shaped widemetaxylem vessel elements (Fig. H).

Vascular bundle sheath:

Shape: Round, circular (Fig. H)

Extent of bundle sheath around the vascular bundle: Sheath complete

Number of cells comprising the bundle sheath: 13-14 parenchyma cells

Bundle sheath cell shape: Elliptical, elongated cells smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of straight horizontal well developed strandon abaxial surface.

LIGULE ANATOMY (Fig. 127 I, J)

Shape: Ligule attached to the midrib region and little with lamina region, and at the connection it is broad round shaped (Fig. I, arrow)

Anatomy: More than three layered mesophyll cells between adaxial and abaxial surfaces (Fig. J)

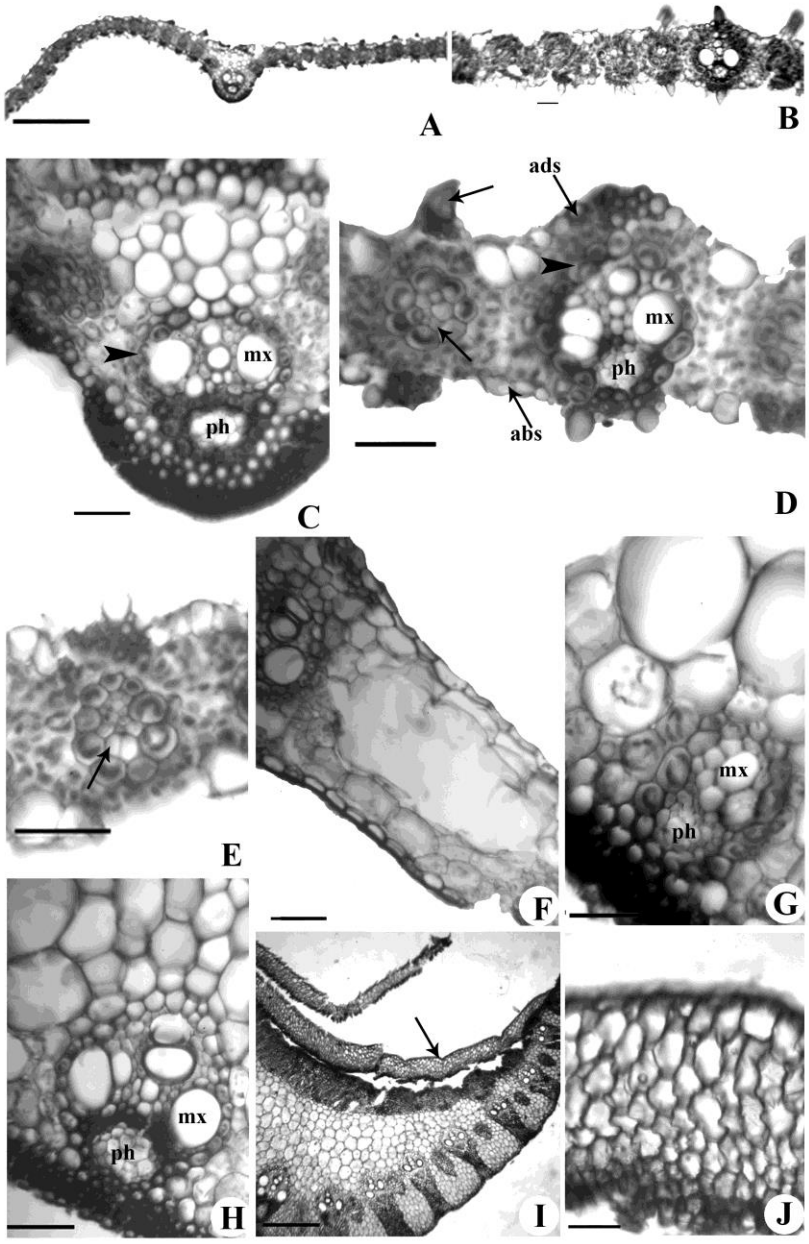

Fig. 127

5. *Arthraxon lanceolatus*

LEAF LAMINA: (Fig. 128 A-E)

Outline of the lamina: Expanded with pleated, distinctly undulating leaf blade. Ribs and furrows present on both surfaces. Wide, deep furrows present between all vascular bundles. All ribs similr, triangular shaped present over all vascular bundle. Keel is not well developed.

Epidermis: Epidermal surface has barrel to rectangular shaped cells with thin cuticle.Bulliform cells are absent. Pointed broad prickle present (Fig. E, arrow).

Mesophyll: Indistinctly or incompletely radiating, small, isodiametric. Cells compactly homogenous chlorenchymatous cells occupying the major area between the adaxial and abaxial epidermides. Chlorenchyma cells are continuous between bundles. Colourless cells absent.

Vascular bundles: Three 1st order vascular bundles regularly arrangement from median bundle to marginal budndle in half lamina. 3 3rd order bundles between consecutive larger bundles and 3-4 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally in leaf blade.

3rd order vascular bundles: Circular with vascular tissue consisting of only few indistinguishable vascular elements (Fig. D).

2nd order vascular bundles: Elliptical shaped (Fig. C).

1st order vascular bundles: (Fig. B)

Shape: Obovate

Relationship of phloem cells and the vascular fibres: Phloem adjoins the inner or parenchyma sheath

Nature of lysigenous cavity and protoxylem: Enlarged protoxylem vessel present, lysigenous cavity absent

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. D, arrow)

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath:

Shape: Elliptical

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 17

Nature of bundle sheath (either complete or incomplete): complete

Chloroplast position in bundle sheath cell: Translucent

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath:

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 23-24 parenchyma cells comprise the sheath

Bundle sheath cell shape: All cells are elliptical, elongated in shape. Chloroplast translucent.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial and abxial sclerenchyma: Minute strand consisting of only a few subepidermal fibers

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming a very small pointed cap. Epidermal cells of margin are thin-walled.

LEAF SHEATH ANATOMY (Fig. 128 F, G)

Outline of lamina: Round shaped withinrolled margins. Shallow ribs and furrows present over all vascular bundle (Fig. F).

Epidermis: Adaxial epidermal cells and abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with oval shaped air cavity present (Fig. F, arrow)

Vascular bundle: (Fig. G)

Arrangement of vascular bundle: Two consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Circular with vascular tissue consisting of only few indistinguishable vascular elements

2nd order vascular bundle: Elliptical shaped

1st order vascular bundle: Elliptical with phloem completely surrounded by thick walled fibers, lysigenous cavity and enlarged protoxylem vessel present. Circular wide metaxylem vessel element.

Vascular bundle sheath:

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Sheath incomplete, interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 14-15 parenchyma cells

Bundle sheath cell shape: All cells are elliptical, elongated in shape.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of well developed wide girder present on abaxial surface.

LIGULE ANATOMY (Fig. H-J)

Shape: Ligule attached along half width of the leaf sheath region and it is round shaped at connection point (Fig. H, arrow).

Anatomy: Two layered mesophyll cells between adaxial and abaxial surfaces. Sclerenchyma cells (Fig. I, arrow) and prickles (Fig. J, arrow) present on abaxial surface.

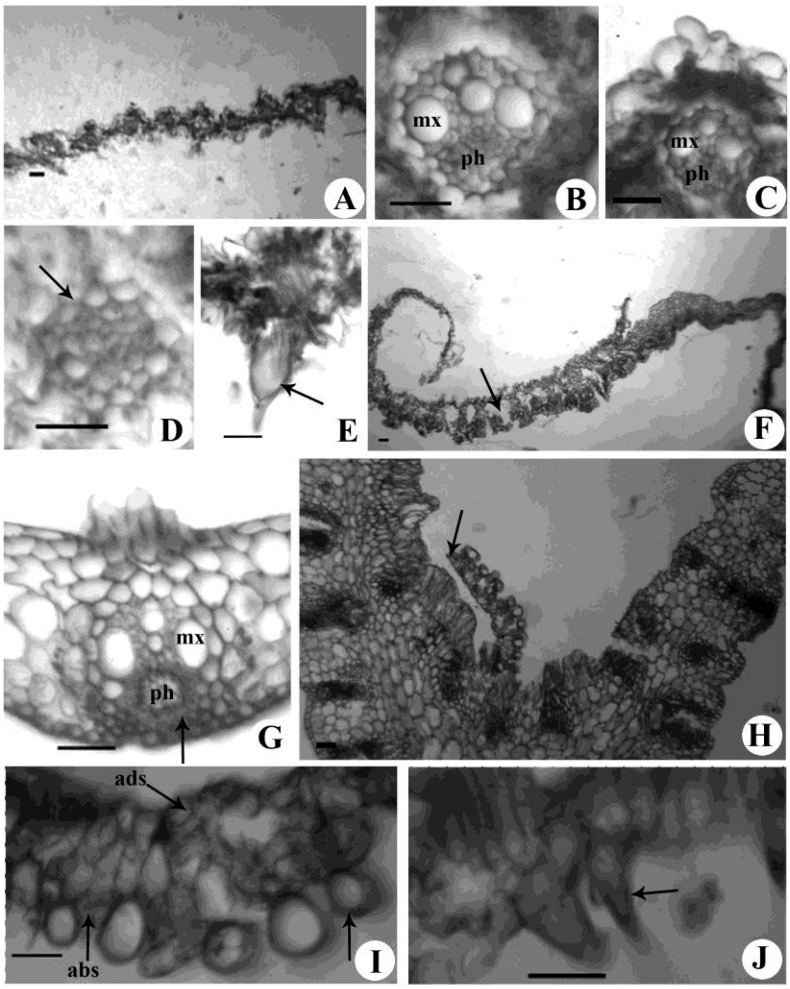

Fig. 128

6. *Bothriochloa pertusa*

LEAF LAMINA: (Fig. 129A-F)

Outline of the lamina: 'V' shaped with wide angle having convex shaped outwardly curving of the arms. Two halves are symmetrical on either side of the median vascular bundle (Fig. A). Ribs and furrows are absent on the leaf surface.

Keel is well developed, V-shaped with a indistinguishable median vascular bundle, one 1st and 2nd oder vascular bundles and two 3rd order vascular bundles arranged abaxially. Small, rounded parenchyma cells are present surrounding the median vascular bundle adaxially. Sclerenchyma present on adaxial surface of keel is associated with vascular bundles in form of straight horizontal well developed strands.

Epidermis: Adaxial epidermal surface has isolated, large, inflated bulliform cells (Fig. D, arrow) interrupted by small groups of inflated and slightly outer thickened walled epidermal cells which are covered with thin cuticle. Abaxial surface has barrel shaped epidermal cells with cuticle. Few epidermal cells have cell wall equal to or greater than the depth of the average epidermal cells (Fig. D, E). Long, slender macrohairs present (Fig. C).

Mesophyll: Radiate, single layered isodiametric chlorenchyma which completely surrounds vascular bundles. Compact homogenous chlorenchymatous cells occupy the major area between the adaxial and abaxial epidermides. Chlorenchyma cells continuous between bundles. Colourless cells absent.

Vascular bundles: 2 1st order vascular bundles regularly arranged from median bundle to marginal bundle in half lamina. 2-3 3rd order bundles between consecutive larger bundles and 2-3 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles are present at the same level and centrally placed in leaf blade.

3rd order vascular bundles: Hexagonal shaped and vascular tissue consisting of only a few indistingushiable vascular elements (Fig. D).

2nd order vascular bundles: Elliptical shaped (Fig. E)

1st order vascular bundles: (Fig. F)

Shape: Circular

Relationship of phloem cells and the vascular fibres: Phloem adjoins the inner or parenchyma sheath

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Shape of metaxylem vessels: Circular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. D, arrowhead)

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath: (Fig. E, arrowhead)

Shape: Elliptical

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 10-11

Nature of bundle sheath (either complete or incomplete): Incomplete, abaxially interrupted by subepidermal sclerenchyma strands

Chloroplast position in bundle sheath cell: Chloroplast centrally situated

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. E, arrowhead)

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath incomplete, abaxially interrupted by parenchyma cells

Extension of bundle sheath: Broad adaxial extension of the bundle sheath

Number of cells comprising the bundle sheath: 16-17 parenchyma cells

Bundle sheath cell shape: All cells are elliptical, elongated in shape and shows gradation in size towards abaxial side. Chloroplast centrally in the cell.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Minute strand consisting of only a few subepidermal fibers

Abaxial sclerenchyma: Minute strand consisting of only a few subepidermal fibers (Fig. F, arrow)

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming well developed fibrous pointed cap (Fig. B). Epidermal cells of margin are thick walled and covered with cuticle.

LEAF SHEATH ANATOMY (Fig. 129 G-J)

Outline of lamina: V shaped with standard angle and inrolled margins. Ribs and furrows absent (Fig. G).

Epidermis: Adaxial and abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle (Fig. H).

Ground tissue: Parenchymatous with absence of air cavity.

Vascular bundle:

Arrangement of vascular bundle: One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Circular with vascular tissue consists of only a few indistinguishable vascular elements (Fig. J)

2nd order vascular bundle: Oval shaped (Fig. H)

1st order vascular bundle: Circular with phloem completely surrounded by thick walled fibers, lysigenous cavity and enlarged protoxylem vessel present. Circular wide metaxylem vessel elements (Fig. I).

Vascular bundle sheath: (Fig. H, J arrowhead)

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath incomplete, interrupted by parenchyma cells adaxially and sclerenchyma cells abaxially

Number of cells comprising the bundle sheath: 14-15 parenchyma cells comprise the sheath

Bundle sheath cell shape: Elliptical, elongated in shape. Cells smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of straight horizontal well developed broad strand on abaxial surface (Fig. F, arrow).

LIGULE ANATOMY (Fig. 129 K, L)

Shape: Ligule attached to the lamina more than half length of it and blunt “V” shaped and narrow at the connection point (Fig. K, arrow)

Anatomy: Single layered mesophyll cells between adaxial and abaxial surfaces (Fig.L)

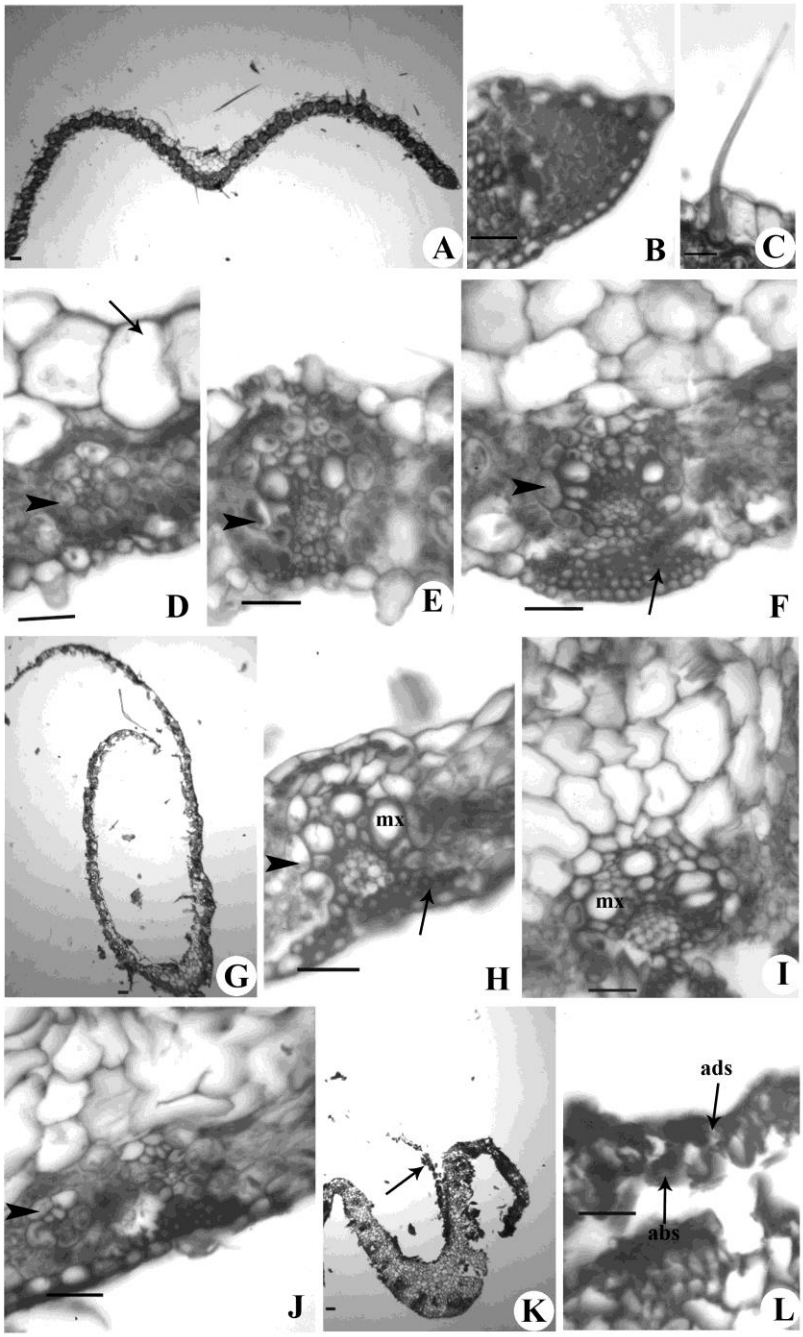

Fig. 129

7. *Capillipedium huegelii*

LEAF LAMINA: (Fig. 130 A-F)

Outline of the lamina: 'V' shaped with wide angle (Fig. A), having straight shape of the arms. Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows present on leaf surface. Medium, wide furrow present between 1st and 2nd order vascular bundles. Round tall ribs on abaxial surface and triangular shorter ribs on adaxial surface present over 1st and 2nd order vascular bundles.

Keel is well developed, V-shaped with single median vascular bundle (Fig. A). Small, round parenchyma present surround the median vascular bundle adaxially. Sclerenchyma on abaxial surface of keel associated with vascular bundles in form of well developed, wide girder (Fig. B, arrow).

Epidermis: Adaxial epidermal surface has isolated large, inflated bulliform cells interrupted with small barrel to rectangular shaped epidermal cells which are covered with thick cuticle. Short prickles present (Fig. D, arrow). Abaxial surface has barrel to rectangular shaped epidermal cells covered with cuticle and single papillae per cell (Fig. E, arrow). Short, slender macrohairs present (Fig. F, arrow).

Mesophyll: Radiate, single layered, tubular, cells completely surrounding vascular bundles. Compactly arranged homogenous chlorenchymatous cells occupy the major area between the adaxial and abaxial epidermides. Chlorenchyma cells continuous between bundles. Colourless cells absent.

Vascular bundles: 8 1st order vascular bundles regularly arranged from median bundle to marginal bundle in half lamina. 6-7 3rd order bundles between consecutive larger bundles and 4-5 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and centrally placed in leaf blade.

3rd order vascular bundles: Hexagonal with vascular tissue consisting of only a few indistingusihable vascular elements (Fig. D).

2nd order vascular bundles: Circular shaped (Fig. C)

1st order vascular bundles: (Fig. E)

Shape: Triangular

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Very wide vessels

Shape of metaxylem vessels: Circular

Median vascular bundles: (Fig. B)

Shape: Obovate

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Very wide vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. D, arrowhead)

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath: (Fig. C, F)

Shape: Circular

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 11-12

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast centrally placed

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath:

Shape: Triangular

Extent of bundle sheath around the vascular bundle: Complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 13-14 parenchyma cells comprise the sheath

Bundle sheath cell shape: All cells are elliptical, elongated in shape; Chloroplast placed centrally.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Minute strand consisting of only a few subepidermal fibers

Abaxial sclerenchyma: Narrow strand, few fiber cells follow the ribs and furrows

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming a small pointed fibrous cap. Epidermal cells of margin are thin with outer thick tangential wall.

LEAF SHEATH ANATOMY (Fig. 130 G-I)

Outline of lamina: 'V' shaped with standard angle and overlapping inrolled margins (Fig. G). Minute ribs and furrows present over the 1st order vascular bundle.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, rectangular to barrel shaped with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavity.

Vascular bundle:

Arrangement of vascular bundle: Two consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Circular with vascular tissue consisting of only few indistinguishable vascular elements (Fig. H).

2nd order vascular bundle: Circular shaped

1st order vascular bundle: Circular with phloem completely surrounded by thick walled fibers, lysigenous cavity and enlarged protoxylem vessel present. Circular very wide metaxylem vessel elements.

Vascular bundle sheath: (Fig. H, I, arrowhead)

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath incomplete, interrupted by few sclerenchyma cells

Number of cells comprising the bundle sheath: 15-16 parenchyma cells

Bundle sheath cell shape: Elliptical, elongated and smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of straight horizontal well developed narrow strand on abaxial surface.

LIGULE ANATOMY (Fig. 130 J, K)

Shape: Ligule attached to the lamina till ¾ portions then is free and blunt, round shaped at the connection (Fig. J, arrow)

Anatomy: Two layered mesophyll cells between adaxial and abaxial surfaces (Fig. K).

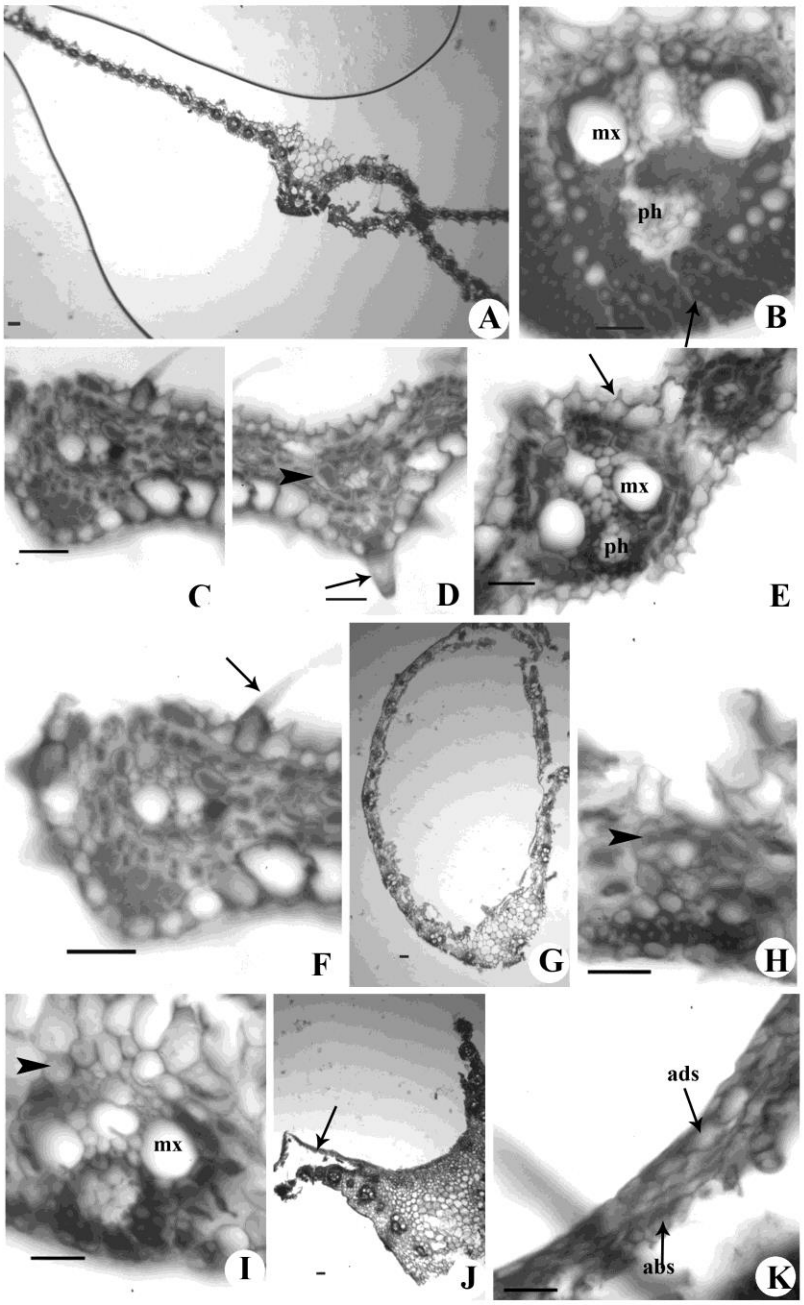

Fig. 130

8. *Chrysopogon fulvus*

LEAF LAMINA: (Fig. 131 A-F)

Outline of the lamina: 'V' shaped with broad angle having striaght arms (Fig. A). Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are absent on the leaf surface.

Keel is well developed, V-shaped with three 1st order vascular bundles, six-seven 2nd and 3rd order vascular bundles. Median and 1st order vascular bundles appear to be of same size. Small, rounded parenchyma cells and chlorenchyma cells are present surrounding adaxial to the median vascular bundle.

Epidermis: Most part of adaxial epidermis made up of rounded, inflated bulliform cells (Fig. E, arrow). Abaxial epidermis with round epidermal cells with thick cuticle. Few cells have papillae (Fig. D, arrow).

Mesophyll: Radiate, single layered, isodiametric cells completely surrounding bundles. Compactly arranged homogenous chlorenchymatous cells occupy the major area between the adaxial and abaxial epidermides and are continuous between bundles. Colourless cells absent.

Vascular bundles: 6 1st order vascular bundles regularly arrange from median bundle to marginal bundle in half lamina. 2-3 3rd order bundles between consecutive larger bundles and 2-3 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally.

3rd order vascular bundles: Pentagonal with vascular tissue consisting of only few indistinguishable vascular elements (Fig. B, arrow).

2nd order vascular bundles: Circular shaped (Fig. F)

1st order vascular bundles:

Shape: Oval

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity present, protoxylem vessel absent

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Shape of metaxylem vessels: Circular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. B, arrowhead)

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath: (Fig. F, arrowhead)

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 8-9

Nature of bundle sheath (either complete or incomplete): Incomplete, abaxially interrupted by sclerenchyma

Chloroplast position in bundle sheath cell: Chloroplast concentrated outer tangential wall

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath:

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath incomplete, abaxially interrupted by sclerenchyma girder

Extension of bundle sheath: Broad adaxial extension of the bundle sheath

Number of cells comprising the bundle sheath: 13-14 parenchyma cells

Bundle sheath cell shape: All cells are elliptical, elongated in shape. Chloroplast concentrated outer tangentially wall.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Absent

Abaxial sclerenchyma: Well developed narrow girder present (Fig. F, arrow)

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very small pointed fibrous cap (Fig. C, arrow). Epidermal cells at margin are thin with outer thick tangential wall.

LEAF SHEATH ANATOMY (Fig. 131 G-J)

Outline of lamina: V shaped with standard angle, concave inrolled margins (Fig. G). Ribs and furrows absent.

Epidermis: Adaxial and abaxial epidermal cells: small, flat, rectangular with thick cuticle.

Ground tissue: Parenchymatous with oval shaped air cavitypresent (Fig. H, arrow).

Vascular bundle:

Arrangement of vascular bundle: One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Circular with vascular tissue consisting of only few indistinguishable vascular elements (Fig. I, arrow).

2nd order vascular bundle: Oval shaped

1st order vascular bundle: Circular with phloem completely surrounded by thick walled fibers. Enlarged protoxylem vessel present, lysigenous cavity absent. Circular wide metaxylem vessel elements.

Vascular bundle sheath: (Fig. I, arrowhead)

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath incomplete, interrupted by parenchyma cells

Number of cells comprising the bundle sheath: 14-15 parenchyma cells

Bundle sheath cell shape: Elliptical, elongated and smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of straight horizontal well developed broad strand present on abaxial surface (Fig. J, arrow).

LIGULE ANATOMY (Fig. 131 K, L)

Shape: Ligule attached to the lamina more than half length of it and blunt “V” shaped and narrow at the connection point (Fig. K)

Anatomy: Many layered mesophyll cells between adaxial and abaxial surfaces (Fig. L, arrow).

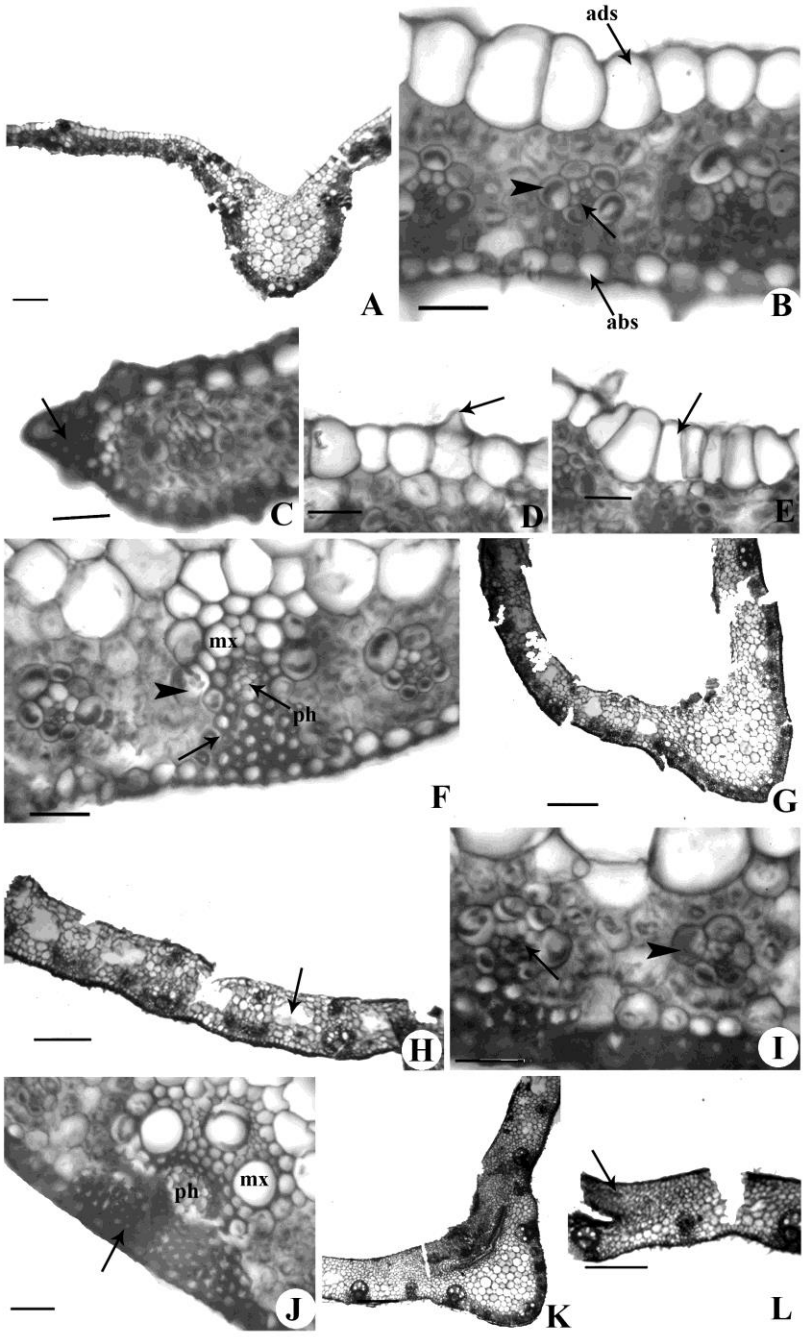

Fig. 131

9. *Cymbopogon martinii*

LEAF LAMINA: (Fig. 132 A-F)

Outline of the lamina: Expanded with flat, even leaf blade, ribs and furrows absent (Fig. A, B).

Keel is well developed, semicircular shaped with single median vascular bundle and two 1st order and two 2nd order vascular bundles. Round parenchyma cells surrounding median vascular bundle adaxially. Sclerenchyma present on adaxial surface in form of strands and on abaxial surface associated with vascular bundles in form of girder.

Epidermis: Adaxial epidermal surface has extensive group of large, inflated bulliform cells present throughout epidermis (Fig. D), size reducing opposite larger bundles and extending over many vascular bundles (Fig. E). Abaxial epidermal cells barrel to round shaped covered with cuticle.

Mesophyll: Radiate, single layered, isodiametric cells completely surrounding bundles. Chlorenchyma cells continuous between bundles and occupy the major area between the adaxial and abaxial epidermides. Colourless cells absent.

Vascular bundles: 7-8 1st order vascular bundles regularly arrangemed from median bundle to marginal bundle in half lamina. Eight 3rd order bundles and two 2nd order bundles between two consecutive 1st order bundles present. All the vascular bundles present at same level and placed abaxially.

3rd order vascular bundles: Hexagonal with vascular tissue consisting of only few indistinguishable vascular elements (Fig. D).

2nd order vascular bundles: Circular shaped (Fig. E).

1st order vascular bundles: (Fig. C)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Protoxylem vessel present, lysigenous cavity absent

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Median vascular bundles:

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. D, arrowhead)

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath: (Fig. E, arrowhead)

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 7-8

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast concentrated near outer tangential wall

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. C, arrowhead)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Complete

Extension of bundle sheath: Narrow, subepidermal strip of girder present on abaxial surface of the bundle sheath

Number of cells comprising the bundle sheath: 15-16 parenchyma cells

Bundle sheath cell shape: All cells are elliptical, elongated in shape. Chloroplast concentrated near outer tangential wall.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Minute strand consisting of only a few subepidermal fibers

Abaxial sclerenchyma: Narrow, subepidermal strip of girder

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming a well developed pointed fibrous cap. Epidermal cells thin with thick tangential wall.

LEAF SHEATH ANATOMY (Fig. 132G-I)

Outline of lamina: Round shaped with single overlapping inrolled margins. Minute, shallow ribs and furrows present (Fig. G).

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous ground tissue, air cavity absent

Vascular bundle:

Arrangement of vascular bundle: One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Circular shaped, vascular tissue consists of only a few indistinguishable vascular elements (Fig. I)

2nd order vascular bundle: Oval shaped

1st order vascular bundle: Circular shaped, phloem completely surrounded by thick walled fibers, lysigenous cavity and enlarged protoxylem vessel present. Circular very wide metaxylem vessel elements (Fig. H).

Vascular bundle sheath: (Fig. H, I arrowhead)

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath incomplete, interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 22-24 parenchyma cells

Bundle sheath cell shape: Elliptical, elongated and smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of narrow well developed girder present on abaxial surface.

LIGULE ANATOMY (Fig. 132 J, K)

Shape: Ligule attached to the half width of the leaf sheath region and it is round shaped at the connection point (Fig. J, arrow)

Anatomy: More than three layered mesophyll cells between adaxial and abaxial surfaces (Fig. K).

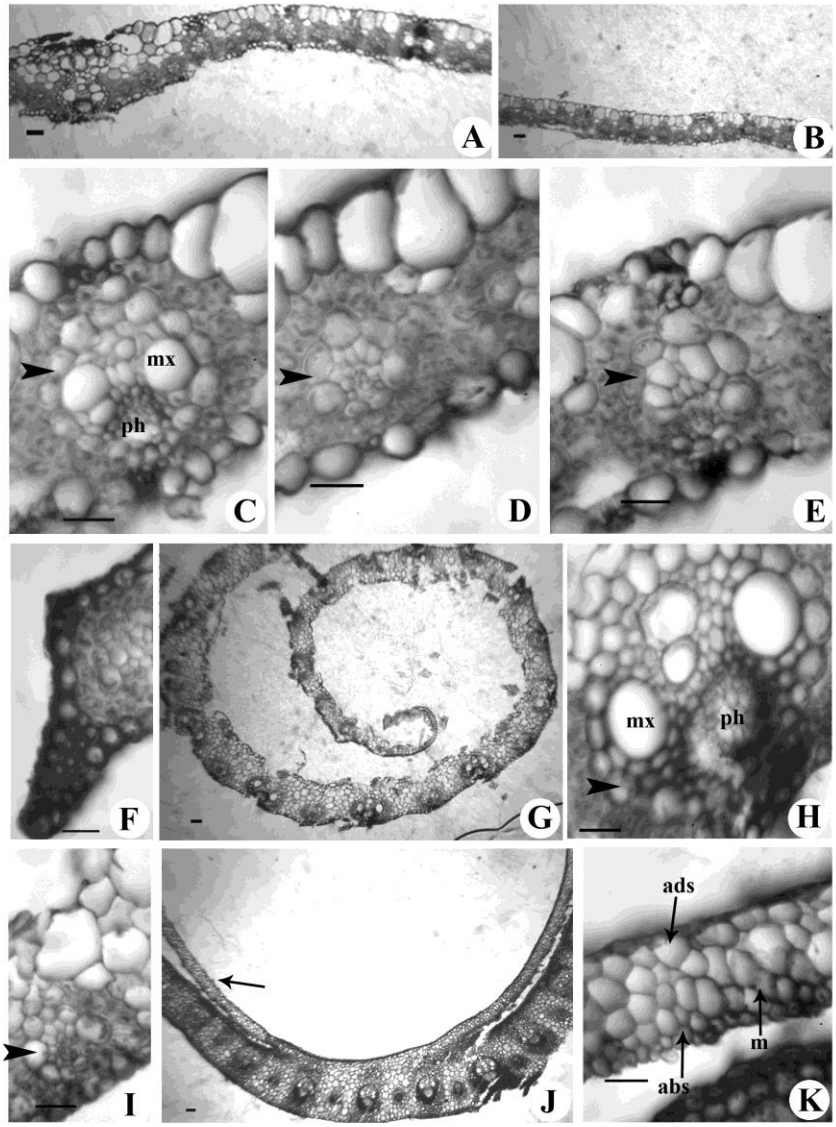

Fig. 132

Dicanthium

10. *Dicanthium annulatum* (Fig. 133)

11. *Dicanthium caricosum* (Fig. 134)

LEAF LAMINA: (Fig. 133, 134 A-E)

Outline of the lamina: 'V' shaped with narrow angle and irregularly wavy (Fig. 133 A, 134 A).

Keel is well developed, inverted 'T' shaped with single median vascular bundle and two 2ndorder and four3rdorder vascular bundle.Rounded parenchyma present surrounding the median vascular bundle abaxially. Sclerenchyma present on abaxial surface in form of horizontal well developed strands (Fig. 133 C, 134 D; arrow).

Epidermis: Adaxial epidermal surface has barrel to square shaped epidermal cells interrupted by restricted groups of large, inflated bullifom cells in level with epidermal cells (Fig. 133 D, arrow; Fig. 134 B, arrow). Abaxial epidermal cells have barrel to rectangular shaped epidermal cells covered with cuticle.

Mesophyll: Radiate, single layered, tubular cells completely surrounding bundles. Chlorenchyma cells continuous between bundles and occuping the major area between the adaxial and abaxial epidermides. Colourless cells absent.

Vascular bundles: 5-6 1st order vascular bundles in *D. annulatum*, 7-8 1st order vascular bundles in *D. caricosum* regularly arranged from median bundle to marginal bundle in half lamina.

4 3rd order bundles and 3 2nd order bundles between two consecutive 1st order bundles present. All the vascular bundles present at same level and placed abaxially.

3rd order vascular bundles: (Fig. 133 B, Fig. 134 E, Fig. 134 B)

Pentagonal shaped in *D. annulatum*; Pentagonal (Fig. 134 E) and elliptical shaped both in *D. caricosum* (Fig. 134 B), xylem and phloem groups distinguishable.

2nd order vascular bundles: Circular shaped

1st order vascular bundles: (Fig. 133, 134 C)

Shape: Obovate

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Protoxylem vessel present, lysigenous cavity absent

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Very wide vessels

Shape of metaxylem vessels: Circular

Median vascular bundles: (Fig. 134 D)

Shape: Obovate

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Protoxylem vessel present, lysigenous cavity absent

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Very wide vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (; Fig. E)

Shape: Round in *D. annulatum* (Fig. 133 B, D arrowhead);

Round (Fig. 134 E, arrowhead) and elliptical (Fig. 134 B, arrowhead) both in *D. caricosum*

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 8-9

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast centrally placed

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath:

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Incomplete, adaxially interuppted by parenchyma and abaxially interrupted by sclerenchyma cells

Extension of bundle sheath: Narrow, subepidermal strip of girder present on abaxial surface of the bundle sheath

Number of cells comprising the bundle sheath: 13-14 parenchyma cells

Bundle sheath cell shape: All cells are elliptical, elongated with different sizes. Chloroplast centrally placed.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Absent

Abaxial sclerenchyma: Minute strand consisting of only a few subepidermal fibers

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming a well developed fibrous pointed cap. Epidermal cells of margin are thin with thick tangential wall (Fig. 133 F, Fig. 134 C).

LEAF SHEATH ANATOMY (Fig. 133, 134 F-H)

Outline of lamina: Round shaped (Fig. 133, 134 F). Ribs and furrows absent.

Epidermis: Adaxial epidermal and abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavity.

Vascular bundle:

Arrangement of vascular bundle: One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Circular shaped, xylem and phloem groups distinguishable (Fig. 133 H, Fig. 134 G)

2nd order vascular bundle: Circular shaped

1st order vascular bundle: Circular shaped, phloem completely surrounded by thick walled fibers, Protoxylem vessel present but no lysigenous cavity. Circular very wide metaxylem vessel elements (Fig. 133 G, Fig. 134 H).

Vascular bundle sheath: (Fig. 133 G, H arrowhead)

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath incomplete, interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 12-14 parenchyma cells comprise the sheath

Bundle sheath cell shape: Elliptical, elongated and smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of wide, horizontal band on abaxial surface.

LIGULE ANATOMY (Fig.133, 134 I, J)

Shape: Ligule attached along half width of the leaf sheath region and it is round shaped at the connection point (Fig. 133, 134 I arrow)

Anatomy: Three layered mesophyll cells between adaxial and abaxial surfaces (Fig. 133, 134 J), *D. annulatum* shows absence of sclerenchyma while *D. caricosum* shows prescence of sclrenchyma on abaxial surface of ligule.

Differentiating features:

Sclerenchyma absent on abaxial surface of ligule……..*D. annulatum*

Sclerenchyma present on abaxial surface of ligule……..……. *D. caricosum*

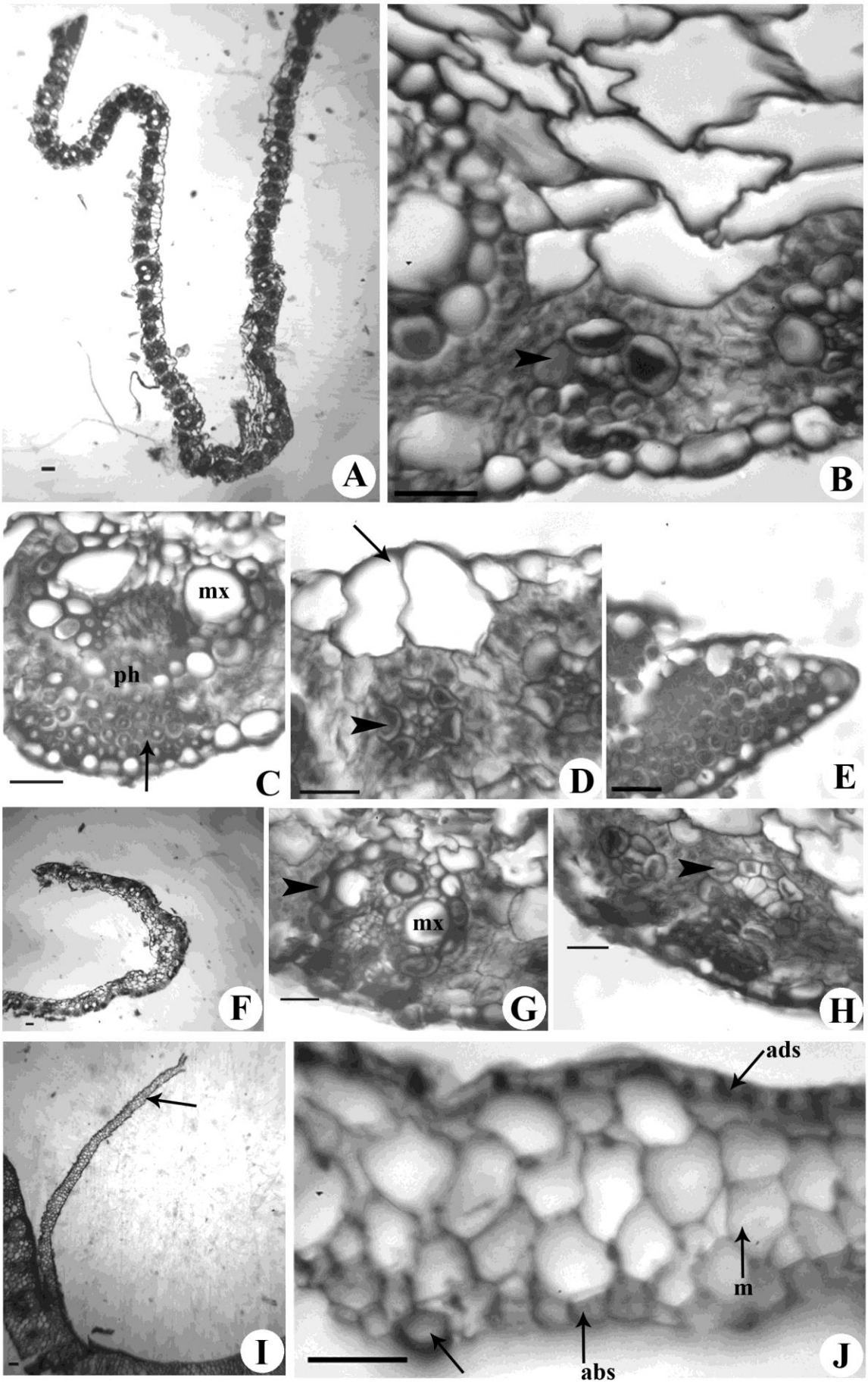

Fig. 133

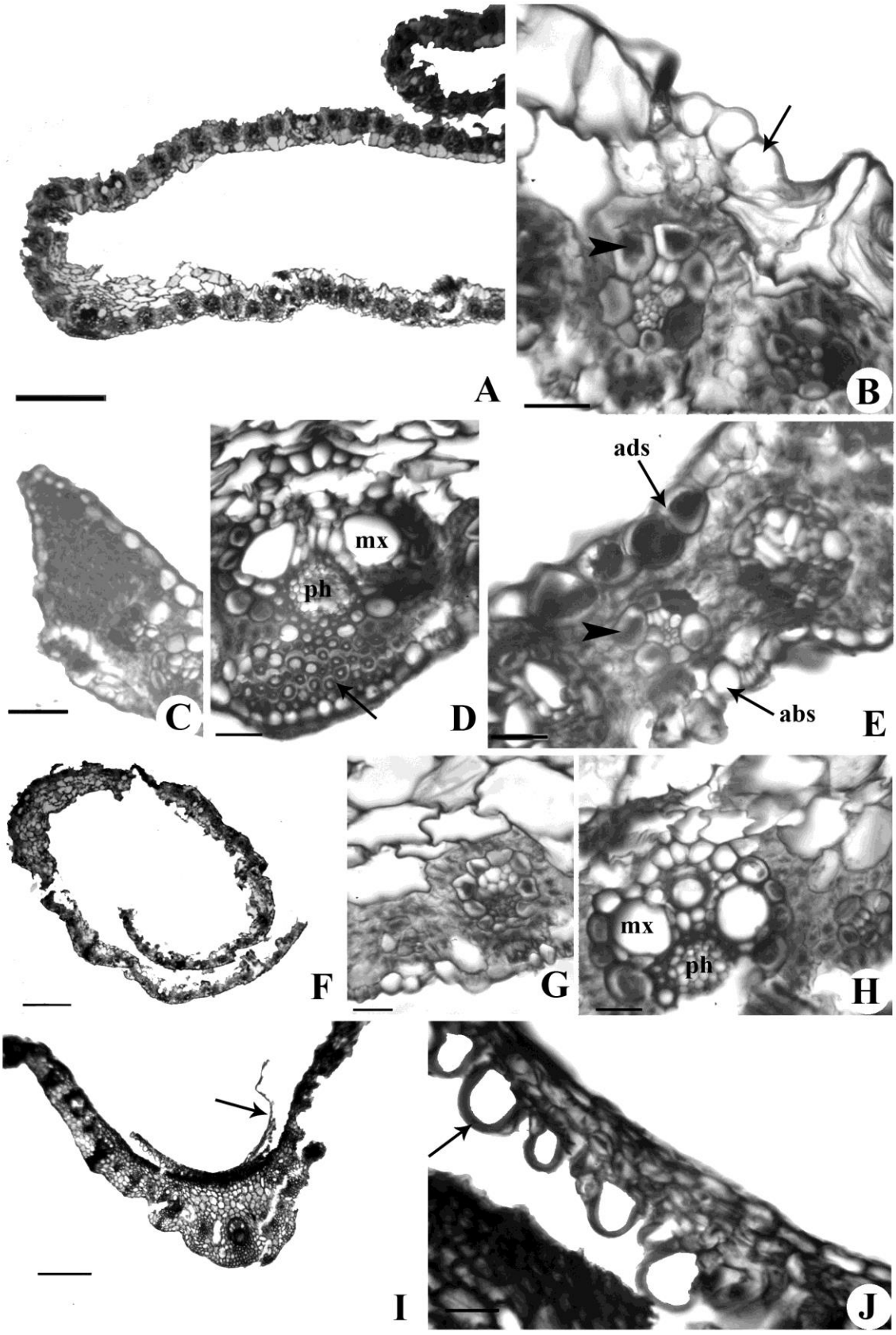

Fig. 134

12. *Hackelochloa granularis*

LEAF LAMINA: (Fig. 135 A-D)

Outline of the lamina: Expanded and distinctly wavy (Fig. A). Ribs and furrows present on leaf surface. Adaxial surface with shallow, wide furrows between all vascular bundles. Abaxial surface with ribs taller than the adaxial ribs and groove present between all vascular bundles.

Keel is not well developed.Sclerenchyma present on abaxial surface in form of narrow subepidermalstrands.

Epidermis: Adaxial epidermal surface has barrel to round shaped epidermal cells covered with thick cuticle. Abaxial epidermal cells have barrel to rectangular shaped epidermal cells covered with cuticle.

Mesophyll: Radiate, single layered, isodiametric cells completely surrounding bundles. Compact arranged chlorenchyma cells continuous between bundles, occuping the major area between the adaxial and abaxial epidermides. Colourless cells absent.

Vascular bundles: 4-5 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundle. 2 3rd order bundles and one 2nd order bundles between 2 consecutive 1st order bundles present. All the vascular bundles present at same level and placed abaxially.

3rd order vascular bundles: Circular with xylem and phloem groups distinguishable (Fig. C).

2nd order vascular bundles: Circular shaped (Fig. D)

1st order vascular bundles:

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Phloem adjoins the inner or parenchyma sheath

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. C, arrowhead)

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath: (Fig. D, arrowhead)

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 7-8

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast small and indistinct

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath:

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 19-20 parenchyma cells

Bundle sheath cell shape: All cells are elliptical, elongated with different sizes. Chloroplast small and indistinct.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Absent

Abaxial sclerenchyma: Well developed broad girder present

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming a very small rounded cap. Epidermal cells of margin are thin with thick tangential wall. Prickle present at margin (Fig. B, arrow).

LEAF SHEATH ANATOMY (Fig. 135 E-G)

Outline of lamina: Round shaped (Fig. E). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells and abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with horizontally oval shaped air cavity present (Fig. E).

Vascular bundle:

Arrangement of vascular bundle: One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Circular shaped, xylem and phloem groups distinguishable (Fig. G)

2nd order vascular bundle: Circular shaped

1st order vascular bundle: Circular shaped, Phloem adjoins the inner or parenchyma sheath, cavity and enlarged protoxylem vessel present. Circular wide metaxylem vessel elements (Fig. F).

Vascular bundle sheath: (Fig. F, G arrowhead)

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath incomplete, interrupted by sclerenchyma cells abaxially and parenchyma cells adaxially

Number of cells comprising the bundle sheath: 12-14 parenchyma cells

Bundle sheath cell shape: Elliptical, elongated and smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of wide, horizontal band well developed girder present on abaxial surface.

LIGULE ANATOMY (Fig. 135 H, I)

Shape: Ligule attached to the leaf sheath more than the half width and very broad round shaped at the connection point (Fig. H, arrow)

Anatomy: Two layered mesophyll cells between adaxial and abaxial (Fig. I)

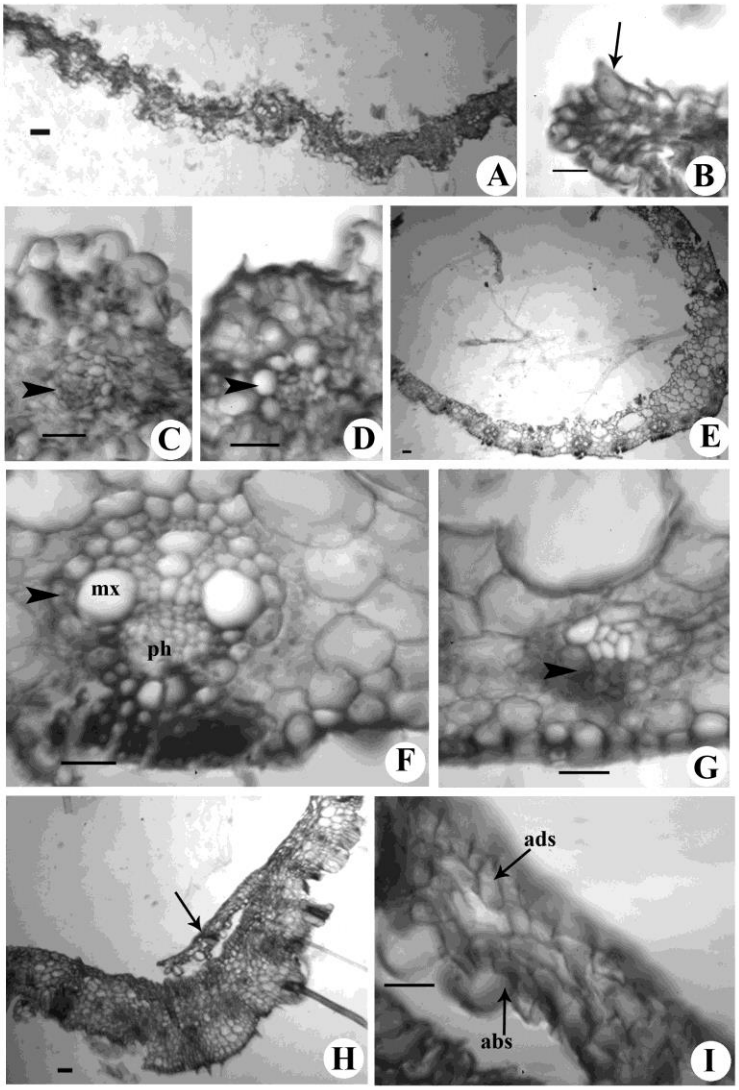

Fig. 135

Heteropogon

13. *Heteropogon contortus var. genuinus sub var. typicus* (Fig. 136)

14. *Heteropogon contortus var. genuinus sub var. hispidissimus* (Fig. 137)

15. *Heteropogon ritcheii* (Fig. 138)

16. *Heteropogon triticeus* (Fig. 139)

LEAF LAMINA: (Fig. 136 A-E, Fig. 137 A-E, Fig. 138 A-D, Fig. 139 A-E)

Outline of the lamina: 'V' shaped with wide angle having straight arms (Fig. 136 A; 137 A, B; 138 A, 139 A). Two halves are symmetrical on either side of the median vascular bundle.

Ribs and furrows present on the leaf surface. Adaxial surface has wide, shallow furrow in all the three species except *H. triticeus* in which the furrows were median and wide. Triangular ribs present with pointed apex in *H.contortus var. genuinus sub var. typicus, H. contortus var. genuinus sub var. hispidissimus* and *H.ritcheii* and round ribs with round apex in *H. triticeus* present only over 1st and 2nd order vascular bundles. Abaxail surface has shallow groove in *H.contortus var. genuinus sub var. typicus, H. contortus var. genuinus sub var. hispidissimus* and *H.ritcheii* and smooth or few undulations in *H. triticeus* between vascular bundles. Abaxial ribs smaller than adaxial ribs.

Keel is well developed, bulliform cells penetrating into leaf on either side of median bundle forming inverted 'V' shape with single median vascular bundle in *H.contortus var. genuinus sub var. typicus* and *H. contortus var. genuinus sub var. hispidissimus*, 'V' shaped keel with single median vascular bundle in *H.ritcheii* and 'V' shaped keel without single median vascular bundle in *H. triticeus*.

2 2nd order and three 3rd order vascular bundle in *H.contortus var. genuinus sub var. typicus, H. contortus var. genuinus sub var. hispidissimus* and *H.ritcheii* and nine 1st order, nine 2nd order and 22-24 3rd order vascular bundle in *H. triticeus*. Small, round parenchyma cells present surrounding the median vascular bundle adaxially.

Sclerenchyma on adaxial surface in form of subepidermal strands and on abaxial surface associated with vascular bundles in form of well developed girder (Fig. 136 D).

Epidermis: Adaxial epidermal surface with isolated large, inflated bulliform cells (Fig. 136 B, arrow; 137 F, 138 D), interrupted by irregular, different sized small groups of epidermal cells (Fig. 137 D). In *H. triticeus* has bulliform cells smaller than barrel shaped epidermal cells (Fig. 139 G, arrow). Stomata present (Fig. 137 D, arrow).

Abaxial epidermal cells are large, round in *H.contortus var. genuinus sub var. typicus, H. contortus var. genuinus sub var. hispidissimus* and *H.ritcheii* while

barrel shaped in *H. triticeus*. All four species showed prescence of single papillae on one cell (Fig. 136 C, arrow; 137 D, arrow; 138 D; 139 D, arrow). Prickles also present (Fig. 136 B).

Mesophyll: Radiate, single layered, tubular chlorenchyma cells completely surrounding bundles. Compact homogenous chlorenchymatous cells occupy the major area between the adaxial and abaxial epidermides. Chlorenchyma cells continuous between bundles. Colourless cells absent.

Vascular bundles: 5 1st order vascular bundles in *H.contortus var. genuinus sub var. typicus, H. contortus var. genuinus sub var. hispidissimus* and *H.ritcheii*, 15-17 1st order vascular bundle in *H. triticeus* regularly arranged from median bundle to marginal bundle in half lamina.

3 3rd and 2nd order bundles in *H.contortus var. genuinus sub var. typicus, H. contortus var. genuinus sub var. hispidissimus* and *H.ritcheii*, 65-70 3rd order and 15-17 2nd order vascular bundles in *H. triticeus* between consecutive 1st order bundles present.

All the vascular bundles are present at the same level and placed centrally in *H.contortus var. genuinus sub var. typicus, H. contortus var. genuinus sub var. hispidissimus* and *H.ritcheii* while in *H. triticeus* it is abaxially.

3rd order vascular bundles: (Fig. 136 B; 137 D, 138 D, 139 D and F).

Pentagonal shaped in *H.contortus var. genuinus sub var. typicus, H. contortus var. genuinus sub var. hispidissimus* and *H.ritcheii*, circular shaped (Fig. 139 D) and elliptical (Fig. 139 F) in *H. triticeus*. Vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: Circular shaped in *H.contortus var. genuinus sub var. typicus, H. contortus var. genuinus sub var. hispidissimus* and *H.ritcheii*, elliptical shaped in *H. triticeus* (Fig. 139, C)

1st order vascular bundles: (Fig. 136 C, 137 C, 138 Cand E, 139 E)

Shape: Circular

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Protoxylem vessel present with absence of lysigenous cavity in *H.contortus var. genuinus sub var. typicus, H. contortus var. genuinus sub var. hispidissimus* while presence of lysigenous cavity in *H.ritcheii* and *H. triticeus.*

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels in all species

Shape of metaxylem vessels: Circular

Median vascular bundles:

Shape: Round

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. 136 B, 137 D, 138 D, 139 D and F, arrowhead)

Shape: Round in *H.contortus var. genuinus sub var. typicus, H. contortus var. genuinus sub var. hispidissimus* and *H.ritcheii* while round (Fig. 139 D) and elliptical (Fig. 139 F) in *H. triticeus.*

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath:

Shape: Round in *H.contortus var. genuinus sub var. typicus, H. contortus var. genuinus sub var. hispidissimus* and *H.ritcheii* while elliptical in *H. triticeus*

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 9-10 in *H.contortus var. genuinus sub var. typicus, H. contortus var. genuinus sub var. hispidissimus*, 11 in *H.ritcheii* and 12-13 in *H. triticeus.*

Nature of bundle sheath (either complete or incomplete): Complete in *H.contortus var. genuinus sub var. typicus, H. contortus var. genuinus sub var. hispidissimus* and *H.ritcheii* and incomplete sheath in *H. triticeus* in which it abaxially interrupted by sclerenchyma cells.

Chloroplast position in bundle sheath cell: Chloroplast centrally placed

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. 136 C, 137 C, 138 C, 139 C arrowhead)

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath incomplete, abaxially interrupted by sclerenchyma

Extension of bundle sheath: Broad abaxial extension of the bundle sheath

Number of cells comprising the bundle sheath: 13-14 parenchyma cells

Bundle sheath cell shape: All cells are elliptical, elongated in shape. Chloroplast centrally placed.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Small strand present above the 1st order vascular bundle

Abaxial sclerenchyma: Well developed strand, wider than deep and it follows shape of abaxial rib in *H.contortus var. genuinus sub var. typicus, H. contortus var. genuinus sub var. hispidissimus* and *H.ritcheii* and narrow strands present in *H. triticeus.*

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very small round fibrous cap. Epidermal cells of margin are thin with outer thick tangential wall (Fig. 137 E, 138 B, 139 H).

LEAF SHEATH ANATOMY (Fig. 136 F-H; 137 G-I; 138 E-H, 139 G-I)

Outline of lamina: 'V' shaped with standard angle with inrolled margins (Fig. 136 F, 137 G, 138 E, 139 I).

Epidermis: Adaxial and abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavity in *H.contortus var. genuinus sub var. typicus, H. contortus var. genuinus sub var. hispidissimus* and *H.ritcheii* and oval shaped air cavity present in *H. triticeus.*

Vascular bundle:

Arrangement of vascular bundle: 2 consecutive 3rd order in *H.contortus var. genuinus sub var. typicus, H. contortus var. genuinus sub var. hispidissimus* and *H.ritcheii* and 6-7 consecutive 3rd order vascular bundle in *H. triticeus* between 1st and 2nd order vascular bundle.

3rd order vascular bundle: Pentagonal shaped in *H.contortus var. genuinus sub var. typicus* and *H. contortus var. genuinus sub var. hispidissimus* (Fig. 136, 137 H), circular in *H.ritcheii* and *H. triticeus.* Vascular tissue consisting of only a few inistinguishable vascular elements

2nd order vascular bundle: Elliptical in *H.contortus var. genuinus sub var. typicus, H. contortus var. genuinus sub var. hispidissimus* and *H.ritcheii* and circular in *H. triticeus.*

1st order vascular bundle: (Fig. 136 G, 137 H, I, 138 F, 139 M)

Circular shaped, phloem completely surrounded by thick walled fibers, lysigenous cavity and enlarged protoxylem vessel present. Circular wide in *H.contortus var. genuinus sub var. typicus, H. contortus var. genuinus sub var. hispidissimus* and *H.ritcheii* and very wide in *H. triticeus* metaxylem vessel elements.

Vascular bundle sheath: (Fig. 136 G, 137 H, I arrowhead, 138 F, 139 M)

Shape: Obovate in *H.contortus var. genuinus sub var. typicus, H. contortus var. genuinus sub var. hispidissimus* and *H.ritcheii*, Circular in *H. triticeus*.

Extent of bundle sheath around the vascular bundle: Sheath incomplete, interrupted by parenchyma cells

Number of cells comprising the bundle sheath: 14-15 in *H.contortus var. genuinus sub var. typicus* and *H. contortus var. genuinus sub var. hispidissimus*, 12-13 in *H.ritcheii* and 20-22 in *H. triticeus* parenchyma cells.

Bundle sheath cell shape: Elliptical, elongated and smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of straight horizontal well developed girder in *H.contortus var. genuinus sub var. typicus, H. contortus var. genuinus sub var. hispidissimus* and *H.ritcheii*; wide, deep horizontal well developed girder in *H. triticeus* present on abaxial surface (Fig. 136 G, H arrow, 138 F, arrow).

LIGULE ANATOMY (Fig. 136 I, 137 J, K, 138 I, 139 O)

Shape: Ligule attached to the lamina only ¼ portions and at connection point it was very broad almost like straight "V" shaped with small sharp angled in *H.contortus var. genuinus sub var. typicys* and *H. contortus var. genuinus sub var. hispidissimus,* ligule attached to the lamina more than half length of it and blunt 'V' shaped at the connection in *H.ritcheii* and ligule attached less than half length of the lamina and at the connection point it is very broad, blunt'V' shaped in *H. triticeus*.

Anatomy: Many layered in *H.contortus var. genuinus sub var. typicus* and *H. contortus var. genuinus sub var. hispidissimus* and two layered in *H.ritcheii* and *H. triticeus* mesophyll cells between adaxial and abaxial surfaces (Fig. 136 I, 137 J, 138 I, arrow). Prickles present on abaxial surface only in *H. contortus var. genuinus sub var. hispidissimus* (Fig. 137 K, arrow).

Differentiating features:

Vascular bundles arranged towards abaxial side of leaf blade…..……. *H. triticeous*

Vascular bundles arranged in the center of the leaf blade

Two layered mesophyll present in ligule…… *H. ritchiei*

More than three layered of mesophyll present in ligule

Presence of prickles on abaxial surface of ligule……..

…...……....…*H. contortus* var. *genuinus* sub var. *hispidissimus*

Absence of prickles on abaxial surface of ligule……

……..……..……..….. *H. contortus* var. *genuinus* sub var. *typicus*

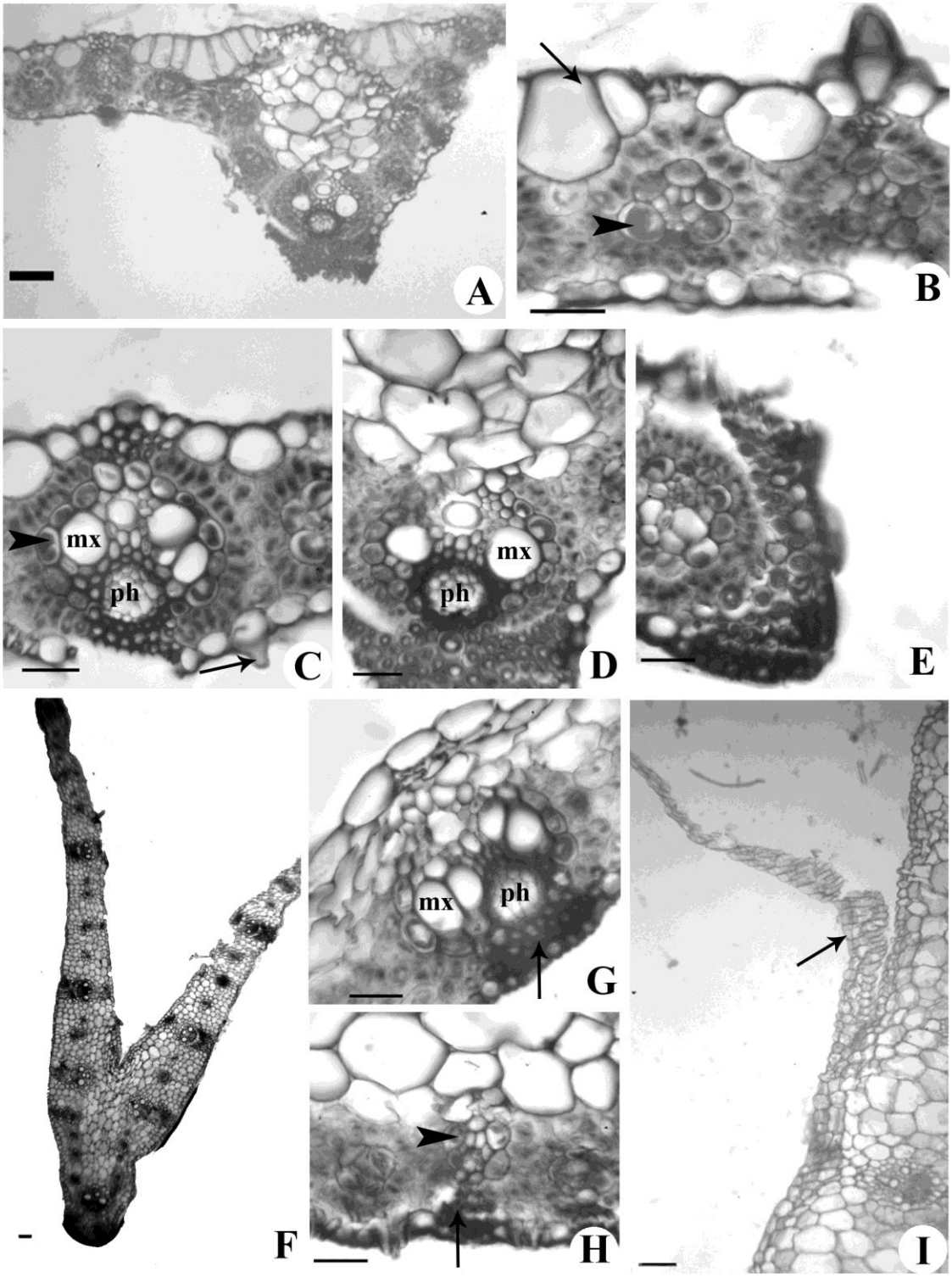

Fig. 136

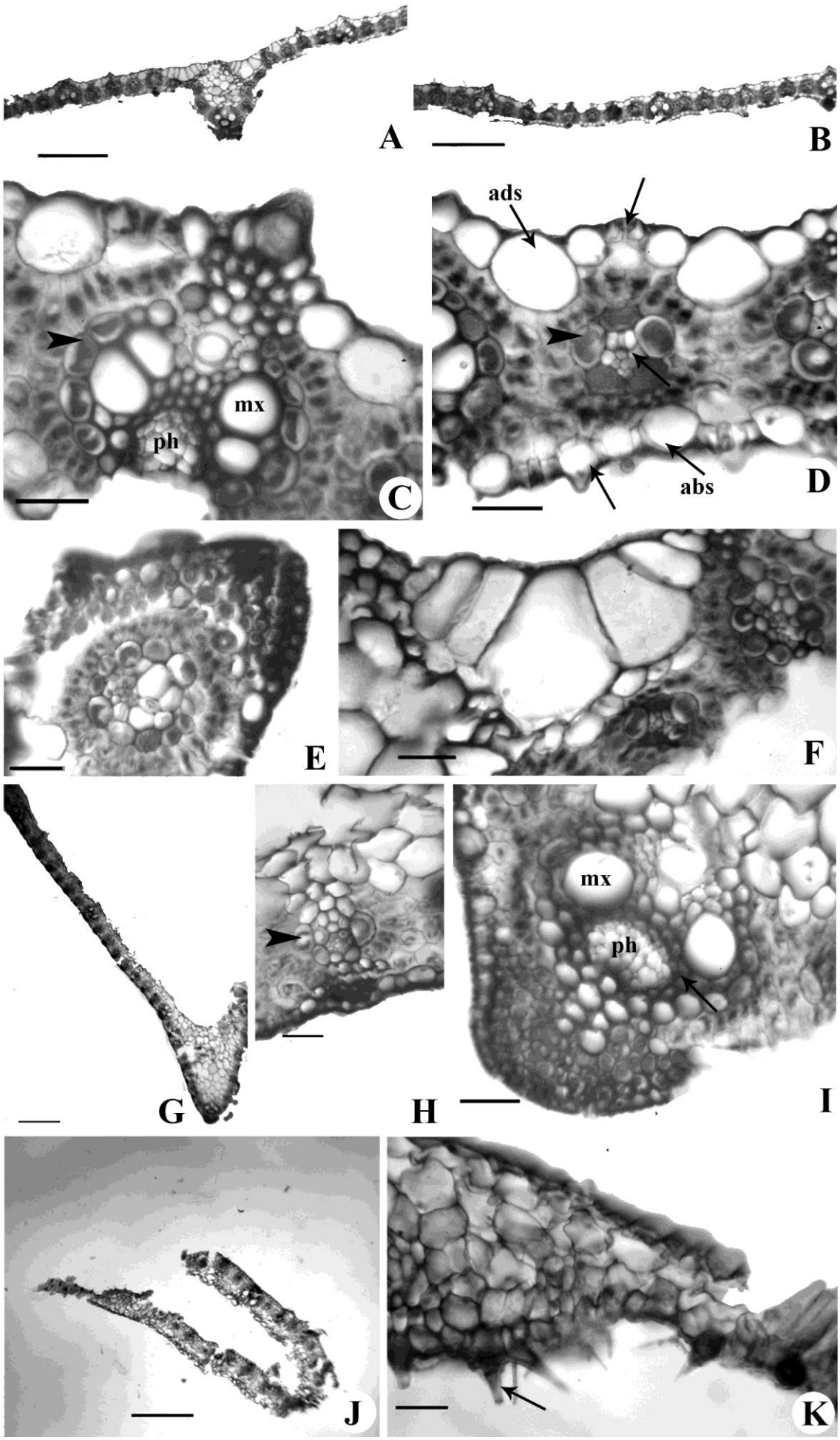

Fig. 137

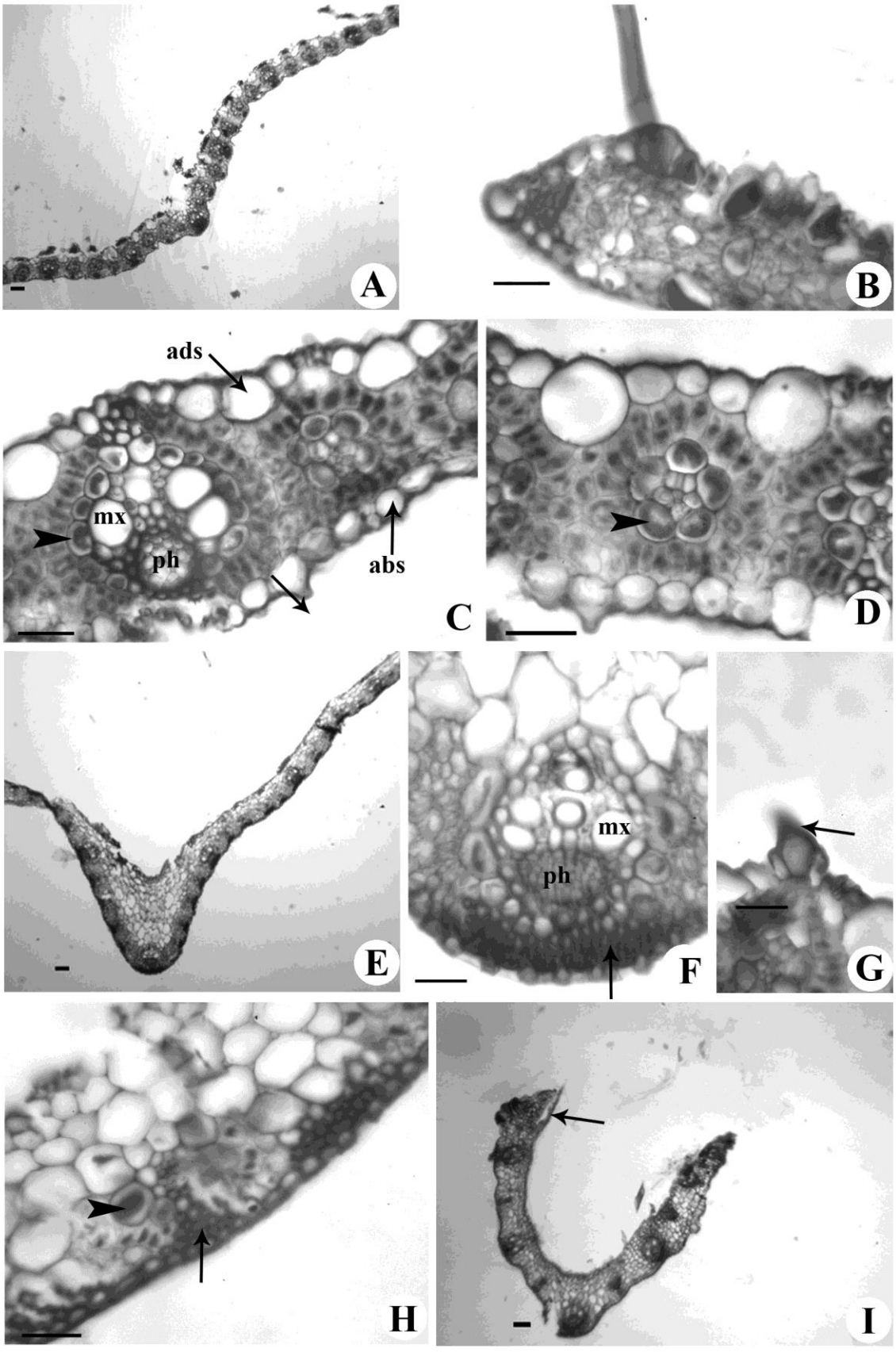

Fig. 138

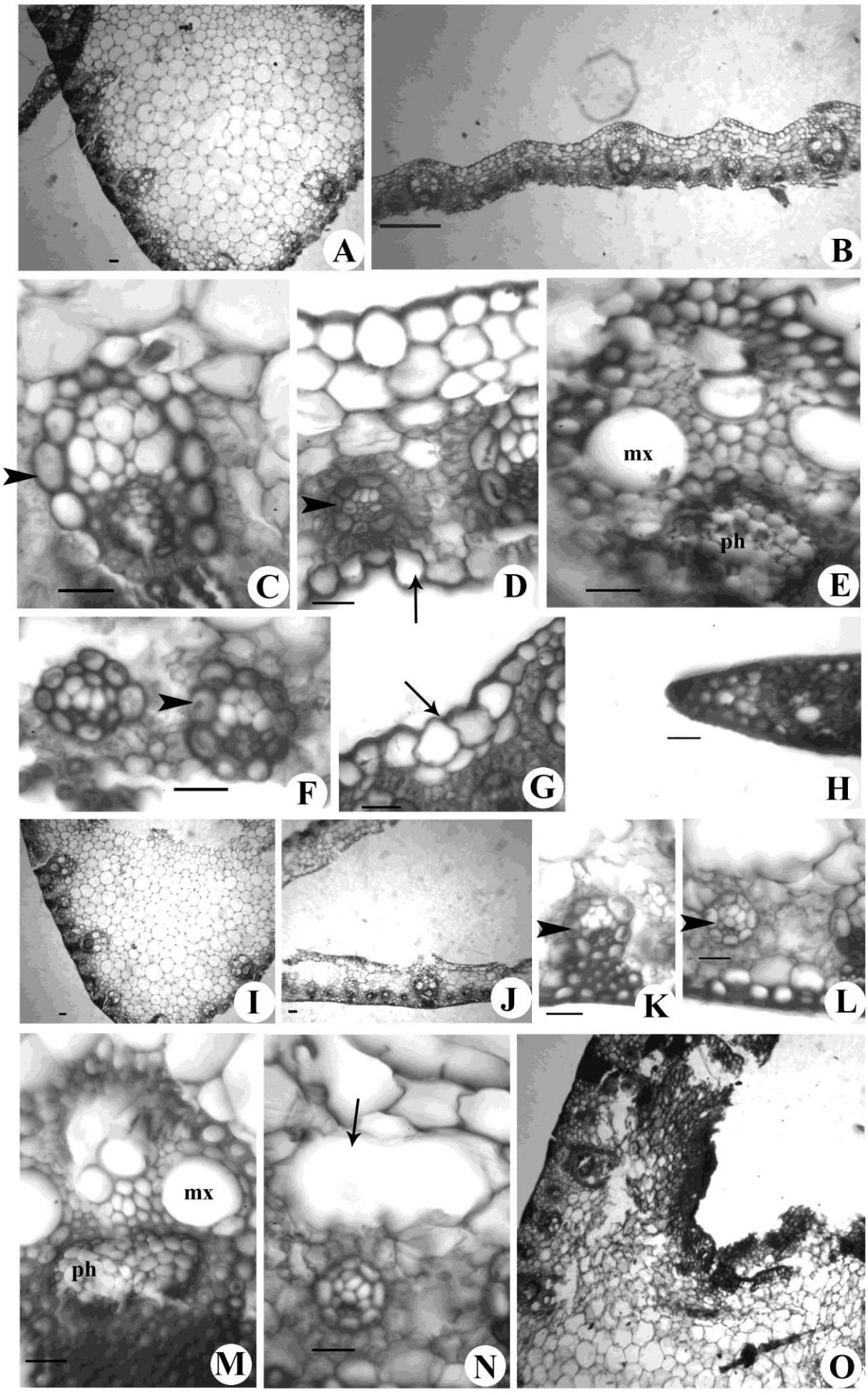

Fig. 139

17. *Imperata cylindrica*

LEAF LAMINA: (Fig. 140 A-E)

Outline of the lamina: Expanded and gently undulating shape of the arms (Fig. A). Two straight halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are present on the leaf surface. Very shallow and wide furrows present between 1st order vascular bundles.

Keel is well developed, round with single 1st order bundle, two 2nd and 3rd order bundles. Small, rounded parenchyma cells are present surrounding the median vascular bundle adaxially. Sclerenchyma present on abaxial surface of keel associated with vascular bundles in form anchor shaped girder.

Epidermis: Adaxial epidermal surface with fan shaped bulliform cells (Fig. E) without furrows or with a very shallow furrow. Round abaxial epidermal cells with cuticle and cell wall equal to or greater than the depth of the average epidermal cells. Long, slender macrohairs present.

Mesophyll: Indistinctly or incompletely radiating chlorenchyma cells which were divided by group of colourless cells. Smaller colourless cells closely associated with bulliform cells with two extensions (Fig. E, arrow).

Vascular bundles: 4 1st order vascular bundles in half and progressively fewer 1st and more 3rd order bundles towads margin. 3 3rd order bundles between consecutive larger bundles and 1 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally.

3rd order vascular bundles: Elongated shaped and vascular tissue consisting of only few indistinguishable vascular elements (Fig. C).

2nd order vascular bundles: Oval shpaed

1st order vascular bundles: (Fig.D)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Shape of metaxylem vessels: Circular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. C, arrowhead)

Shape: Round

Shape of bundle sheath cell: Cells with straight radial walls and tangential inflated walls

2nd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Cells with straight radial walls and tangential inflated walls

Number of bundle sheath cell: 9-10

Nature of bundle sheath (either complete or incomplete): Incomplete, abaxially interrupted by sclerenchyma

Chloroplast position in bundle sheath cell: Translucent sheath cell

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. D, arrowhead)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Sheath incomplete, abaxially interrupted by sclerenchyma

Extension of bundle sheath: Broad abaxial extension of the bundle sheath

Number of cells comprising the bundle sheath: 12-13 parenchyma cells

Bundle sheath cell shape: Cells with straight radial walls and tangential inflated walls. Translucent chloroplast in sheath cell.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Well developed strand present

Abaxial sclerenchyma: Well developed narrow and deep girder

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming a well developed rounded cap; consists of a couple of fibers. Epidermal cells of margin are thin with thick radial wall.

LEAF SHEATH ANATOMY (Fig. 140F-I)

Outline of lamina: 'U' shaped (Fig.F).

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, square shaped with thick cuticle.

Ground tissue: Parenchymatous with round shaped air cavity (Fig. F).

Vascular bundle:

Arrangement of vascular bundle: One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Hexagonal with vascular tissue consisting of only few indistinguishable vascular elements (Fig. G)

2nd order vascular bundle: Circular shaped (Fig. H)

1st order vascular bundle: Elliptical shaped, phloem completely surrounded by thick walled fibers (Fig. I, arrow), lysigenous cavity and enlarged protoxylem vessel present. Circular narrow metaxylem vessel elements (Fig. I)

Vascular bundle sheath: (Fig. G, H arrowhead)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Sheath incomplete, interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 13-14 parenchyma cells

Bundle sheath cell shape: Cells with straight radial walls and tangential inflated walls. Cells similar in size of the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of narrow, deep well developed girder present on abaxial surface.

LIGULE ANATOMY (Fig. 140 J,K)

Shape: Ligule attached to the lamina more than half length of it and blunt "V" shaped at the connection point and narrow (Fig. J, arrow).

Anatomy: Two layered mesophyll cells between adaxial and abaxial surfaces (Fig. K, arrow).

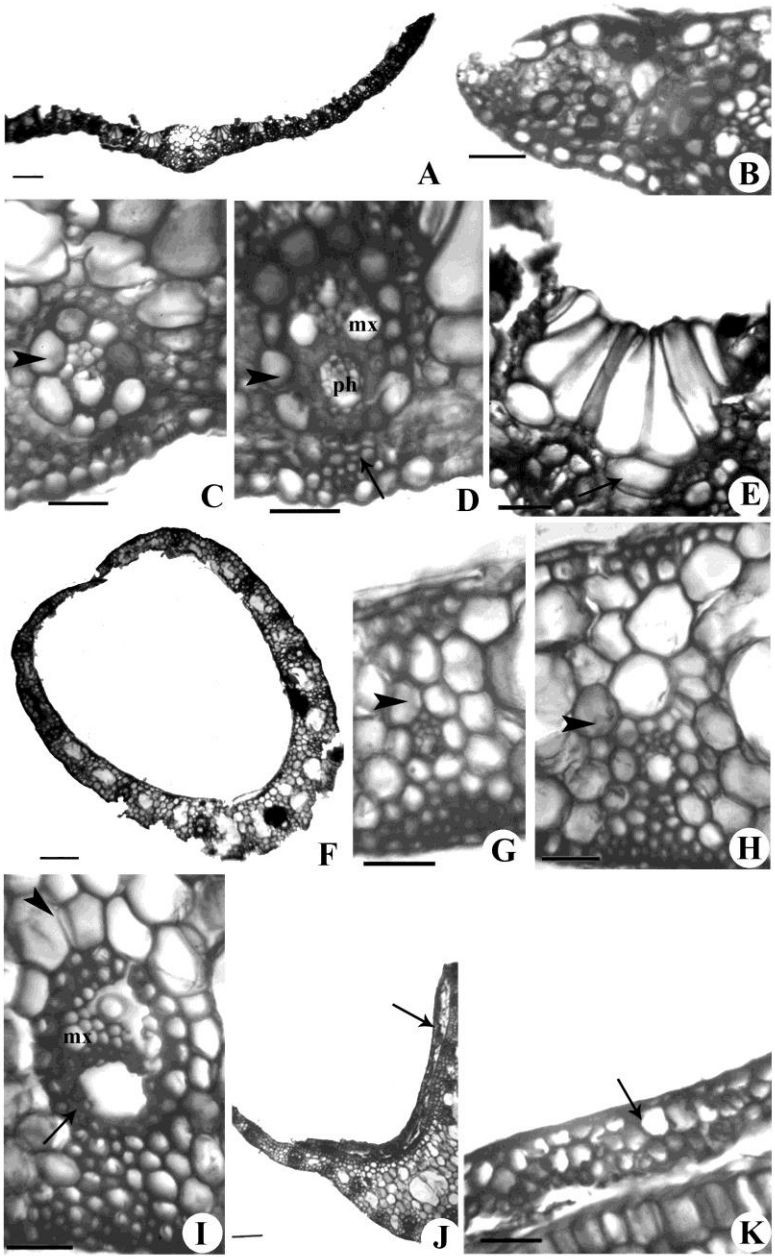

Fig. 140

Ischaemum

18. *Ischaemum indicus* (Fig. 141)

19. *Ischaemum molle* (Fig. 142)

20. *Ischaemum pilosum* (Fig. 143)

21. *Ischaemum rugosum* (Fig. 144)

LEAF LAMINA: (Fig. 141 A-E, 142 A-E, 143 A- I, 144 A-G)

Outline of the lamina: 'V' shaped with standard angled having straight shape of the arms in *I. indicus* and *I. rugosum* (Fig. 141 A, 144 A), with wide angled having straight arms *I. pilosum* (Fig. 143 A) or with outwardly curving arms in *I. molle* (Fig. 142 A).

Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are absent on the leaf surface in all the species except *I. pilosum.* Ribs are present on 1st and 2nd order vascular bundles and the furrows are shallow, round, wide and with a sharp apex (Fig. 143 I).

Keel is well developed, 'V' shaped with single median vascular bundle, presence of 2 2nd and 4 3rd order vascular bundles in *I. indicus*, 5-6 3rd order vascular bundles *I. pilosum*. Keel is semicircular in *I. molle* or inverted triangular shaped in *I. rugosum* (Fig. 144 B).

Small, round parenchyma cells are present surrounding the median vascular bundle adaxially. Sclerenchyma present on adaxial surface in form of strand in the subepidermal layers and on abaxial surface associated with vascular bundles in form of well developed strands in all species.

Epidermis: Adaxial epidermal surface has most part of the epidermis made up of inflated bulliform cells in *I. indicus* and *I. pilosum* (Fig. 141B, 143 H). Abaxial epidermal cells are barrel shaped with one in (Fig. 142 D, 144 D) or two papillae per cell in *I. rugosum* (Fig. 144 E, arrow). Stomata could be observed interrupting the epidermal layer in *I. pilosum* and *I. rugosum* (Fig. 143 G, 144 D, arrow). Prickels, macrohiars, hooks are absent.

Mesophyll: Chlorenchyma is not arranged in any specific pattern. Compactly arranged homogenous layer of chlorenchyma cells present between the adaxial and abaxial epidermides. Chlorenchyma cells continuous between bundles and arranged in form of an horizontally elongated strap. Colourless cells absent.

Vascular bundles: 2-3 1st order vascular bundles present in all the species except *I. pilosum* which has 5-6 1st order vascular bundle arranged in regular manner from median bundle to marginal bundles in half lamina.

I. indicus and *I. rugosum* have 3 3rd order and 2 2nd order bundles bundles, *I. molle* has 7-8 3rd order and 2-3 2nd order bundles bundles and *I. pilosum* has 4 3rd order and 3 2nd order bundles between consecutive larger bundles.

All the vascular bundles present at same level and placed abaxially in *I. indicus* and *I. rugosum* or centrally in *I. molle.* Vascular bundles placed at different leavels in *I. pilosum* i.e 1st and 2nd order bundles present in center and 3rd order bundles present on abaxial surface of leaf blade.

3rd order vascular bundles: (Fig. 141 E, 142 C, 143 D, 144 E)

Pentagonal and circular in *I. indicus*, circular in *I. molle*, only pentagonal in *I. pilosum* and *I. rugosum*; xylem and phloem groups distinguishable in all except *I. molle* has vascular tissue consists of only a few indistinguishable vascular elements.

2nd order vascular bundles: Circular in all species except in *I. pilosum* elliptical

1st order vascular bundles: (Fig. 141 D, 143 F, 144 G)

Shape: Circular in all species except in *I. pilosum* elliptical

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Enlarged protoxylem present in all species and lysigenous cavity absent only in *I. indicus.*

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Angular

Median vascular bundles: (Fig. 141 C, 142 B, 143 E, 144 F)

Shape: Round

Relationship of phloem cells and the vascular fibres: Complete surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Enlarged protoxylem present in all species and lysigenous cavity absent only in *I. indicus.*

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. 141 E, 142 C arrowhead, 144 E)

Shape: Round

Shape of bundle sheath cell: Fan shaped in *I. indicus* and *I. rugosum*
Elliptical in *I. molle* and *I. pilosum*

2nd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Radial wall straight, tangential walls inflated in *I. indicus* and *I. rugosum* while round to elliptical in *I. molle* and *I. pilosum*

Number of bundle sheath cell: 10-11 (*I. indicus*), 7-8 (*I. molle*), 14 (*I. rugosum*), 12-13 (*I. pilosum*)

Nature of bundle sheath (either complete or incomplete): Complete in all species except *I. indicus* in which it is inomplete, interrupted by sclerenchyma on abaxial side

Chloroplast position in bundle sheath cell: Chloroplast concentrated near the inner (*I. indicus*) or outer tangential wall (*I. rugosum*, *I. pilosum*) or centrally placed (*I. molle*).

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath:

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Incomplete interrupted by sclerenchyma on abaxial side in *I. indicus* and *I. molle*, complete in *I. rugosum* and *I. pilosum*.

Extension of bundle sheath: Absent in *I. rugosum* and *I. molle*. Wide abaxial extension of the bundle sheath in *I. indicus* and abaxial/ and or adaxial extension in *I. pilosum*.

Number of cells comprising the bundle sheath: 14-15 in *I. indicus, I. molle*, 19-20 in *I. rugosum* and *I. pilosum* parenchyma cells

Bundle sheath cell shape: All cells are elliptical and elongated. Chloroplast concentrated near the inner in *I. indicus* or outer tangential wall in *I. rugosum* and *I. pilosum* or centrally placed in *I. molle*.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Absent in all species except *I. pilosum* with well developed horizontal strand

Abaxial sclerenchyma: Well developed narrow girder in all species except *I. rugosum* with wide girder.

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very small pointed fibrous cap. Epidermal cells of margin are thin with outer thick tangential wall.

LEAF SHEATH ANATOMY (Fig. 141F-I, 142 F-I, 143 J-L, 144 H-J)

Outline of lamina: Round shaped with double overlapping inrolled margins in *I. indicus, I. rugosum* (Fig. 141 F, 144 H) while with inrolled margins in *I. molle, I. pilosum* (Fig. 142 F, 143 J).

Minute ribs and furrows present opposite to 1st order vascular bundle on abaxial surface in *I. indicus, I. rugosum* while ribs and furrows absent in *I. molle, I. pilosum.*

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: barrel shaped with thick cuticle.

Bulliform cells inflated, projecting above the level of epidermal cells only in *I. rugosum* (Fig. 144 I, arrow).

Ground tissue: Parenchymatous with vertically oval shaped air cavities in *I. indicus, I. molle* and *I. rugosum* (Fig. 141 G, 142 G). Air cavities absent in *I. pilosum.*

Vascular bundle:

Arrangement of vascular bundle: One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: (Fig. 141 I, 142 H, 143 K)

Circular in *I. indicus, I. rugosum* and *I. molle*, hexagonal in *I. rugosum*. Xylem and phloem groups distinguishable in all except *I. molle* with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundle: Circular shaped

1st order vascular bundle: (Fig. 141 H, 142 I, 143 L, 144 J)

Circular with phloem completely surrounded by thick walled fibers. Enlarged protoxylem present in all species and lysigenous cavity absent only in *I. indicus.* Circular wide metaxylem vessel elements (Fig. H).

Vascular bundle sheath: (Fig. 141 I, arrowhead)

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Complete in *I. rugosum* while incomplete in all other species abaxially being interrupted by sclerenchyma and adaxially by parenchyma cells in *I. indiucm* and only abaxially interrupted by sclerenchyma in *I. molle* and *I. pilosum.*

Number of cells comprising the bundle sheath: 12-13 in *I. indiucm*, 14-15 in *I. molle*, 17-18 in *I. pilosum* and 19-20 in *I. rugosum* parenchyma cells

Bundle sheath cell shape: Different sized elliptical, elongated cells. Cells smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of wide well developed grider present on abaxial surface (Fig. 141 H, I, arrow) in *I. indiucm, I. pilosum* while well developed broad girder present on abaxial surface (Fig. 142 H, arrow) in *I. molle, I. rugosum.*

LIGULE ANATOMY (Fig. 141 J, K, 142 J, K, 143 M, N, 144 K, L)

Shape: Ligule attached only to the midrib region and broad round shaped at connection point in *I. indiucm, I. pilosum, I. rugosum* (Fig. 141 J arrow, 143 M, 144 K), ligule attached to the midrib region and slightly with lamina region, and at the connection it is broad round shaped (Fig. 142 J) in *I. molle.*

Anatomy: Three layered mesophyll cells between adaxial and abaxial surfaces (Fig. 141 K, 142 K, 143 N) in *I. indiucm, I. pilosum, I. molle* while more than three layered in *I. rugosum* (Fig. 144 L).

Differentiating features:

Ribs and furrows absent on leaf lamina……..……...… *I. pilosum*

Ribs and furrows present on leaf lamina

3rd order vascular bundle sheath cells are elliptical…… *I. molle*

3rd order vascular bundle sheath cells are fan shaped

Chloroplast concentrated near inner tangential wall...…….... *I. indicus*

Chloroplast concentrated near outer tangential wall……. *I. rugosum*

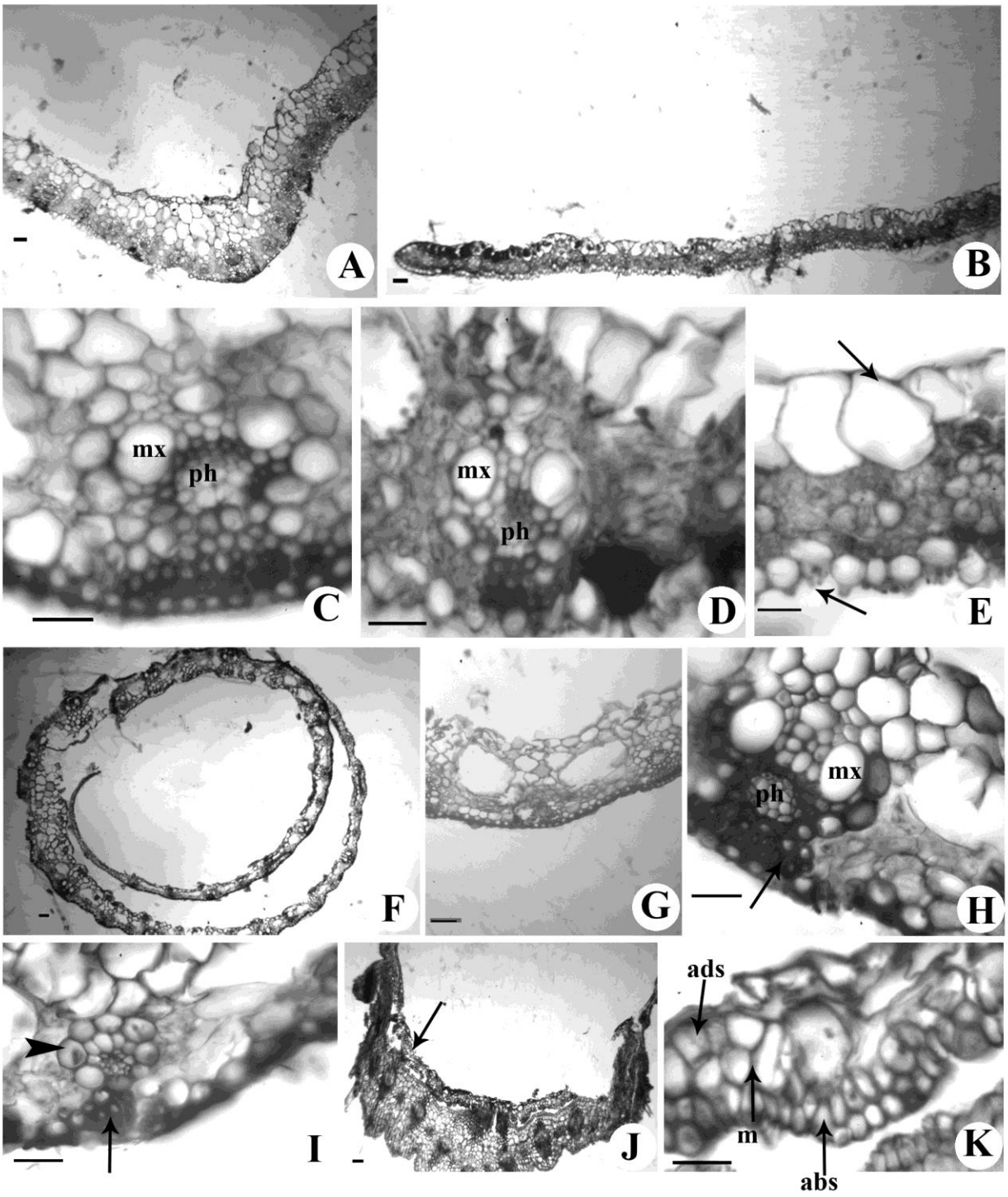

Fig. 141

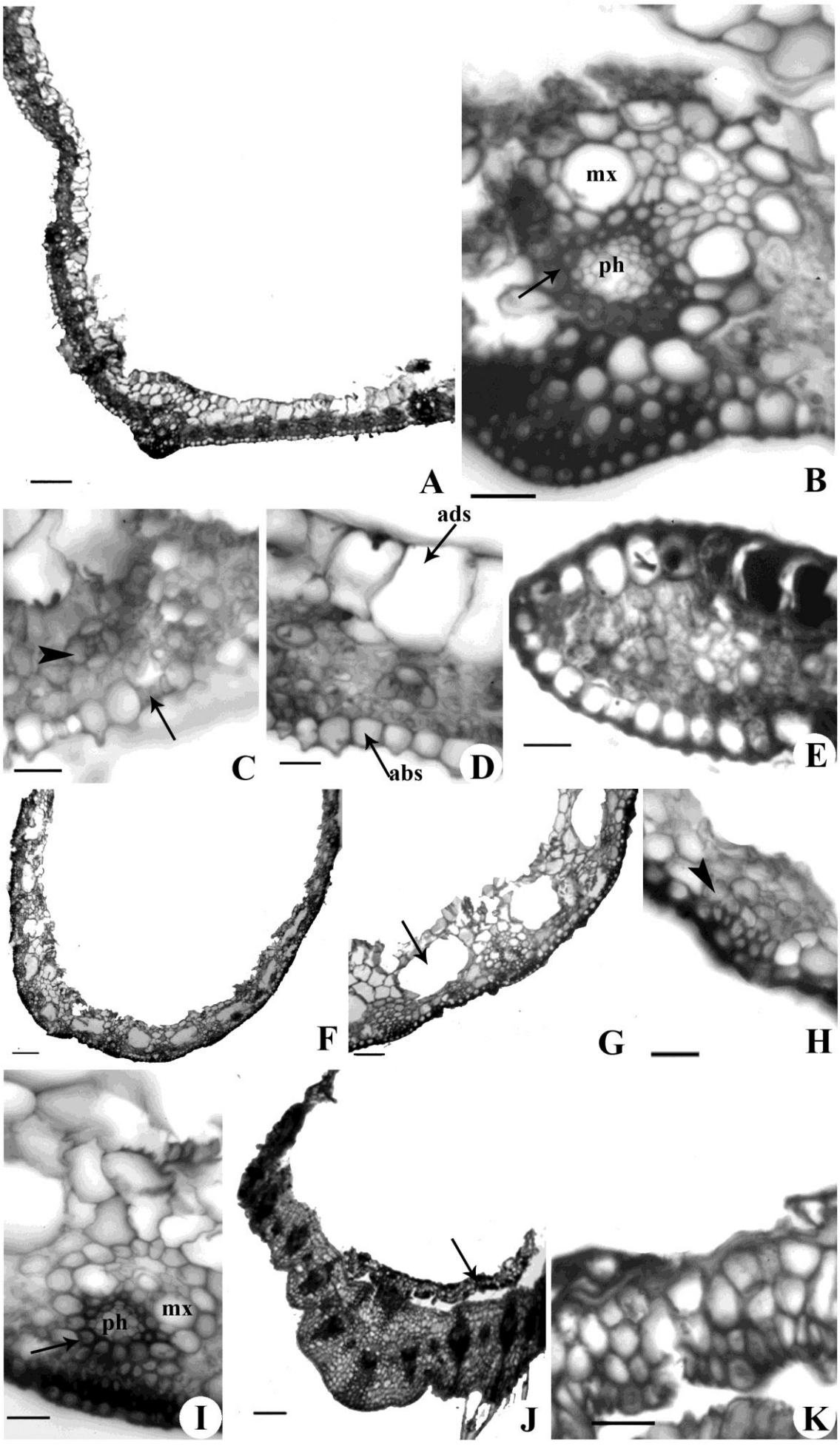

Fig. 142

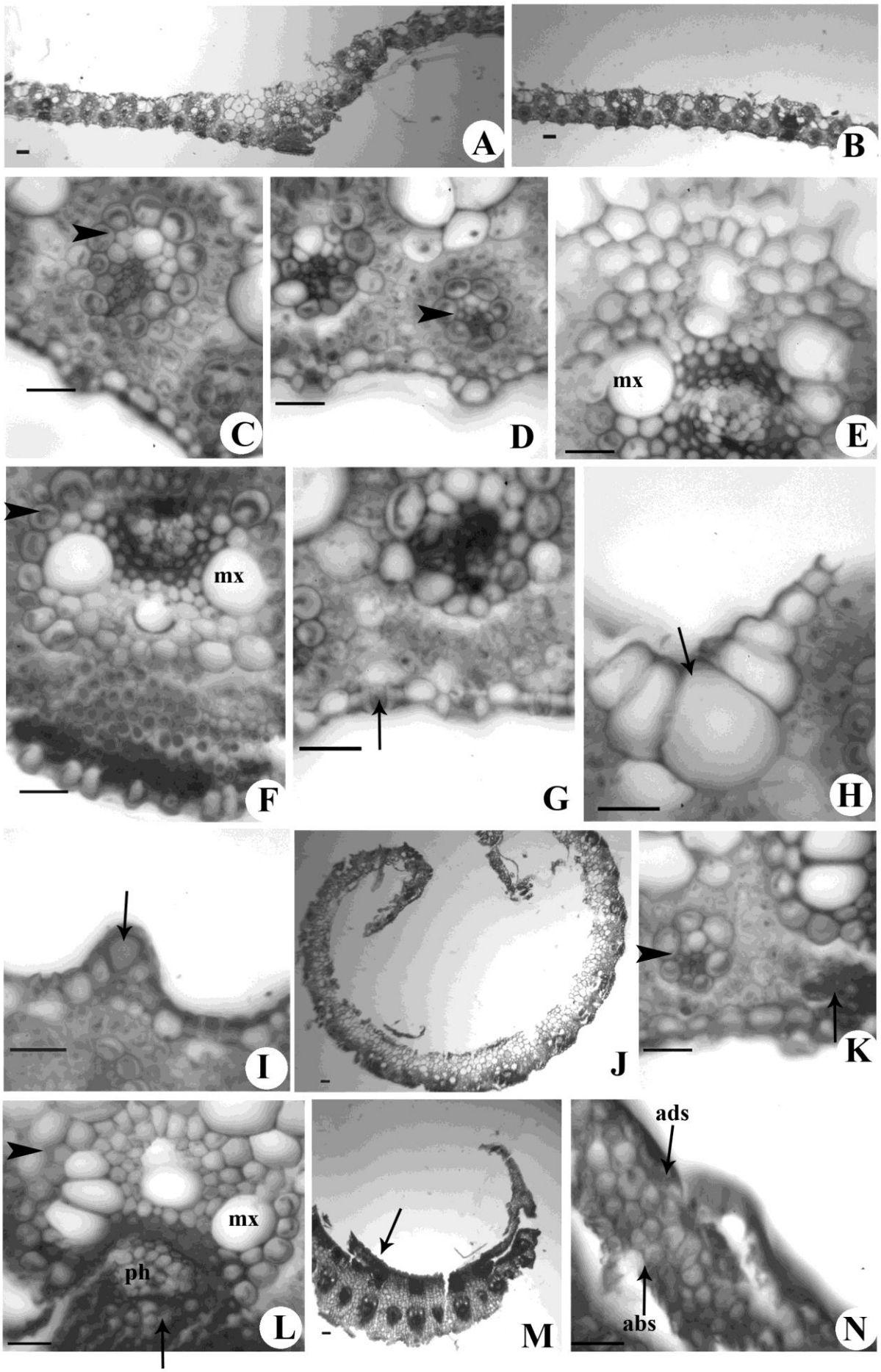

Fig. 143

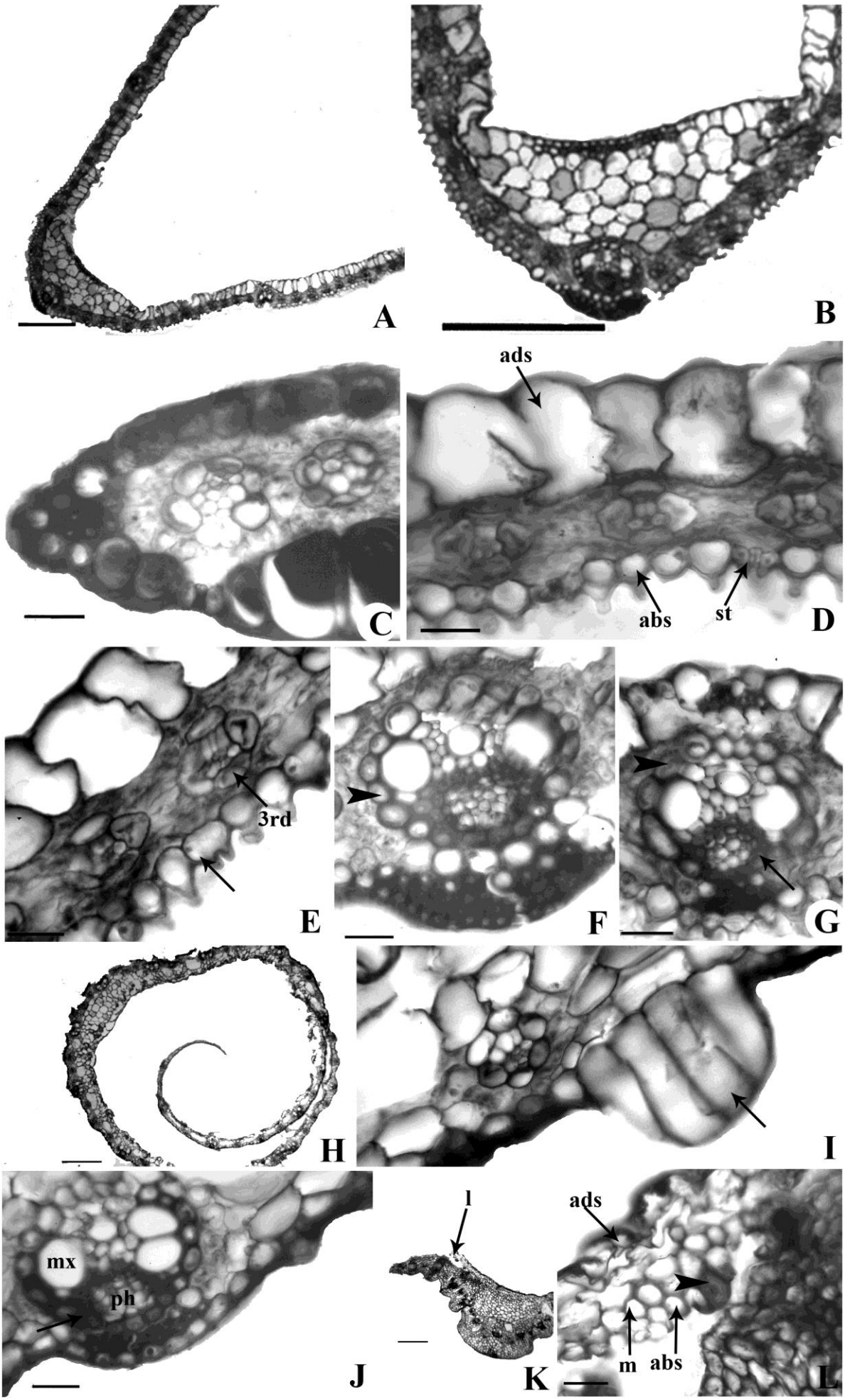

Fig. 144

22. *Iseilema laxum*

LEAF LAMINA: (Fig. 145 A-D)

Outline of the lamina: Expanded with flat, straight leaf blade. Ribs and furrows are present on the leaf surface.Adaxial surface with medium furrow between all vascular bundles and triangular ribs present above all vascular bundles. Abaxial surface has shallow ribs and furrows. Keel is inconspicuous.

Epidermis: Adaxial epidermal surface with fan shaped bulliform cells and small round epidermal cells. Abaxial epidermal cells are barrel shaped with thick cuticle which occupies less than half of the depth of the cells.

Mesophyll: Radiate, single layered, isodiametric chlorenchyma cells completely surrounding bundles. Compact homogenous chlorenchymatous cells occuping the major area between the adaxial and abaxial epidermides. Chlorenchyma cells continuous between bundles and forming a horizontally elongated strap. Colourless cells absent.

Vascular bundles: Four 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundle. Six 3rd order bundles between consecutive larger bundles present. All the vascular bundles are at same level and placed centrally.

3rd order vascular bundles: Pentagonal shaped and vascular tissue consisting of only few indistinguishable vascular elements (Fig. B).

2nd order vascular bundles: Circular shaped (Fig. C)

1st order vascular bundles:

Shape: Circular

Relationship of phloem cells and the vascular fibres: Phloem adjoins the inner or parenchyma sheath

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Shape of metaxylem vessels: Circular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. B, arrowhead)

Shape: Triangular

Shape of bundle sheath cell: Fan shaped

2nd order vascular bundle's bundle sheath: (Fig. C, arrowhead)

Shape: Round

Shape of bundle sheath cell: Elliptical and fan shaped

Number of bundle sheath cell: 8-9

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast placed centrally

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath:

Shape: Circular

Extent of bundle sheath around the vascular bundle: Complete
Extension of bundle sheath: Absent
Number of cells comprising the bundle sheath: 8-9 parenchyma cells
Bundle sheath cell shape: Few cells are fan shaped and few elliptical
Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Absent
Abaxial sclerenchyma: Minute strand consisting of only a few subepidermal fibers
Sclerenchyma between bundles: Absent
Sclerenchyma in leaf margin: Forming fiberous pointed cap. Epidermal cells of margin are thin with thick tangential wall.

LEAF SHEATH ANATOMY (Fig. 145 E-H)

Outline of lamina: Round shaped inrolled margins. Minute ribs and furrows present.
Epidermis: Adaxial epidermal cells: flat, rectangular
Abaxial epidermal cells: broad, barrel shaped with thick cuticle.
Ground tissue: Parenchymatous with oval shped air cavity (Fig. E, arrow).
Vascular bundle:

Arrangement of vascular bundle: One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle
3rd order vascular bundle: Circular shaped with vascular tissue consisting of only few indistinguishable vascular elements (Fig. G)
2nd order vascular bundle: Circular shaped
1st order vascular bundle: Circular shaped with Phloem adjoins the inner or parenchyma sheath. Lysigenous cavity and enlarged protoxylem vessel present. Circular wide metaxylem vessel elements (Fig. H)

Vascular bundle sheath: (Fig. G, arrowhead)

Shape: Half circle
Extent of bundle sheath around the vascular bundle: Sheath incomplete, interrupted by sclerenchyma cells
Number of cells comprising the bundle sheath: 9-10 parenchyma cells
Bundle sheath cell shape: Fan shaped. Cells smaller than the ground tissue.
Mestome/ Inner sheath: Absent

Sclerenchyma: In form of well developed broad girder present on abaxial surface (Fig. H, arrow).

LIGULE ANATOMY (Fig. 145 I, J)

Shape: Ligule attached to the leaf sheath more than the half width and very broad round shaped at the connections point (Fig. I, arrow)
Anatomy: Two layered mesophyll cells between adaxial and abaxial surface, abaxial few sclerenchyma cells present on abaxial surface (Fig. J, arrow)

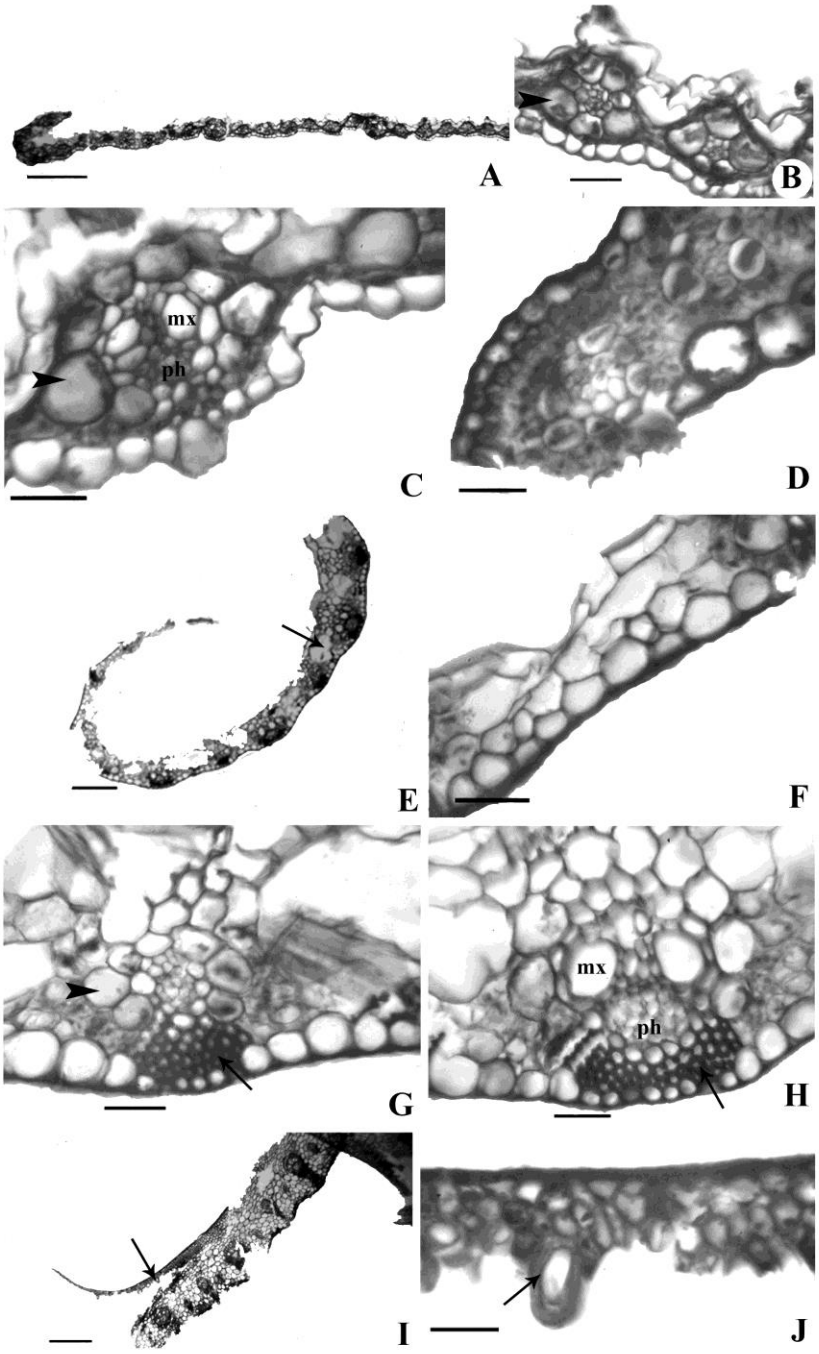

Fig. 145

23. *Ophiuros exaltatus*

LEAF LAMINA: (Fig. 146 A-G)

Outline of the lamina: 'V' shaped with wide angle having straight arms (Fig. A). Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are absent on the leaf surface.

Keel is well developed, inverted triangular shaped with 3 1st order vascular bundle, 6-7 2nd order and 9-10 3rd order vascular bundles (Fig. C). Small, rounded parenchyma cells are present surrounding the median vascular bundle adaxially. Sclerenchyma present on abaxial surface associated with vascular bundles in form of well developed wide anchored girder.

Epidermis: Adaxial epidermal surface has groups of bulliform cells which are similar in size with epidermal cells. Abaxial epidermis has round to square shaped epidermal cells with cuticle. Stomata (Fig. E, arrow) and silica bodies (Fig. D, arrow) present on abaxial surface.

Mesophyll: Radiate, single layered, tubular chlorenchyma cells completely surrounding bundles. Compact homogenous chlorenchymatous cells occuping the major area between the adaxial and abaxial epidermides. Chlorenchyma cells arranged in form of horizontal elongated strap. Colourless cells absent.

Vascular bundles: 9-10 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundle. 2-3 3rd order bundles between consecutive larger bundles and 5-6 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally.

3rd order vascular bundles: Circular shaped and vascular tissue consisting of only few indistinguishable vascular elements (Fig. G).

2nd order vascular bundles: Circular shpaed

1st order vascular bundles: (Fig. F)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. G, arrowhead)

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 7-8

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast towards outer tangential wall

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. F, arrowhead)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: complete

Extension of bundle sheath: 1st order vascular bundles showed adaxial and abaxial broad extension, extend to bundle sheath

Number of cells comprising the bundle sheath: 20-22 parenchyma cells comprise the sheath

Bundle sheath cell shape: Different sized elliptical, elongated cells. Chloroplast concentrated towards outer tangential wall.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Well developed broad girder present above 1st order vascular bundle

Abaxial sclerenchyma: Well developed girder below the 1st order vascular bundle

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming well developed rounded cap. Epidermal cells of margin are thin with otuer thick tangential wall (Fig. B).

LEAF SHEATH ANATOMY (Fig. 146H-J)

Outline of lamina: Round shaped inrolled margins. Minute ribs and furrows absent (Fig. H).

Epidermis: Adaxial and abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with round shaped air cavity (Fig. I, arrow).

Vascular bundle:

Arrangement of vascular bundle: Six consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Pentagonal shaped with vascular tissue consisting of only few indistinguishable vascular elements (Fig. J)

2nd order vascular bundle: Circular shaped

1st order vascular bundle: Elliptical shaped with phloem completely surrounded by thick walled fibers. Lysigenous cavity and enlarged protoxylem vessel present. Circular wide metaxylem vessel elements

Vascular bundle sheath: (Fig. J, arrowhead)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Incomplete, interrupted by parenchyma cells

Number of cells comprising the bundle sheath: 12-13 parenchyma cells

Bundle sheath cell shape: Different sized elliptical, elongated cells. Chloroplast concentrated towards outer tangential wall. Cells smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of straight horizontal well developed anchored girder present on abaxial surface.

LIGULE ANATOMY (Fig. 146 K, L)

Shape: Ligule attached to the lamina more than half width and very broad round shaped at the connection point (Fig. K, arrow)

Anatomy: Two layered mesophyll cells between adaxial and abaxial surfaces (Fig. L)

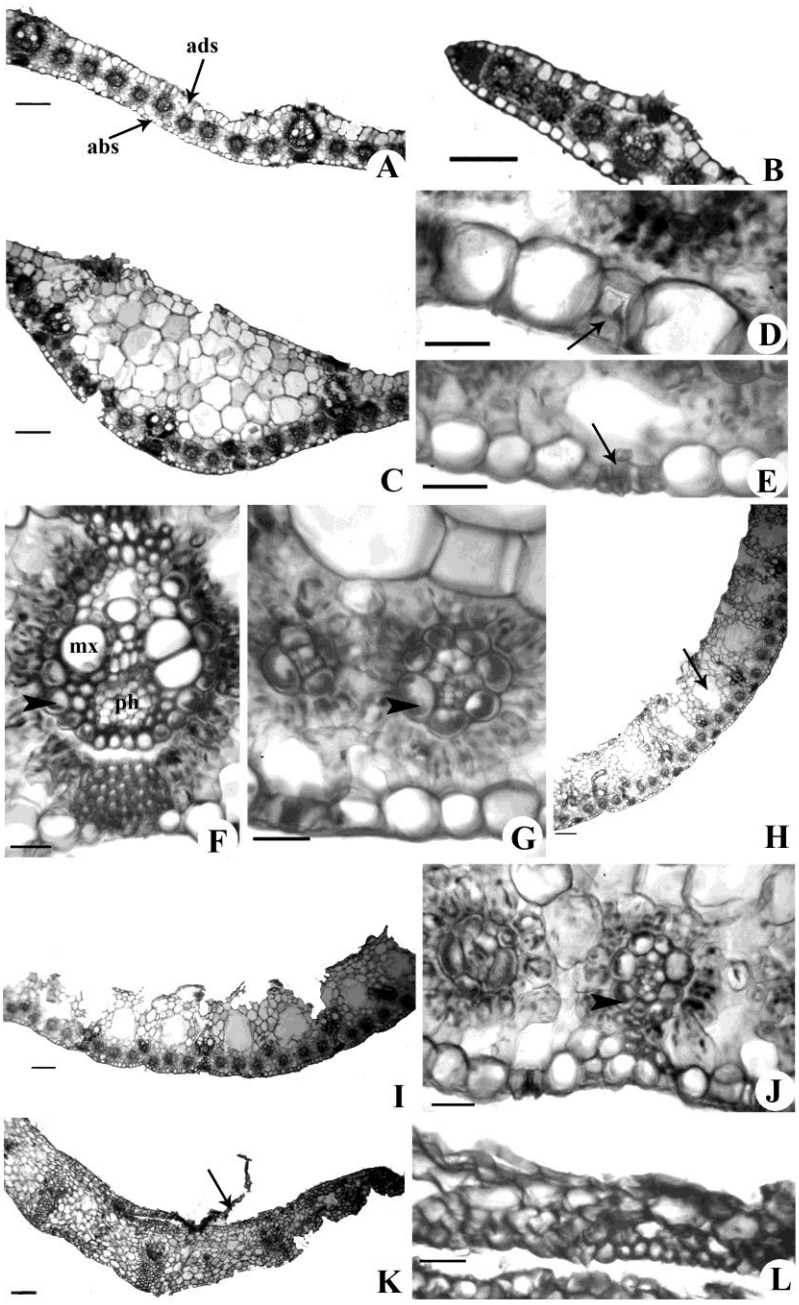

Fig. 146

24. *Rottboellia exaltata*

LEAF LAMINA: (Fig. 147 A-G)

Outline of the lamina: 'V' shaped with wide angle and having straight arms (Fig. A).Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are absent on the leaf surface.

Keel is well developed, V-shaped with 6 1st order vascular bundles, 4 2nd and 8-9 3rd order vascular bundles. Median vascular bundle surrounded by small round parenchyma cells (Fig. B). Sclerenchyma in form of strands adaxially and on abaxially surface associated with vascular bundles.

Epidermis: Adaxial epidermal surface shows two types of bulliform cells: (1) most of epidermal cell which are inflated and big bulliform cells (Fig. G, arrow) (2) restricted group of inflated bulliform cells projecting above the epidermal surface (Fig. E) and at the base of bulliform cell, hair is present (Fig. E, arrow). Abaxial epidermial cells rectangular to barrel shaped with cuticle.

Mesophyll: Radiate, single layered, isodiametric chlorenchyma cells completely surrounding bundles. Compact homogenous chlorenchymatous cells occupy the major area between the adaxial and abaxial epidermides. Chlorenchyma cells form an elongated strap continuous between bundles. Colourless cells absent.

Vascular bundles: 6-7 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundles. 8-9 3rd order bundles between consecutive larger bundles and 3-4 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and centrally placed.

3rd order vascular bundles: Hexagonal with vascular tissue consisting of only few indistinguishable vascular elements (Fig. D).

2nd order vascular bundles: Elliptical shaped

1st order vascular bundles: (Fig. F)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Phloem adjoins the inner or parenchyma sheath

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. D)

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 9-10

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast concentrated towards outer tangential wall

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. F)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Sheath incomplete, abaxially interrupted by sclerenchyma

Extension of bundle sheath: Narrow abaxial extension of the bundle sheath

Number of cells comprising the bundle sheath: 23-25 parenchyma cells

Bundle sheath cell shape: Different sized, elliptical, elongated cells.Chloroplast concentrated towards outer tangential wall.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Absent

Abaxial sclerenchyma: Well developed strand, wider than deep and it follows shape of abaxial rib

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very small fiberous pointed cap. Epidermal cells of margin are with thick tangential wall.

LEAF SHEATH ANATOMY (Fig. 147 H-L)

Outline of lamina: Round shaped inrolled margins (Fig. H). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with outer tangential wall covered with very thick cuticle. It also shows short trichomes (Fig. L, arrow)

Ground tissue: Parenchymatous with an absence of air cavity.

Vascular bundle:

Arrangement of vascular bundle: One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Hexagonal with vascular tissue consisting of only few indistinguishable vascular elements

2nd order vascular bundle: Elliptical shaped

1st order vascular bundle: Elliptical shaped with phloem adjoins the inner or parenchyma sheath. Lysigenous cavity and enlarged protoxylem vessel present. Circular wide metaxylem vessel elements (Fig. I)

Vascular bundle sheath: (Fig. I, J arrowhead)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Sheath incomplete, interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 13-14 parenchyma cells

Bundle sheath cell shape: Round similar in size than ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of well developed arched girder on abaxial surface (Fig. J, arrow).

LIGULE ANATOMY (Fig. 147M, N)

Shape: Ligule attached to the leaf sheath more than the half width and very broad round shaped at the connection point (Fig. M, arrow)

Anatomy: Two layered mesophyll cells between adaxial and abaxial surfaces (Fig. N)

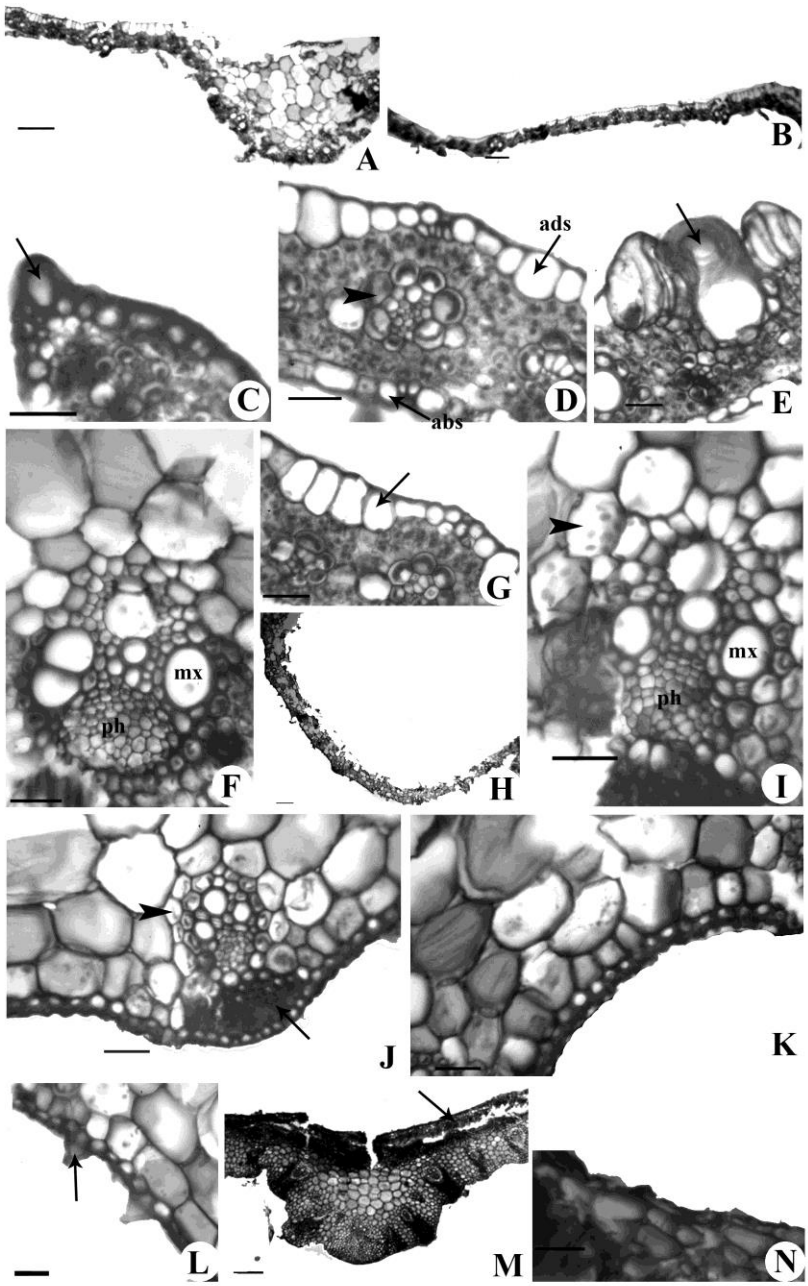

Fig. 147

25. *Saccharum spontaneum*

LEAF LAMINA: (Fig. 148 A-H)

Outline of the lamina: 'V' shaped with wide angle having outwardly curving arms (Fig. A, B).Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are absent on the leaf surface.

Keel is well developed, V-shaped with 15-17 1st order vascular bundle, 16-17 2nd and 28-29 3rd order vascular bundles. Small, round parenchyma cells are present surrounding the median vascular bundle adaxially. Sclerenchyma present on adaxial surface in form of subepidermal strands and on abaxial surface associated with vascular bundles in form of girders.

Epidermis: Adaxial epidermal surface has two types of bulliform cells: (1) restricted group of inflated bulliform cells in level with the epidermal surface (Fig. H, arrow) (2) fan shaped bulliform cells (Fig. E, arrow). Abaxial epidermal cells round to square shaped (Fig. D, arrow) with thick cuticle.

Mesophyll: Incomplete radiate chlorenchyma cells completely surrounding bundles. Compact homogenous chlorenchymatous cells occuping the major area between the adaxial and abaxial epidermides. Chlorenchyma cells continuous between bundles. Colourless cells absent.

Vascular bundles: 7 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundles. 33-34 3rd order bundles between consecutive larger bundles and 14-16 2nd order bundles between consecutive 1st order bundles. All the vascular bundles present at same level and placed abaxially.

3rd order vascular bundles: Hexagonal (Fig. C) or elliptical (Fig. D) with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: Elliptical shaped

1st order vascular bundles: (Fig. G)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Phloem completely surrounded by sclerenchyma cells

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath:

Shape: Round (Fig. C, arrowhead) and elliptical (Fig. D, arrowhead)

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Cells elliptical to round

Number of bundle sheath cell: 11-12

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast placed centrally

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. G, arrowhead)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Sheath incomplete, abaxially interrupted by sclerenchyma

Extension of bundle sheath: Narrow abaxial extension of the bundle sheath

Number of cells comprising the bundle sheath: 17-19 parenchyma cells comprise the sheath

Bundle sheath cell shape: Different sized, elliptical, elongated cells. Chloroplast placed centrally.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Absent

Abaxial sclerenchyma: Well developed girder, narrower deeper than wide (Fig. C, arrow).

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very small fiberous pointed cap. Epidermal cells of marign are with thick tangential wall.

LEAF SHEATH ANATOMY (Fig. 148 I-N)

Outline of lamina: Round shaped inrolled margins (Fig. K). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular and with outer tangential wall have double thick cuticle.

Ground tissue: Parenchymatous with round shaped air cavity (Fig. K)

Vascular bundle:

Arrangement of vascular bundle: One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Elliptical shaped with vascular tissue consisting of only few indistinguishable vascular elements (Fig. N)

2nd order vascular bundle: Elliptical shaped (Fig. L)

1st order vascular bundle: Elliptical shaped with phloem completely surrounded by sclrenchyma. Lysigenous cavity and enlarged protoxylem vessel present. Circular very wide metaxylem vessel elements (Fig. J)

Vascular bundle sheath: (Fig. J, L, arrowhead)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Complete

Number of cells comprising the bundle sheath: 16-17parenchyma cells

Bundle sheath cell shape: All cells are round to elliptical in shape. Cells smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of well developed narrow girder present on abaxial surface.

LIGULE ANATOMY (Fig. 148 O, P)

Shape: Ligule attached to the midrib region and partially with lamina region and at the connection it is broad round shaped (Fig. O, arrow)

Anatomy: Three layered mesophyll cells between adaxial and abaxial surfaces (Fig. P).

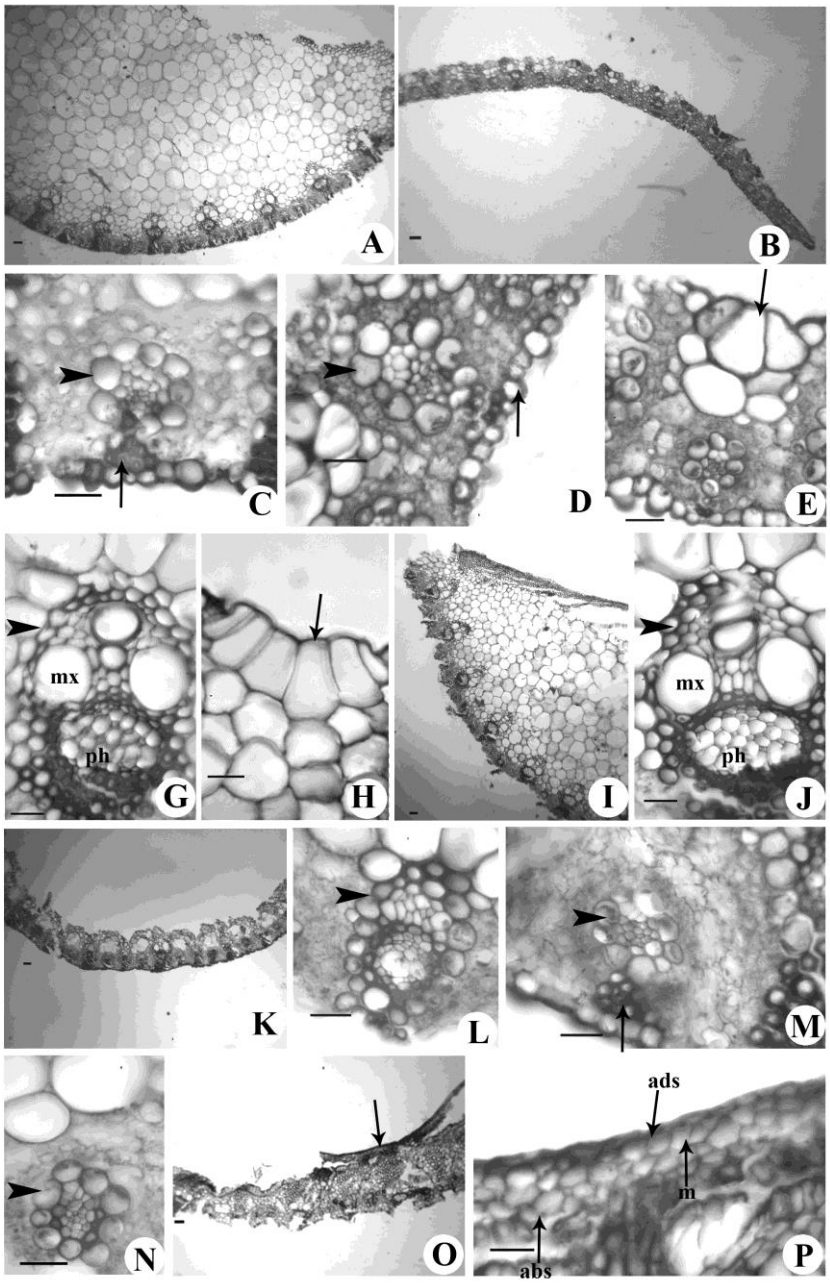

Fig. 148

Sehima

26. *Sehima ischaemoides* (Fig. 149)

27. *Sehima nervosum* (Fig. 150)

28. *Sehima sulcatum* (Fig. 151)

LEAF LAMINA: (Fig. 149 A-E, 150 A-F, 151 A-E)

Outline of the lamina: Expanded with undulating surface in *S. ischaemoides* (Fig. 149 A, B), straight leaf blade in *S. nervosum* and *S.sulcatum* (Fig. 150 A, 151 A).

Ribs and furrows are present on the leaf surface in all except *S. nervosum.* Medium in *S. ischaemoides* or shallow furrows in *S.sulcatum* on adaxial and abaxial surface present between 1st and 2nd order vascular bundles and triangular ribs with pointed apex present only over 1st and 2nd order vascular bundles.

Keel formed due to sclerenchyma projecting outwards abaxially is well developed, semicircular with single median vascular bundle. Sclerenchyma is present on abaxial surface associated with vascular bundles in form of girders.

Epidermis: Adaxial epidermal layer with fan shaped bulliform cells present at bases of furrows in *S. ischaemoides* (Fig. 149 D) or large, inflated restricted bulliform cells on adaxial surface of *S. nervosum* and *S.sulcatum* (Fig. 150 E, F arrow, 151 E, arrow). Long hairs present on abaxial surface (Fig. 150 B). Abaxial epidermal cells have barrel shaped epidermal cells with thick cuticle. Prickles are present in *S. ischaemoides* (Fig. 149 D, arrow).

Mesophyll: Radiate, single layered, isodiametric chlorenchyma cells which completely surrounds bundles. Compactly arranged homogenous chlorenchyma cells occupy the major area between the adaxial and abaxial epidermides and is continuous between bundles. Colourless cells absent.

Vascular bundles: 3-4 1st order vascular bundles in *S. ischaemoides*, 2-3 1st order vascular bundles in *S. nervosum* and *S.sulcatum* arranged regularly from median bundle to marginal bundle in half lamina.

5-6 3rd order bundles between consecutive larger bundles and 3-4 2nd order bundles between consecutive 1st order bundles. 1st and 2nd order vascular bundles centerally placed while 3rd order vascular bundles present abaxially to leaf blade.

3rd order vascular bundles: (Fig. 149 E, 150 E, 151 E)

Circular in *S. ischaemoides*), pentagonal in *S. nervosum* and *S.sulcatum* with xylem and phloem distinguishable

2nd order vascular bundles: Circular shpaed

1st order vascular bundles:

Shape: Circular

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Enlarged protoxylem vessel present and lysigenous cavity absent

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Median vascular bundles: (Fig. 149 C, 150 D, 151 C)

Shape: Circular

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Enlarged protoxylem vessel present and lysigenous cavity absent

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Fan shaped

2nd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 7-8

Nature of bundle sheath (either complete or incomplete): Incomplete, abaxially interrupted by sclerenchyma

Chloroplast position in bundle sheath cell: Translucent in *S. ischaemoides* or placed centrally as in *S. nervosum* and *S.sulcatum*

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath:

Shape: Round

Extent of bundle sheath around the vascular bundle: Sheath incomplete, abaxially interrupted by sclerenchyma

Extension of bundle sheath: Broad abaxial extension of the bundle sheath

Number of cells comprising the bundle sheath: 13-14 in *S. ischaemoides*, 15-16 in *S. nervosum* and 12-13 in *S.sulcatum* parenchyma cells

Bundle sheath cell shape: All cells are elliptical, elongated in shape. Chloroplast translucent in *S. ischaemoides* or placed centrally as in *S. nervosum* and *S.sulcatum*.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Absent

Abaxial sclerenchyma: Subepidermal strands of 2-4 fibers in *S. ischaemoides* and *S. nervosum*, well developed small girder in *S.sulcatum*

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very small pointed fibrous cap. Epidermal cells thick tangential wall.

LEAF SHEATH ANATOMY (Fig. 149 F-H, 150 G, H, 151 F-H)

Outline of lamina: Round in all spcies (Fig. 149 F, 150 G, 151 F). Ribs and furrows present in all except *S.sulcatum*. Abaxial surface has furrows which are

medium and wide in *S. ischaemoides*, shallow and wide with rounded ribs in *S. nervosum*.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavity

Vascular bundle:

Arrangement of vascular bundle: One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: (Fig. 149 H, 150 H, 151 H)

Circular with distinguishable xylem and phloem

2nd order vascular bundle: Circular shaped

1st order vascular bundle: (Fig. 151 G) Circular with phloem completely surrounded by thick walled fibers. Lysigenous cavity present and enlarged protoxylem vessel absent. Circular wide metaxylem vessels elements

Vascular bundle sheath:

Shape: Round

Extent of bundle sheath around the vascular bundle: Complete in all except *S. ischaemoides* in which bundle sheath is incomplete because it is interrupted adaxailly by parenchyma cells and abaxially by sclerenchyma cells.

Number of cells comprising the bundle sheath: 11-12 in *S. nervosum* and *S.sulcatum*, 12-13 in *S. ischaemoides* parenchyma cells.

Bundle sheath cell shape: All cells are elliptical, elongated in shape and smaller than the ground tissue cells.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of straight horizontal well developed broad abaxial strand present.

LIGULE ANATOMY (Fig. 149I, J, 150 I, 151 I)

Shape: Ligule attached to half width of leaf sheath and it is round shaped at the connection point (Fig. 149 I, 150 I, 151 I)

Anatomy: More than three layered mesophyll cells between adaxial and abaxial surfaces (Fig. 149 J).

Differentiating features:

Circular shaped 3rd order vascular bundles……..……..……*S. ischaemoides*

Pentagonal shaped 3rd order vascular bundles

Shallow furrows present on abaxial leaf surface, subepidermal strands of 2-4 fibers on abaxial leaf surface …..……..…...*S. nervosum*

Deep furrows present on abaxial leaf surface, well developed sclerenchymatous girder present on abaxial leaf surface……..…*S. sulcatum*

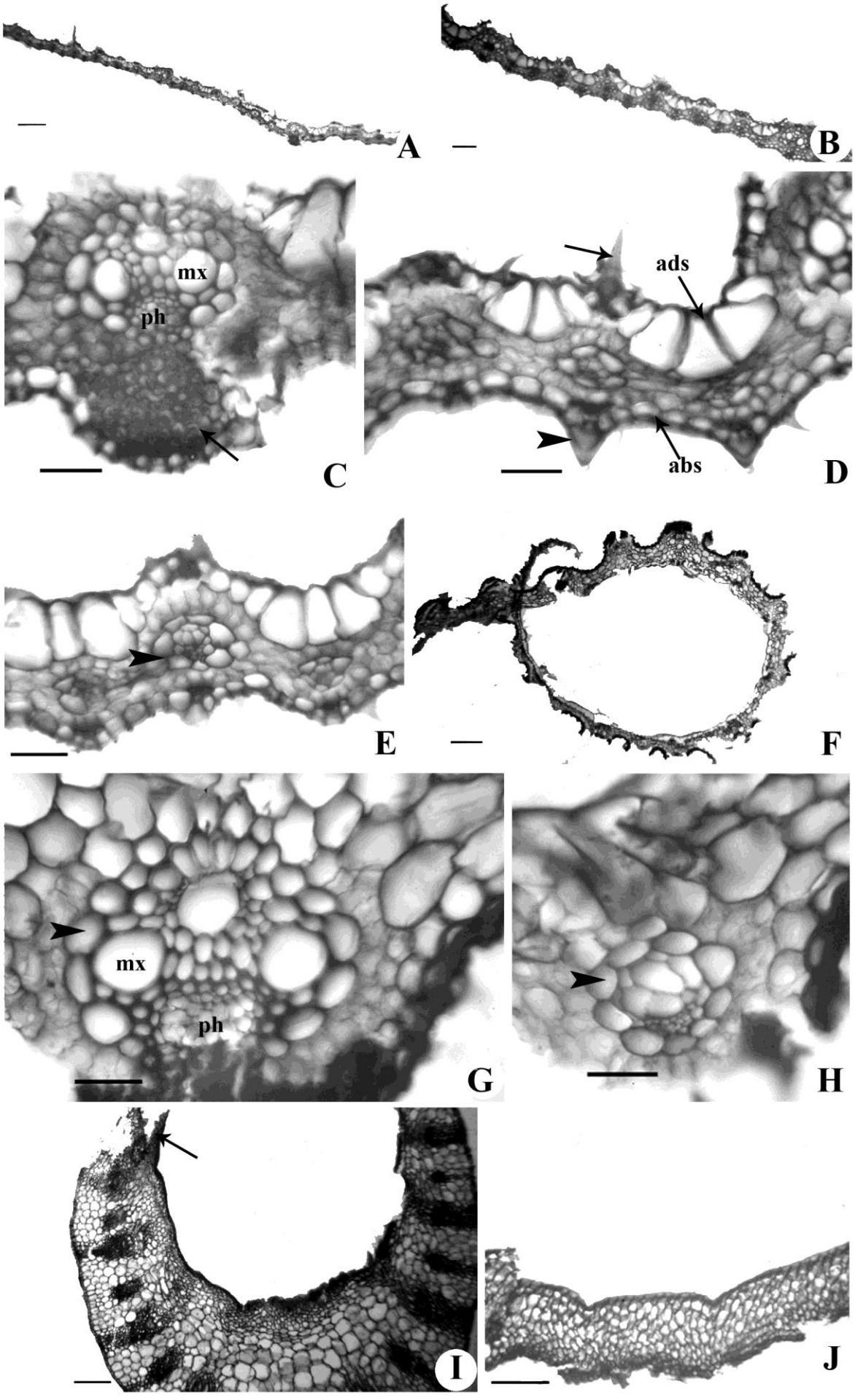

Fig. 149

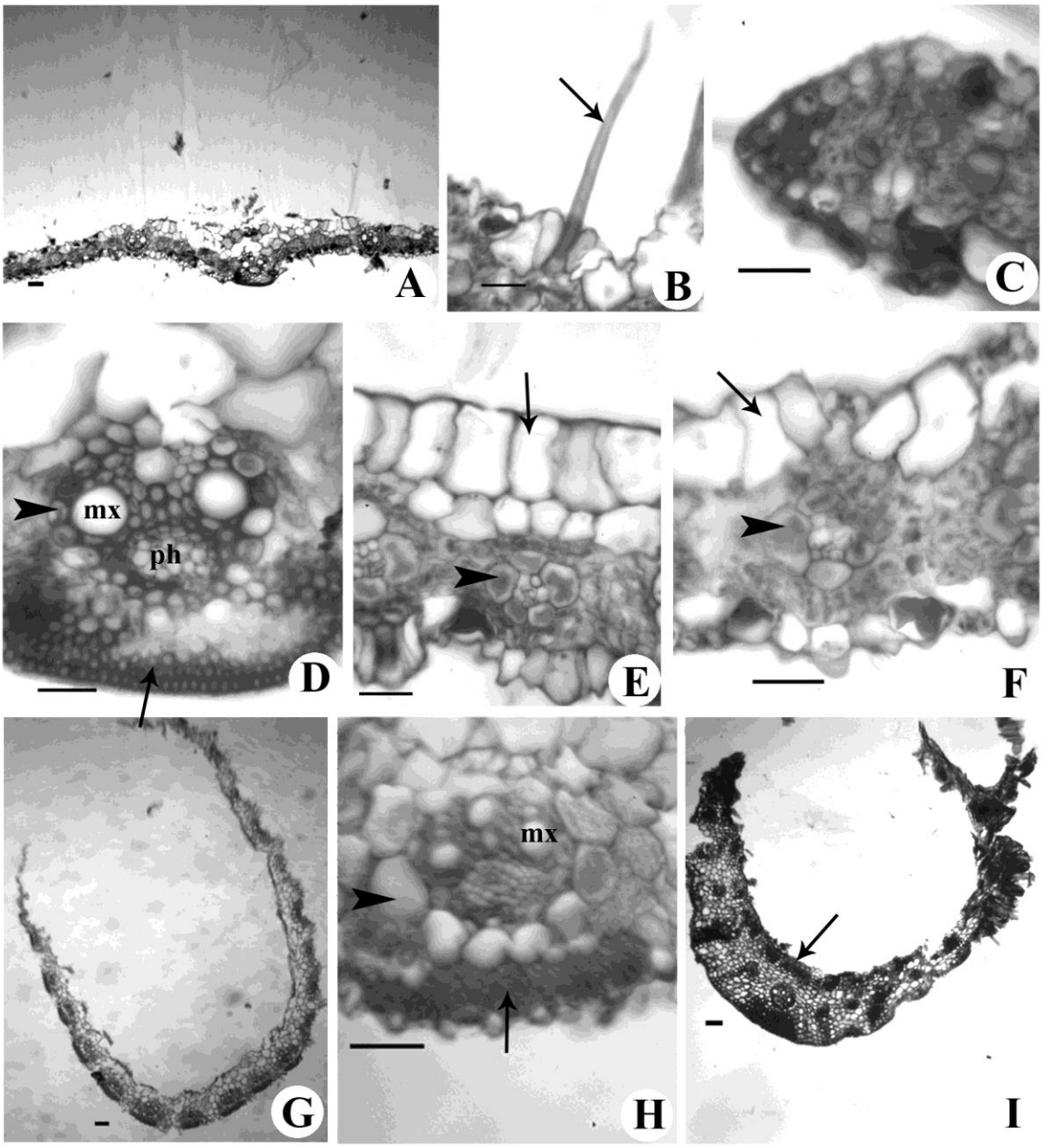

Fig. 150

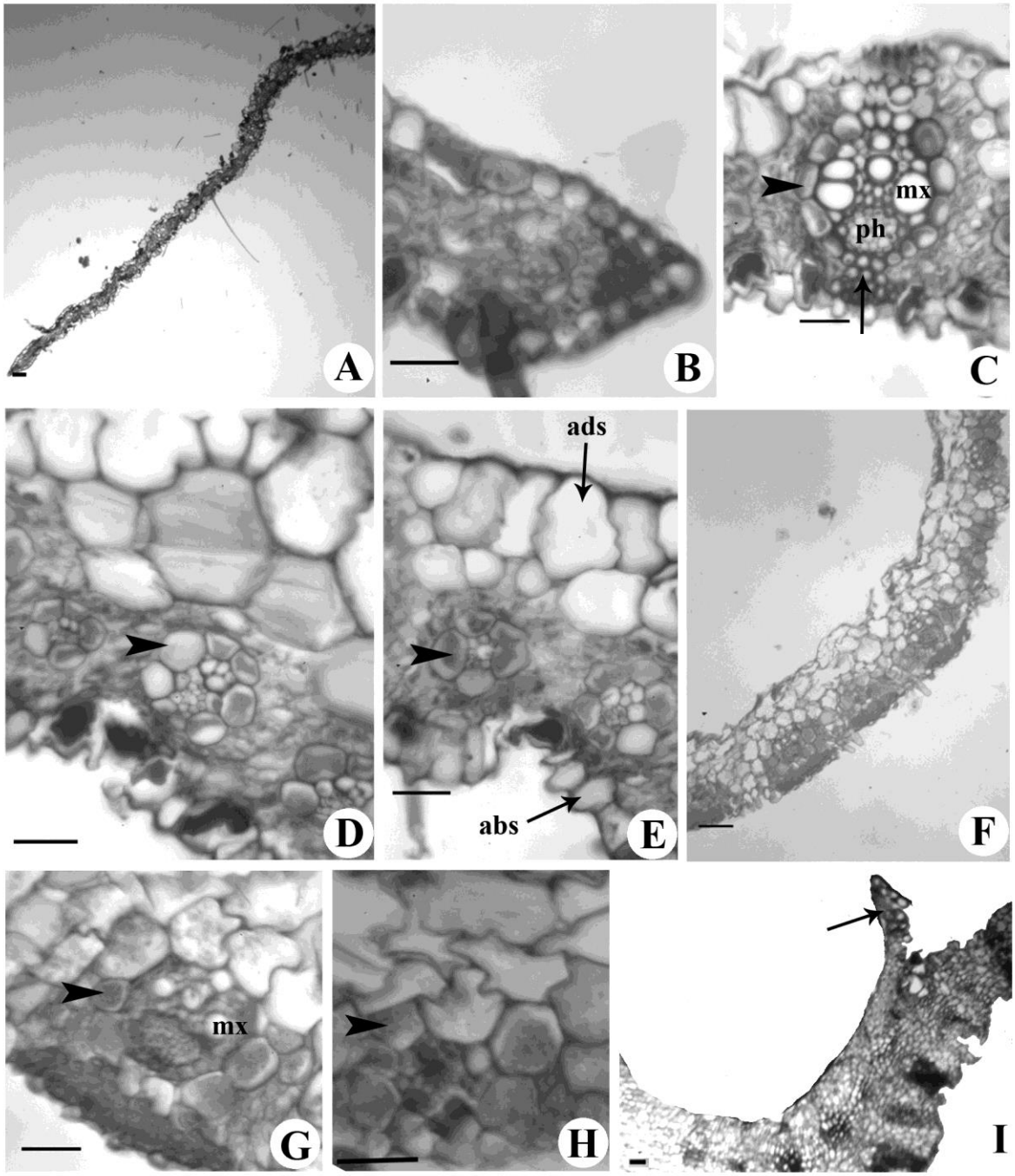

Fig. 151

29. *Sorghum halepense*

LEAF LAMINA: (Fig. 152 A-G)

Outline of the lamina: 'V' shaped with wide angles having straight arms. Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are absent on the leaf surface.

Keel is well developed, inverted triangle shaped with three 1st order vascular bundles, 4-5 2nd order vascular bundles, 6-7 3rd order vascular bundles. Small, round parenchyma cells surrounds the median vascular bundle adaxially. Sclerenchyma is present on adaxial surface in form of well developed subepidermal strands and on abaxial surface associated with vascular bundles in form of girder.

Epidermis: Adaxial epidermis major part made up of inflated, large bulliform cells. Prickles present (Fig. G, arrow). Abaxial epidermal cells barrel shaped with thick cuticle. Stomata present (Fig. F, arrow)

Mesophyll: Radiate, single layered, isodiametric cells completely surrounding bundles. Compact homogenous chlorenchymatous cells occuping the major area between adaxial and abaxial epidermides. Chlorenchyma cells continuous forming a horizontally elongated strap between bundles. Colourless cells absent.

Vascular bundles: 9-10 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundles. 7-8 3rd order bundles between consecutive larger bundles and 2-3 2nd order bundles between consecutive 1st order bundles. All the vascular bundles are centrally placed at same level.

3rd order vascular bundles: Circular with vascular tissue consisting of only few indistinguishable vascular elements (Fig. F).

2nd order vascular bundles: Circular shaped

1st order vascular bundles: (Fig. E)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Enlarged protoxylem vessel present and lysigenous cavity absent

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Very wide vessels

Shape of metaxylem vessels: Circular

Median vascular bundles: (Fig. D)

Shape: Round

Relationship of phloem cells and the vascular fibres: complete surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Enlarged protoxylem vessel present and lysigenous cavity absent

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Very wide vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. F, arrowhead)

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 12-14

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast positioned towards outer tangential wall

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. E)

Shape: Circular

Extent of bundle sheath around the vascular bundle: Incomplete, abaxially interrupted by sclerenchyma cells

Extension of bundle sheath: Narrow extension towards both epidermises present

Number of cells comprising the bundle sheath: 21-22 parenchyma cells

Bundle sheath cell shape: All cells are elliptical and elongated. Chloroplast positioned towards outer tangential wall

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Minute strand consisting of only a few subepidermal fibers

Abaxial sclerenchyma: Well developed girder below the 1st order vascular bundle

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming well developed (Fig. C, arrow) round cap. Epidermal cells at margin are fibrous; thick walled.

LEAF SHEATH ANATOMY (Fig. 152 H-K)

Outline of lamina: Round shaped (Fig. H, I). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with horizontal oval shaped air cavity (Fig. I, arrow)

Vascular bundle:

Arrangement of vascular bundle: One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Elliptical with vascular tissue consisting of only a few indistinguishable vascular strands (Fig. K)

2nd order vascular bundle: Elliptical shaped

1st order vascular bundle: Elliptical shaped with phloem completely surrounded by thick walled fibers (Fig. J, arrow). Lysigenous cavity and enlarged protoxylem vessel present. Circular wide metaxylem vessel elements (Fig. J)

Vascular bundle sheath: (Fig. J, K arrowhead)

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath incomplete and interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 19-20 parenchyma cells comprise the sheath

Bundle sheath cell shape: All cells are elliptical, elongated in shape; cells smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of straight horizontal well developed abaxial strands present.

LIGULE ANATOMY (Fig. 152 L, M)

Shape: Ligule attached to the midrib region and broad round shaped at connection point (Fig. M, arrow)

Anatomy: More than three layered mesophyll cells between adaxial and abaxial surfaces (Fig. L).

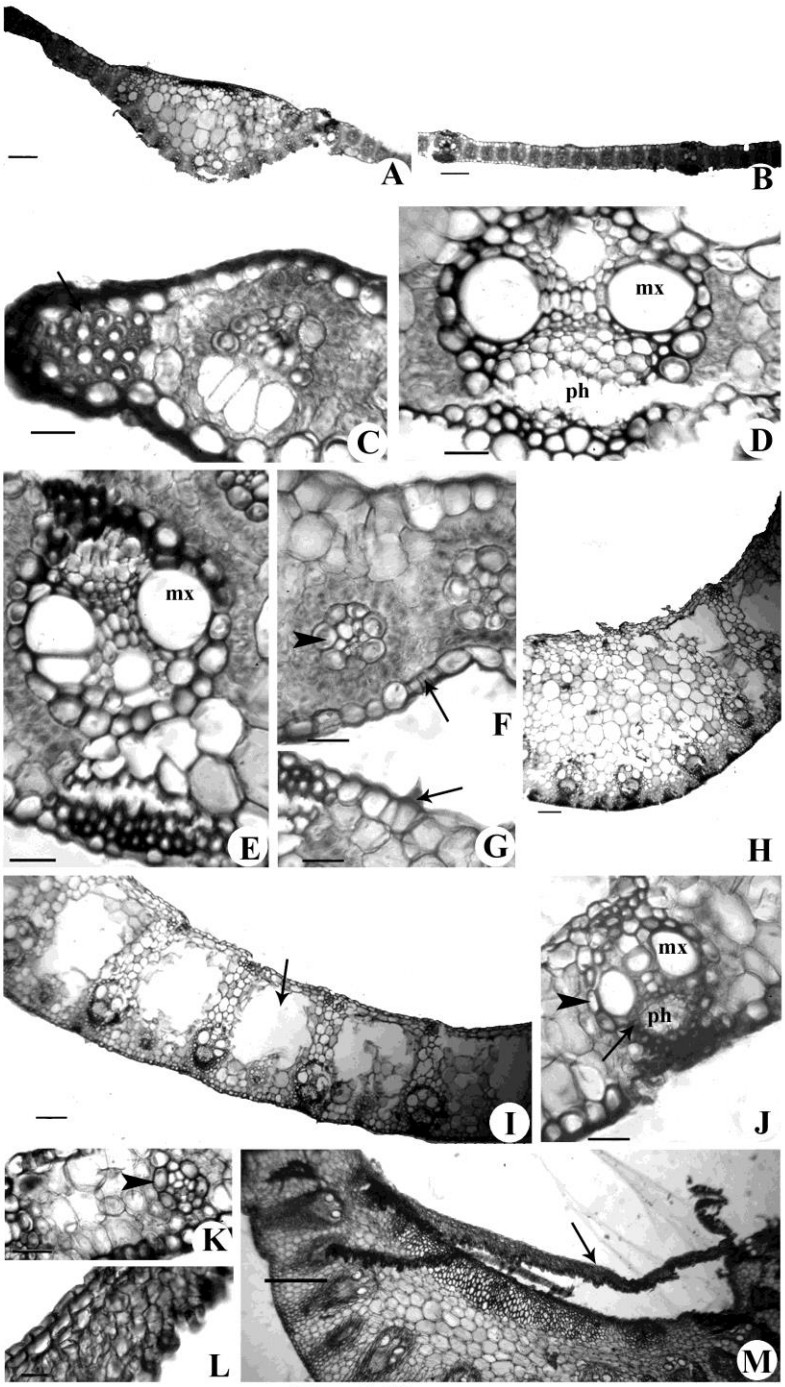

Fig. 152

30. *Thelepogon elegans*

LEAF LAMINA: (Fig. 153 A-G)

Outline of the lamina: Expanded with flat, straight leaf blade (Fig. A, B). Ribs and furrows are absent on the leaf surface.

Keel is well developed, semicircular with two 1st order vascular bundle, 3-4 3rd order vascular bundles.Sclerenchyma present on abaxial surface associated with vascular bundles in form of narrow strands.

Epidermis: Adaxial epidermis major part of adaxial epidermis made up of inflated bulliform cells interrupted by small group of epidermal cells (Fig. D, arrow). Long, slender constriction of hair above bulbose base, embedded in large, inflated bulliform cells (Fig. G). Barrel shaped abaxial epidermal cells with thick cuticle.

Mesophyll: Radiate, two layered, isodiametric chlorenchyma cells which completely surrounds the bundles. Compact homogenous chlorenchymatous cells occupy the major area between the adaxial and abaxial epidermides and continuous between bundles. Colourless cells absent.

Vascular bundles: 4-5 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundle. 3 3rd order bundles between consecutive larger bundles and 3 2nd order bundles between consecutive 1st order bundles present. All bundles are at same level and placed centrally.

3rd order vascular bundles: Hexagonal with xylem and phloem distinguishable (Fig. D)

2nd order vascular bundles: Circular shaped (Fig. E)

1st order vascular bundles: (Fig. F)

Shape: Circular

Relationship of phloem cells and the vascular fibres: Phloem adjoins the inner or parenchyma sheath

Nature of lysigenous cavity and protoxylem: Enlarged protoxylem vessel and lysigenous cavity absent

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Angular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. D, arrowhead)

Shape: Round

Shape of bundle sheath cell: Round shaped

2nd order vascular bundle's bundle sheath: (Fig. E, arrowhead)

Shape: Round

Shape of bundle sheath cell: Cells round in shape

Number of bundle sheath cell: 9-10

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast small and indistinct

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. F, arrowhead)

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 12-13

Bundle sheath cell shape: All cells are elliptical to round in shape. Chloroplast small and indistinct

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Absent

Abaxial sclerenchyma: Small, 2-4 fibers in form of strands

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming a well developed round cap. Epidermal cells at margin are with thick outer tangential wall (Fig. C)

LEAF SHEATH ANATOMY (Fig. 153H-J)

Outline of lamina: 'V' shaped with inrolled margins. Ribs and furrows absent (Fig. H).

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavity

Vascular bundle:

Arrangement of vascular bundle: One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle.

3rd order vascular bundle: Circular shaped with xylem and phloem distinguishable (Fig. J)

2nd order vascular bundle: Circular shaped

1st order vascular bundle: Elliptical shaped with phloem adjoins the inner or parenchyma sheath. Lysigenous cavity absent and enlarged protoxylem vessel present. Circular wide metaxylem vessels elements (Fig. I)

Vascular bundle sheath: (Fig. I, J arrowhead)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Complete

Number of cells comprising the bundle sheath: 13-14 parenchyma cells

Bundle sheath cell shape: All cells are elliptical, elongated in shape. There is gradation in size of cells with large cells towards abaxial and adaxial surfaces, cells smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of straight horizontal well developed broad strand present on abaxial surface (Fig. I, arrow).

LIGULE ANATOMY (Fig. 153 K)

Shape: Ligule attached to the half width of the leaf sheath region and it is round shaped at the connection point (Fig.K, arrow)

Anatomy: Three layered mesophyll cells between adaxial and abaxial surfaces

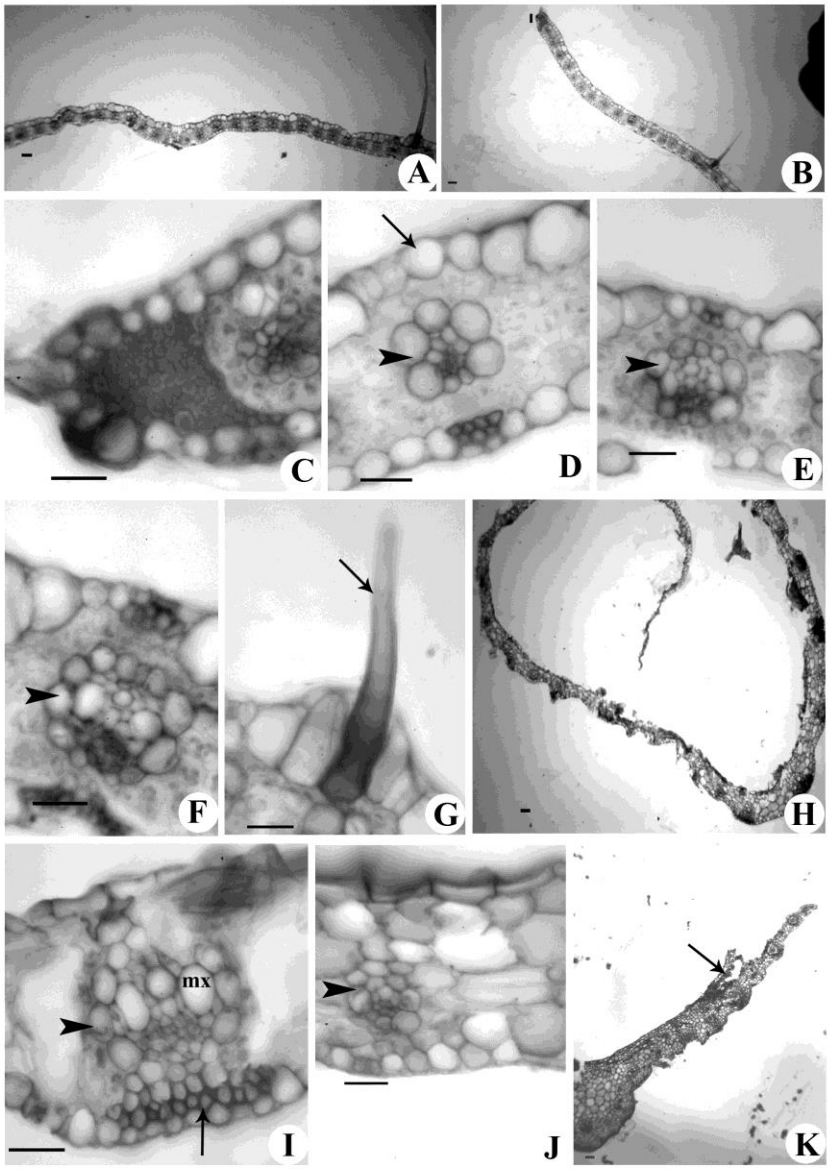

Fig. 153

Themeda

31. *Themeda cymbaria* (Fig. 154)

32. *Themeda laxa* (Fig. 155)

33. *Themeda triandra* (Fig. 156)

34. *Themeda quadrivalvis* (Fig. 157)

LEAF LAMINA: (Fig. 154 A-G, 155 A-D, 156 A-F, 157 A-E)

Outline of the lamina: 'V' shaped with standard angled in *T. cymbaria* and *T. laxa* (Fig. 154 A, B, 155 A), narrow angled in *T. triandra* (Fig. 156 A) having outwardly curving convex shaped arms or broad angled with straight arms in *T. quadrivalvis* (Fig. 157 A).

Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are absent in all species except in *T. cymbaria* in which it has medium, wide furrows between 1st and 2nd order vascular bundles and triangular shaped ribs with pointed apex only on adaxial surface.

Keel is well developed, V-shaped with single median vascular bundle, 15-16 3rd order and 3-4 2nd order bundles in *T. cymbaria*, 2 large, 8-9 3rd and 3-4 2nd order in *T. laxa*, 10-11 3rd order and 2-3 2nd order bundles in *T. triandra* and 2-3 3rd order bundles in *T. quadrivalvis*. Small, round parenchyma cells present surrounding the median vascular bundle adaxially. Sclerenchyma present on abaxial surface associated with vascular bundles in form of strands.

Epidermis: Adaxial epidermal surface has fan shaped bulliform cells (Fig. 154 C, arrow) which occupy less than ½ of the leaf thickness in *T. cymbaria*, most of the adaxial epidermis is made up of large, inflated buliform cells in *T. laxa* (Fig. 155 D) while adaxial epidermal surface has restricted group of bulliform cells in *T. triandra* and *T. quadrivalvis* (Fig. 156 D, 157 D) which are not larger than the epidermal cells. There are not associated with colourless cells in *T. triandra* and *T. quadrivalvis*.

Abaxial epidermal cells have barrel shaped cells in *T. cymbaria* and *T. triandra* or elongatd, rectangular shaped cells in *T. laxa* or small, rectangular to barrel shaped cells in *T. quadrivalvis* with thick cuticle. Papillae present on few epidermal cells one papillae per cell in *T. cymbaria* and *T. triandra* (Fig. 154 G, 156 D). Pointed trichomes present on abaxial surface in *T. cymbaria* (Fig. 154 E). Restricted group of large, inflated buliform cells projecting above epidermis are present on abaxial surface in *T. laxa*, *T. triandra* (Fig. 155 D, 156 F, arrow).

Mesophyll: Radiate, single layered, isodiametric cells completely surrounding bundles. Compactly arranged homogenous chlorenchyma cells occupy the major area between the adaxial and abaxial epidermides. Chlorenchyma cells form horizontal elongated strap continuous between bundles. Colourless cells absent.

Vascular bundles: Vascular bundles regularly arranged from median bundle to marginal bundles in half lamina. 3 1st orders in *T. cymbaria* and *T. triandra*, 4-5 1st order in *T. laxa*, 5 1st order in *T. quadrivalvis*. 4-5 3rd order and 2-3 2nd order in *T. cymbaria*, 3-4 3rd order and 1-2 2nd order in *T. laxa*, 7-8 3rd order and 2-3 2nd order in *T. triandra*, 3-4 3rd order and 2-3 2nd order in *T. quadrivalvis* bundles between consecutive 1st order bundles present. 1st and 2nd order vascular bundles

placed centrally and 3rd order vascular bundles placed abaxially of leaf blade in *T. cymbaria, T. laxa* while in *T. triandra, T. quadrivalvis,* all vascular bundles are placed abaxially at same level.

3rd order vascular bundles: (Fig. 155D, 156 E, 157 D)

Hexagonal with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: (Fig. 154 F, 155 F)

Elliptical in *T. cymbaria* and *T. laxa*

Circular in *T. triandra* and *T. quadrivalvis*

1st order vascular bundles: (Fig. 156 C, 157 C)

Shape: Elliptical in all except circular in *T. quadrivalvis*

Relationship of phloem cells and the vascular fibres: Complete surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Enlarged protoxylem vessel present in all and lysigenous cavity absent only in *T. quadrivalvis*

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Median vascular bundles: (Fig. 155 C)

Shape: Round in *T. cymbaria* and *T. quadrivalvis*, Elliptical in *T. laxa* and *T. triandra*

Relationship of phloem cells and the vascular fibres: Complete surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Enlarged protoxylem vessel present in all and lysigenous cavity absent only in *T. quadrivalvis*

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Vascular bundle sheath: (Fig. 157 D, arrow)

3rd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 7-8 cells in all except 8-9 in *T. triandra*

Nature of bundle sheath (either complete or incomplete): Complete in *T. cymbaria* and *T. laxa*, Incomplete and abaxially interrupted by sclerenchyma in *T. triandra* and *T. quadrivalvis*

Chloroplast position in bundle sheath cell: Chloroplast positioned towards outer tangential wall in all species except in *T. laxa* where it is centrally located.

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath:

Shape: Elliptical in all species except in *T. cymbaria* which is circular.

Extent of bundle sheath around the vascular bundle: Sheath incomplete and abaxially interrupted by sclerenchyma

Extension of bundle sheath: Absent in *T. cymbaria* and *T. quadrivalvis*. In *T. laxa* and *T. triandra*, small abaxial extension of the bundle sheath.

Number of cells comprising the bundle sheath: 16-17 in *T. cymbaria*, 12-14 in *T. laxa*, 13-14 in *T. triandra*, 11-12 in *T. quadrivalvis* parenchyma cells

Bundle sheath cell shape: All cells are elliptical and elongated in shape. Chloroplast concentrated towards outer tangential wall in all species except in *T. laxa* where it is centrally placed.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Absent in *T. triandra* and *T. laxa*, minute strand consisting of 2-4 fibers present above 1st and 2nd order vascular bundles in *T. cymbaria* or well developed strands in *T. quadrivalvis*.

Abaxial sclerenchyma: Narrow strand present below 1st and 2nd order vascular bundles in *T. laxa* and *T. cymbaria* but well developed narrow, small girder present in *T. triandra* and *T. quadrivalvis*.

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very small pointed fibrous cap. In *T. quadrivalvis* sclerenchymatous cells curving towards adaxial surface (Fig. 157 E). Marginal epidermal cells thin with outer thick tangential wall.

LEAF SHEATH ANATOMY (Fig. 154H-K, 155 E-G, 156 G-I, 157 F-I)

Outline of lamina: V shaped standard angled in *T. laxa* and *T. cymbaria*, narrow angled in *T. triandra* and *T. quadrivalvis* with inrolled margins (Fig. 154 H, 155 E, 156 G, 157 F).

Ribs and furrows absent in *T. triandra, T. quadrivalvis* while shallow furrows with pointed triangular ribs in *T. cymbaria* and round abaxial ribs in *T. laxa* (Fig. 154 K).

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular to barrel shaped with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavity.

Vascular bundle:

Arrangement of vascular bundle: Two in *T. cymbaria*, one in *T. laxa* or three in *T. triandra* and *T. quadrivalvis* consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: (Fig. 154 J, 155 F, 156 I, 157 H)

Pentagonal in all species except in *T. cymbaria* where it is circular with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundle: (Fig. 155 G)

Circular in all species except elliptical in *T. cymbaria*

1st order vascular bundle: (Fig. 154 I, 157 I)

Circular with phloem completely surrounded by thick walled fibers. Enlarged protoxylem vessel and lysigenous cavity present in all species except in *T. quadrivalvis* which showed absence of lysigenous cavity. Circular metaxylem wide vessel element.

Vascular bundle sheath:

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath incomplete and interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 15-16 in *T. cymbaria* and *T. laxa*, 14-15 in *T. triandra*, 13-15 in *T. quadrivalvis* parenchyma cells.

Bundle sheath cell shape: All cells are elliptical and elongated in shape; cells smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of narrow strands present on abaxial surface.

LIGULE ANATOMY (Fig. 154 L, M, 155 H, I, 156 J, K, 157 J, K)

Shape: Ligule is attached less than half length of the lamina and the connection point is very broad, blunt "V" shaped in *T. cymbaria* and *T. laxa* (Fig. 154 L, 155 H). Ligule is attached to the lamina more than half length of it and blunt narrow "V" shaped at the connection point in *T. triandra* and *T. quadrivalvis* (Fig. 156 J, 157 J).

Anatomy: Mesophyll cells between adaxial and abaxial surfaces is two layered in all species except three layered in *T. triandra*. Few abaxial cells have sclerenchyma cells in *T. cymbaria* and *T. laxa* (Fig. 154 M arrow, 155 I). Prickles present on abaxial surface in *T. quadrivalvis* (Fig. 157 K, arrowhead).

Differentiating features:

Vascular bundles placed towards the abaxial surface of leaf blade

Circular shaped 1st order vascular bundle…..…… *T. qurqdrivalvis*

Elliptical shaped 1st order vascular bundle…….…….…….. *T. triandra*

1st and 2nd order vascular bundles placed centrally and 3rd order vascular bundles present towards abaxial surface of leaf blade

Chloroplast concentrated near outer tangential wall of mesophyll cells…….

……..…… *T. cymbaria*

Chloroplast placed centrally of mesophyll cells…….…….…….. *T. laxa*

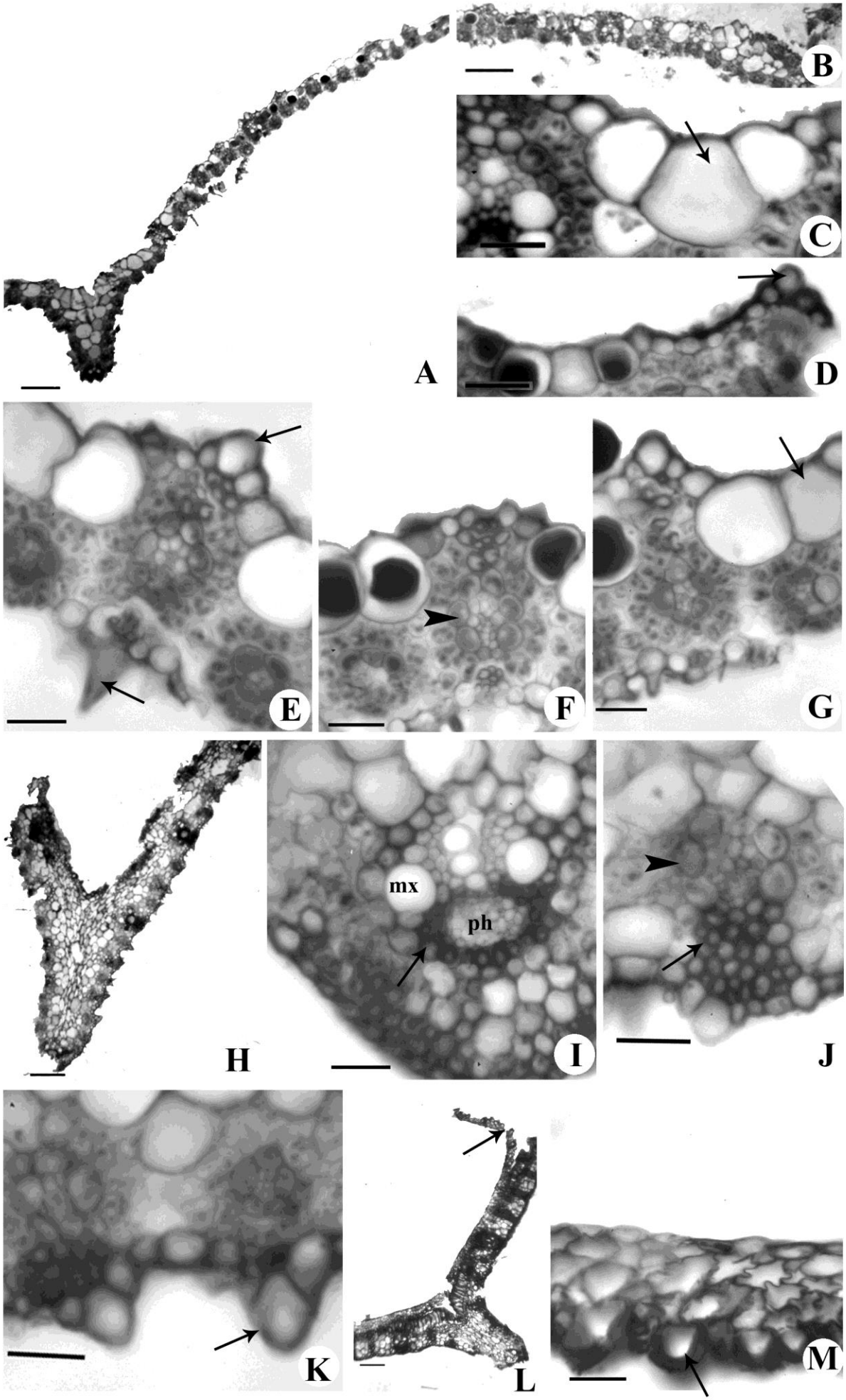

Fig. 154

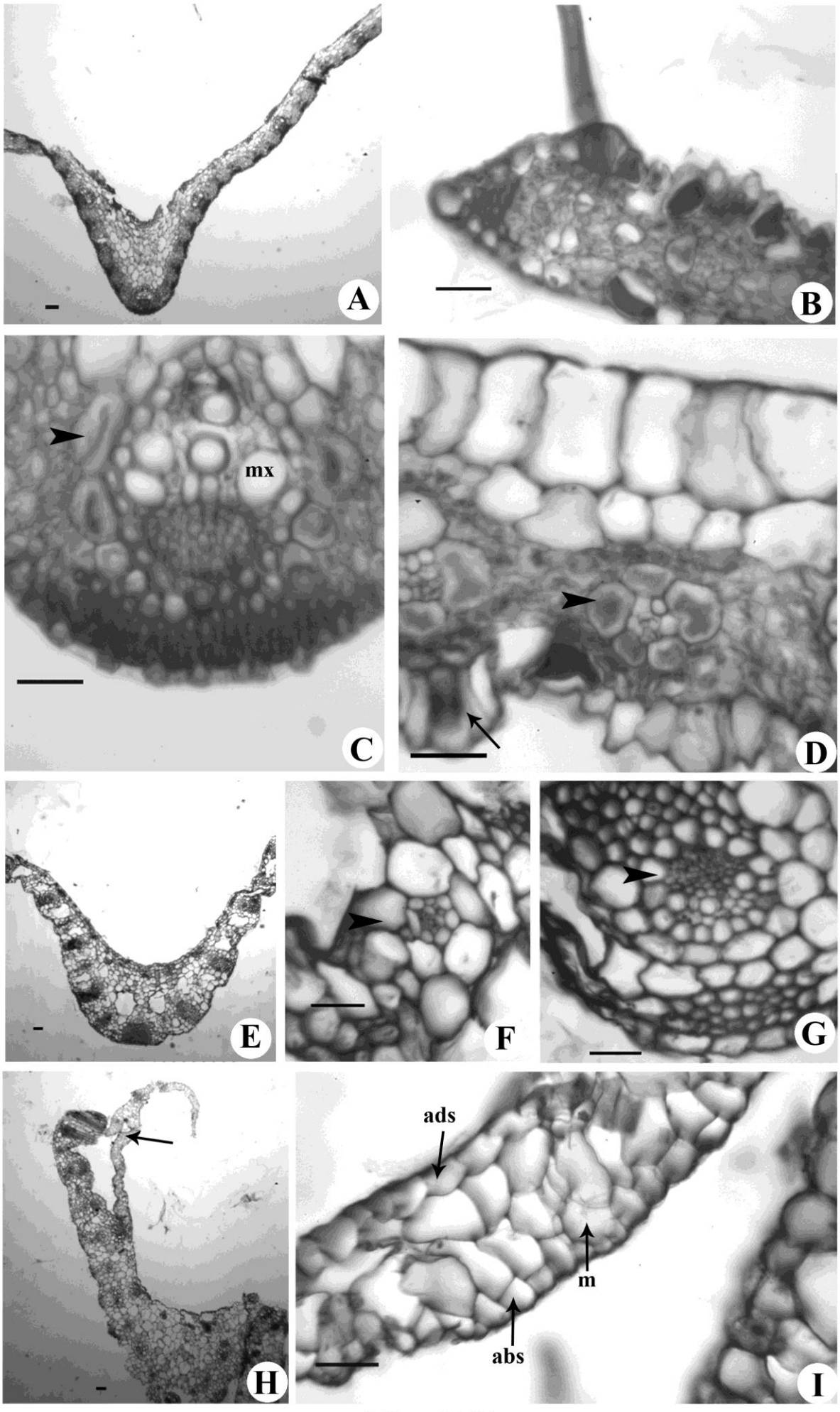

Fig. 155

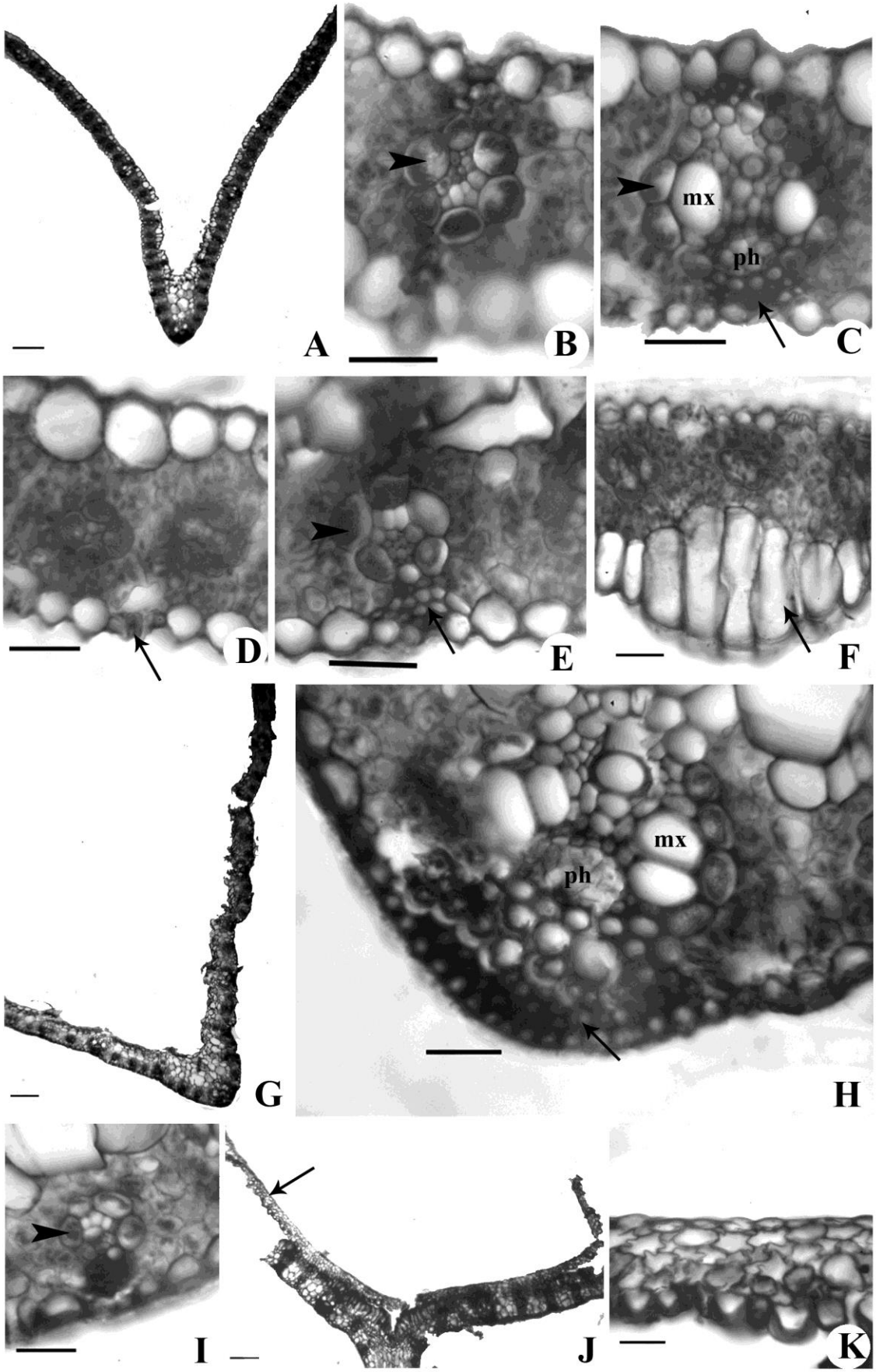

Fig. 156

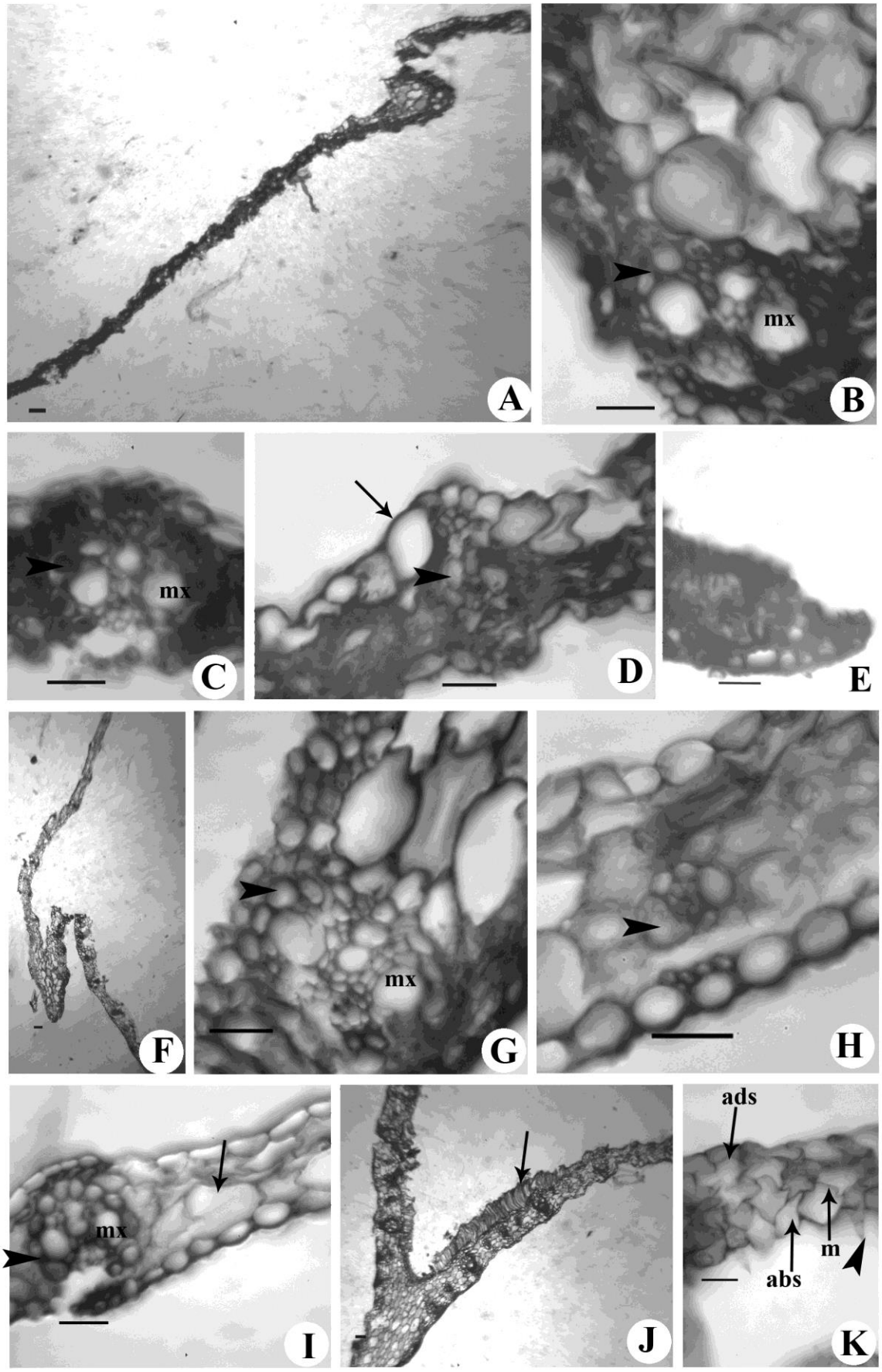

Fig. 157

35. *Triplopogon ramosissimus*

LEAF LAMINA: (Fig. 158 A-F)

Outline of the lamina: Inrolled from both margin, involute (Fig. A, B). Ribs and furrows are present on the leaf surface. Shallow furrows with rounded ribs present.

Keel is well developed, semicircular with three large vascular bundle, 3-4 3rd order vascular bundles, and 2-3 2nd order vascular bundles. Small, round parenchyma cells are present surrounding the median vascular bundle adaxially. Sclerenchyma is present on abaxial surface associated with vascular bundles in form of strands.

Epidermis: Adaxial epidermal surface has restricted group of large, inflated bulliform cells which are projecting above epidermis. Short hairs are present with bulbous base sunken in bulliform cells (Fig. F, arrow). Abaxial epidermal cells are square to rectangular shaped.

Mesophyll: Incomplete radiate chlorenchyma cells. Compact homogenous occupy the major area between the adaxial and abaxial epidermides. Chlorenchyma cells are arranged in form of horizontal elongated strap continuous between bundles. Colourless cells absent.

Vascular bundles: 6 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundles. 4-5 3rd order bundles between consecutive larger bundles and 3-4 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles centrally placed at same level.

3rd order vascular bundles: Hexagonal with vascular tissue consisting of only a few indistinguishable vascular strands.

2nd order vascular bundles: Circular shaped

1st order vascular bundles: (Fig. E)

Shape: Circular

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Median vascular bundles:

Shape: Round

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 12-13

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast placed centrally

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath:

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 15-16 parenchyma cells

Bundle sheath cell shape: All cells are elliptical and elongated in shape. Chloroplast positioned centrally in the cell.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Minute strand consisting of only a few subepidermal fibers

Abaxial sclerenchyma: Well developed strand, wider than deep and it follows shape of abaxial rib

Sclerenchyma between bundles: absent

Sclerenchyma in leaf margin: Forming very small fiberous pointed cap. Epidermal cells at margin of thin with outer thick tangential wall (Fig. C, arrow).

LEAF SHEATH ANATOMY (Fig. 158 G, H)

Outline of lamina: Round shaped with inrolled margins. Minute ribs and furrows present.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with oval shaped air cavity (Fig. G, arrow)

Vascular bundle:

Arrangement of vascular bundle: 3-4 consecutive 3rd order vascular bundles between 1st and 2nd order vascular bundle

3rd order vascular bundle: Circular with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundle: Circular shaped

1st order vascular bundle: Circular shaped with phloem completely surrounded by thick walled fibers. Lysigenous cavity and enlarged protoxylem vessel present. Circular wide metaxylem vessel elements (Fig. H)

Vascular bundle sheath:

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath incomplete and interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 15-16 parenchyma cells comprise the sheath

Bundle sheath cell shape: All cells are elliptical and elongated in shape; cells smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of well developed broad girder present on abaxial surface (Fig. H, arrow).

LIGULE ANATOMY (Fig. 158 I, J)

Shape: Ligule attached to the midrib region and partially with lamina region and the connection point it is broad round shaped (Fig. I, arrow)

Anatomy: More than three layered mesophyll cells between adaxial and abaxial surfaces (Fig. J).

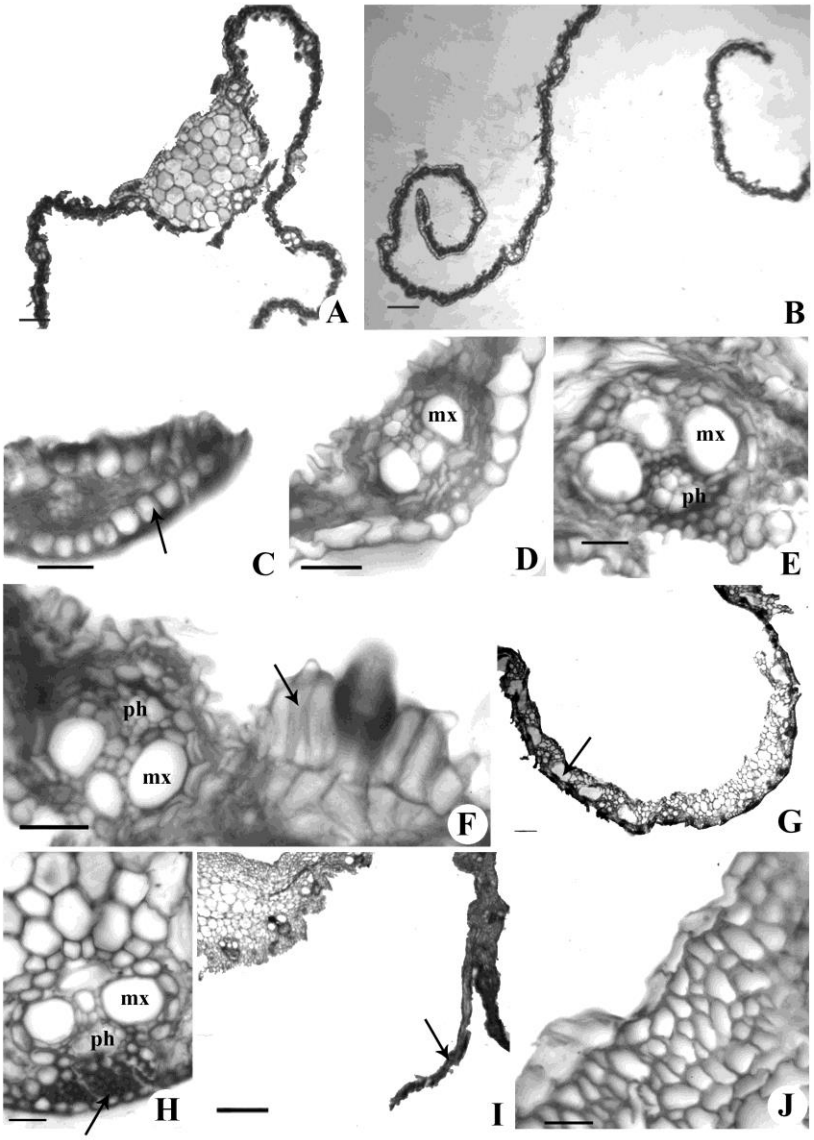

Fig. 158

36. *Vetivaria zinzanoides*

LEAF LAMINA: (Fig. 159 A-F)

Outline of the lamina: 'V' shaped with wide angle and having outwardly curving arms (Fig. A). Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are absent on the leaf surface. Air cavities present in leaf lamina.

Keel is well developed, V-shaped with single median vascular bundle, and 2-3 3rd order vascular bundles. Small, rounded parenchyma cells surround the median vascular bundle adaxially. Sclerenchyma is present on adaxial surface in form of strands and on abaxial surface associated with vascular bundles in form of strands. Elongated bulliform cells form 'U' as well as layers of elongated parenchyma cells.

Epidermis: Adaxial epidermal surface has group of bulliform cells which are not associated with colourless cells and occupy less than ¼ of the leaf thickness. Abaxial epidermial cells barrel shaped and covered with thick cuticle. Stomata is present (Fig. C and E, arrow).

Mesophyll: Radiate, single layered, isodiametric chlorenchyma cells completely surrounding bundles. Compact homogenous chlorenchymatous cells occupy the major area between the adaxial and abaxial epidermides. Colourless cells absent.

Vascular bundles: 9-10 1st order vascular bundles in half lamina regularly arrangedfrom median bundle to marginal bundles. 3-4 3rd order bundles between consecutive larger bundles and 2-3 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles abaxially placed at same level.

3rd order vascular bundles: Pentagonal (Fig. B) and round shaped (Fig. C) with distinguishable xylem and phloem elements.

2nd order vascular bundles: Elliptical shaped (Fig. F)

1st order vascular bundles:

Shape: Circular

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Very wide vessels

Shape of metaxylem vessels: Circular

Median vascular bundles:

Shape: Circular

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Very wide vessels

Shape of metaxylem vessels: Circular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. B, C arrowhead)

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath: (Fig. F, arrowhead)

Shape: Elliptical

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 9-10

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast positioned near outer tangential wall.

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. D, arrowhead)

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath incomplete, abaxially interrupted by sclerenchyma

Extension of bundle sheath: Narrow adaxial extension and well developed triangular girder present on abaxial side

Number of cells comprising the bundle sheath: 13-14 parenchyma cells

Bundle sheath cell shape: All cells are elliptical, elongated in shape. Chloroplast positioned near outer tangential wall.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Narrow, small, 4-6 fibers, girder present above 1st order vascular bundle

Abaxial sclerenchyma: Well developed triangular shaped girder present below 1st order vascualar bundle

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very small fiberous pointed cap. Epidermal cells at margin of thin with thick outer tangential wall.

LEAF SHEATH ANATOMY (Fig. 159 G-J)

Outline of lamina: V shaped narrow angle with inrolled margins are. Ribs and furrows absent. (Fig. G, H).

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle. Stomata present (Fig. J)

Ground tissue: Parenchymatous with oval shaped air cavity (Fig. G, arrow)

Vascular bundle:

Arrangement of vascular bundle: Two consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Pentagonal with xylem and phloem distinguishable.

2nd order vascular bundle: Elliptical shaped

1st order vascular bundle: Elliptical shaped with phloem completely surrounded by thick walled fibers. Lysigenous cavity and enlarged protoxylem vessel present. Circular wide metaxylem vessel elements (Fig. I)

Vascular bundle sheath:

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath incomplete, interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 18-19 parenchyma cells

Bundle sheath cell shape: All cells are elliptical and elongated smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of well developed broad anchor shaped girder present on abaxial surface (Fig. I, arrow).

LIGULE ANATOMY (Fig. 159 K, L)

Shape: Ligule attached to the lamina more than half length of it and blunt ‘V’ shaped and narrow at the connection point (Fig. K, arrow).

Anatomy: Single layered mesophyll cells between adaxial and abaxial surfaces (Fig. L).

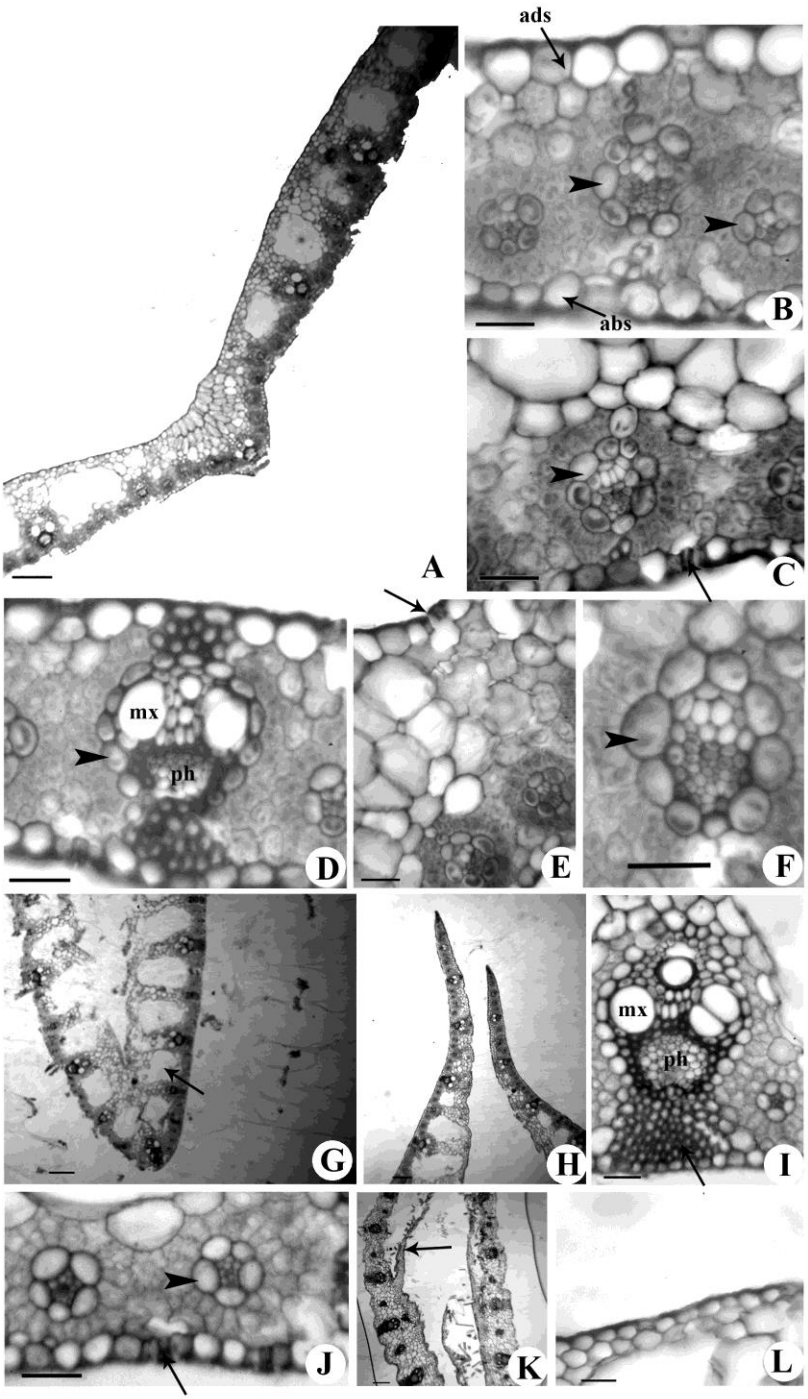

Fig. 159

37. *Alloteropis cimiciana*

LEAF LAMINA: (Fig. 160 A-F)

Outline of the lamina: 'V' shaped with standard angle with straight arms (Fig. A, B); two halves symmetrical on either side of the median vascular bundle. Ribs and furrows present on the leaf surface. Abaxial surface has narrow, medium furrows with rounded ribs.

Keel is well developed, inverted triangular shaped (Fig. A) with three 1st order, 2-3 2nd order and 6-7 3rd order vascular bundles. Small, round parenchyma cells surround the median vascular bundle adaxially. Adaxial sclerenchyma present in form of strands in subepidermal layers and abaxial sclerenchyma associated with vascular bundles in form of strands.

Epidermis: Adaxial epidermal surface is majorly made up of inflated bulliform cells (Fig. c) with outer walls slightly thickened and covered with thin cuticle. Abaxial epidermal cells barrel shaped. Prickels present on abaxial surface (Fig. E, arrow).

Mesophyll: Irregular chlorenchyma with small isodiametric, cells. Compact homogenous chlorenchymatous cells occupy the major area between the adaxial and abaxial epidermides. Chlorenchyma cells continuous and horizontally elongated strap shaped between bundles. Colourless cells absent.

Vascular bundles: 4-5 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundle. 9-10 3rd order bundles between consecutive larger bundles and 3-4 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and towards the abaxial surface.

3rd order vascular bundles: Circular with xylem and phloem distinguished (Fig. C).

2nd order vascular bundles: Circular shaped

1st order vascular bundles: (Fig. D)

Shape: Circular

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Protoxylem present and lysigenous cavity is absent

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Very wide vessels

Shape of metaxylem vessels: Circular

Median vascular bundles:

Shape: Circular

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Protoxylem present and lysigenous cavity is absent

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Very wide vessels

Shape of metaxylem vessels: Circular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. C, arrowhead)

Shape: Round

Shape of bundle sheath cell: Elliptical in shape

2nd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Elliptical

Number of bundle sheath cell: 10-11

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast positioned near the outer tangential wall

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. D, arrowhead)

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 17-18 parenchyma cells

Bundle sheath cell shape: All cells are elliptical and elongated in shape. Chloroplast positioned near the outer tangential wall.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Absent

Abaxial sclerenchyma: Well developed wider strands present below 1st order vascular bundles (Fig. D, arrow)

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming well developed rounded fibrous cap. Epidermal cells at margin are thin with outer thick tangential wall.

LEAF SHEATH ANATOMY (Fig. 160G-I)

Outline of lamina: 'V' shaped with inrolled margins (Fig. G). ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: barrel shaped with thick cuticle (Fig. I).

Ground tissue: Parenchymatous with vertical oval shaped air cavity (Fig. G, arrow)

Vascular bundle:

Arrangement of vascular bundle: One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Circular with xylem and phloem distinguishable

2nd order vascular bundle: Circular shaped

1st order vascular bundle: Circular shaped with phloem completely surrounded by thick walled fibers. Protoxylem and lysigenous cavity present. Circular wide metaxylem vessels elements (Fig. H).

Vascular bundle sheath:

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath incomplete and interrupted by sclerenchyma abaxially.

Number of cells comprising the bundle sheath: 13-14 parenchyma cells

Bundle sheath cell shape: All cells are elliptical and elongated, smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of straight horizontal well developed abaxial strand (Fig. H, arrow).

LIGULE ANATOMY (Fig. 160 J, K)

Shape: Ligule attached to the midrib and few parts of lamina region, hairy ligule (Fig. J, arrow).

Anatomy: More than three layered mesophyll cells between adaxial and abaxial surfaces (Fig. K)

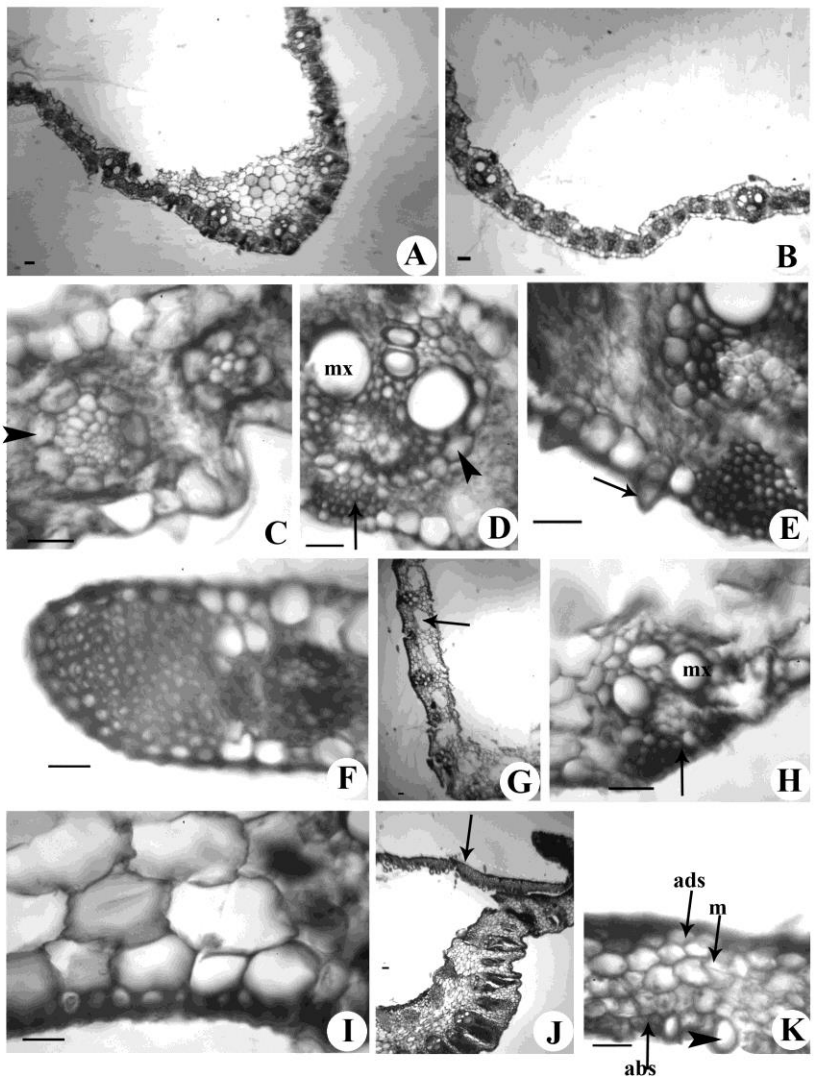

Fig. 160

Brachiaria

38. *Brachiaria distachya* (Fig. 161)

39. *Brachiaria eruciformis* (Fig. 162)

40. *Brachiaria ramosa* (Fig. 163)

41. *Brachiaria reptans* (Fig. 164)

LEAF LAMINA: (Fig. 161 A-G, 162 A-H, 163 A-E, 164 A-H)

Outline of the lamina: Expanded with gently undulating leaf blade in *B. eruciformis, B. ramosa, B. distachya* and *B. reptans* (Fig. 161 A, 162 A, 163 A, B, 164 A). Ribs and furrows are present on the leaf surface. Shallow, wide furrows present between all vascular bundles. Rounded ribs present over all vascular bundles.

Keel inconspicuous in all species except well developed in *B. reptans*, semicircular keel with 1 1st order vascular bundles, 3-3 3rd order vascular bundles. Sclerenchyma is associated with vascular bundles in form of girder.

Epidermis: Adaxial epidermal surface has fan shaped bulliform cells in all the species (Fig. 161 B, 162 F, G, arrow, 163 C arrow, 164 G arrow) and it occupies ¼ -1/2 portion of the leaf thickness in *B. eruciformis, B. ramosa, B. distachya* while less than ¼ portion of the leaf thickness in *B. reptans*. Abaxial epidermis surface has round epidermal cells which have thick cuticle. Long, slender macrohairs with bulbous base sunken in bulliform cells are present in *B. distachya* (Fig. 161 E, F), prickles present in *B. distachya* (Fig. 161 G). Trichomes present in *B. reptans* (Fig. 164, F, arrow).

Mesophyll: Radiate, single layered, isodiametric chlorenchyma cells completely surrounds the bundles. Compactly arranged homogenous chlorenchymatous cells occupy the major area between the adaxial and abaxial epidermides. Colourless cells present only in *B. eruciformis* which are closely related to bulliform cells (Fig. 162 E, arrow).

Vascular bundles: 4-5 1st order vascular bundles in *B. distachya* and *B. eruciformis*, 3-4 1st order in *B. ramosa* and *B. reptans*.

Vascular bundles regularly arranged from median bundle to marginal bundles in half lamina. 3-4 3rd order and 2-3 2nd order in *B. distachya, B. eruciformis* and *B. ramosa*, 4-5 3rd order and 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally.

3rd order vascular bundles: (Fig. 161 B, 162 C, E, 163 C, 164 E)

Pentagonal in *B. distachya* and *B. reptans*, Hexagonal in *B. eruciformis* and *B. ramosa* with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: Elliptical in *B. distachya* and *B. ramosa*, circular in *B. eruciformis* and *B. reptans*.

1st order vascular bundles: (Fig. 161 C, 162 D, 163 D, 164 C)

Shape: Elliptical in *B. distachya* and *B. ramosa*, circular in *B. eruciformis* and *B. reptans*.

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity absent and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Shape of metaxylem vessels: Circular

Median vascular bundles: (Fig. 161 D, 163 F, 164 D)

Shape: Elliptical in *B. distachya* and *B. ramosa*, circular in *B. eruciformis* and *B. reptans*

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present in all species but lysigenous cavity absent in *B. eruciformis* and *B. reptans*.

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. 162 C, E, 163 C arrowhead, 164 E)

Shape: Round

Shape of bundle sheath cell: Fan shaped

2nd order vascular bundle's bundle sheath:

Shape: Ellliptical

Shape of bundle sheath cell: Fan shaped

Number of bundle sheath cell: 8-9 in all species except 10-11 in *B. ramosa*

Nature of bundle sheath (either complete or incomplete): Complete in all species except *B. distachya* in which bundle sheath is abaxially interrupted by sclerenchyma

Chloroplast position in bundle sheath cell: Chloroplast centrally placed

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath:

Shape: Horse shoe shaped

Extent of bundle sheath around the vascular bundle: Complete in *B. eruciformis* and *B. reptans,* incomplete and abaxially interrupted by sclerenchyma in *B. distachya* and *B. ramosa*

Extension of bundle sheath: Absent in all specis except *B. distachya* has broad abaxial extension

Number of cells comprising the bundle sheath: 10-11 parenchyma cells in all speceies but *B. ramosa* has 12-13 cells.

Bundle sheath cell shape: Fan shaped. Chloroplast placed centrally in *B. distachya* and *B. ramosa* and near outer tangential wall in *B. eruciformis*, *B. reptans.*

Mestome/ Inner sheath: Complete sheath present with cells smaller than the outer bundle sheath.

Sclerenchyma:

Adaxial sclerenchyma: Absent

Abaxial sclerenchyma: Well developed in form of small, narrow girder in *B. distachya* and *B. ramosa* and minute subepidermal strands in *B. eruciformis* and *B. reptans*.

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very small marginal area in *B. distachya* and *B. ramosa* while well developed in *B. eruciformis* and *B. reptans* with pointed fibrous cap. Epidermal cells at margin of thin with thick outer tangential wall.

LEAF SHEATH ANATOMY (Fig. 161 H-K, 162 I-M, 163 F-H, 164 I -L)

Outline of lamina: Round with overlapping inrolled margins in *B. distachya, B. ramosa* and *B. reptans* (Fig. 161 H, 163 F, 164 I) while V' shaped inrolled margins of arms in *B. eruciformis* (Fig. 162 I). Ribs and furrows present. Shallow, wide furrows present between all vascular bundles on abaxial surface.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle. Prickles present (Fig. 162 L, arrow) in *B. eruciformis.*

Ground tissue: Parenchymatous with verticlally oval shaped air cavity in *B. distachya* and *B. eruciformis* (Fig. 161 K, arrow, 162 M arrow), oval shaped in *B. ramosa* (Fig. 163 F) while absent in *B. reptans.*

Vascular bundle:

Arrangement of vascular bundle: One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: (Fig. 161 J, 162 M)

Circular in *B. distachya*, hexagonal in *B. eruciformis* and *B. reptans*, elliptical in *B. ramosa* with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundle: Elliptical shaped

1st order vascular bundle: (Fig. 161 I, 162 J, 163 H, 164 J, K)

Elliptical with phloem completely surrounded by thick walled fibers. Lysigenous cavity absent and enlarged protoxylem vessel present in all species but lysigenous cavity present in *B. ramosa*. Circular wide metaxylem vessel element.

Vascular bundle sheath: (Fig. 164 K, arrowhead)

Shape: Horse shoe shaped

Extent of bundle sheath around the vascular bundle: Sheath incomplete, interrupted by sclerenchyma cells on abaxial surface

Number of cells comprising the bundle sheath: 8-9 in *B. distachya* and *B. reptans*, 10-11 in *B. eruciformis* and *B. ramosa* parenchyma cells

Bundle sheath cell shape: Fan shaped cells. All cells similar in *B. eruciformis* and *B. ramosa* while adaxial cells larger than the other cells of sheath cell in *B. distachya* and *B. reptans.*

Mestome/ Inner sheath: Complete sheath present with cells are smaller than the outer bundle sheath.

Sclerenchyma: In form of well developed straight horizontal broad strand present on abaxial surface in *B. distachya*, *B. reptans* and *B. eruciformis* while ancored shaped girder in *B. ramosa.*

LIGULE ANATOMY (Fig. 161L, M, 162 N, 163 I, 164 M, N)

Shape: Ligule attached to the midrib and few parts of lamina region because it is hairy ligule (Fig. 161 L, 162 N, 163 I, 164 M)

Anatomy: Three layered in *B. distachya*, *B. ramosa* and *B. eruciformis* while single layered in *B. reptans* mesophyll cells between adaxial and abaxial surfaces (Fig. 161 M, 164 N).

Differentiating features:

Colourless cells present……. *B. eruciformis*

Colourless cells absent

Extension of vascular bundle sheath is present…….....…… *B. distachya*

Extension of vascular bundle sheath is absent

Chloroplast placed centrally of mesophyll cells...……..… *B. ramosa*

Chloroplast concentrated near outer tangential walls of mesophyll cells ……..…… *B. reptans*

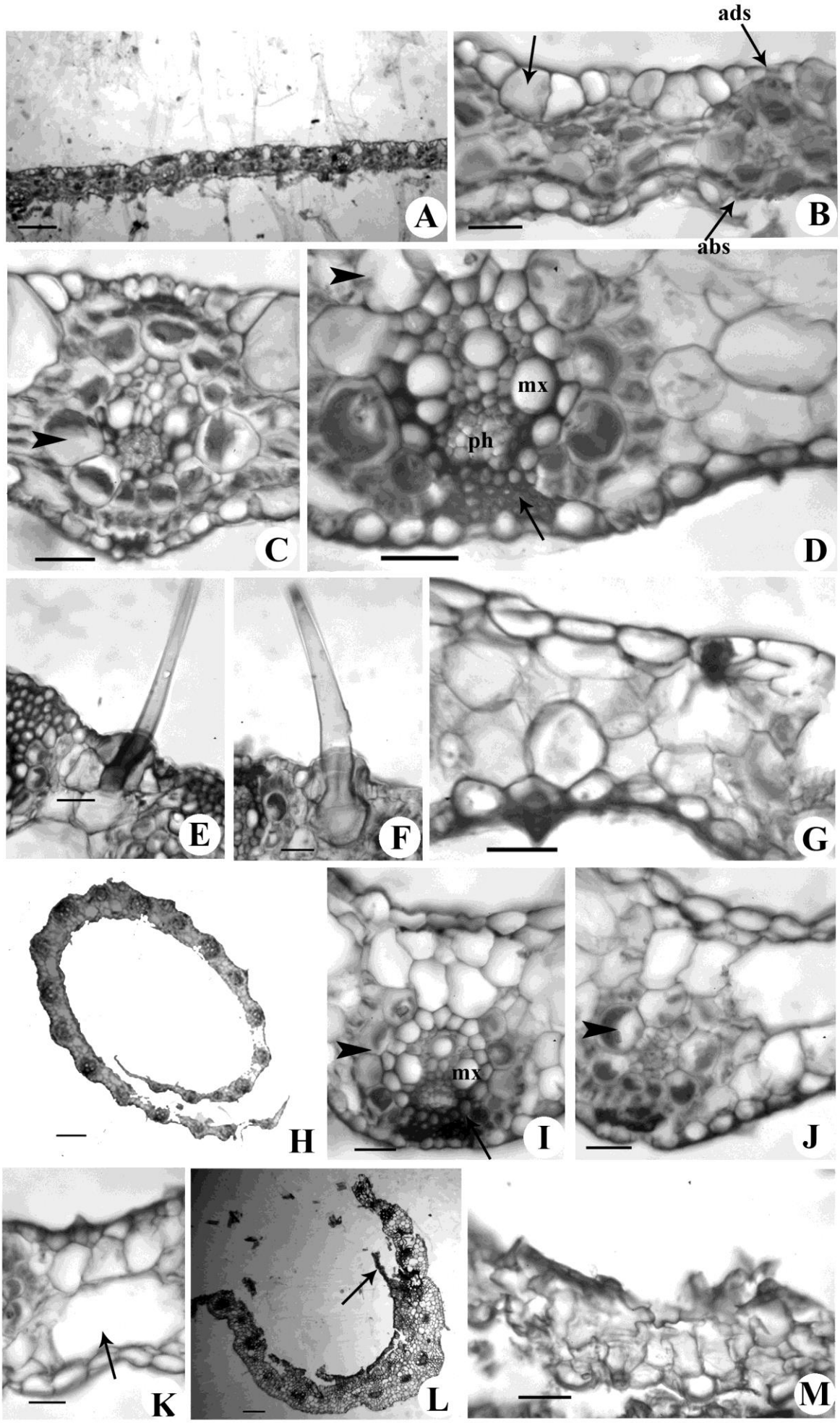

Fig. 161

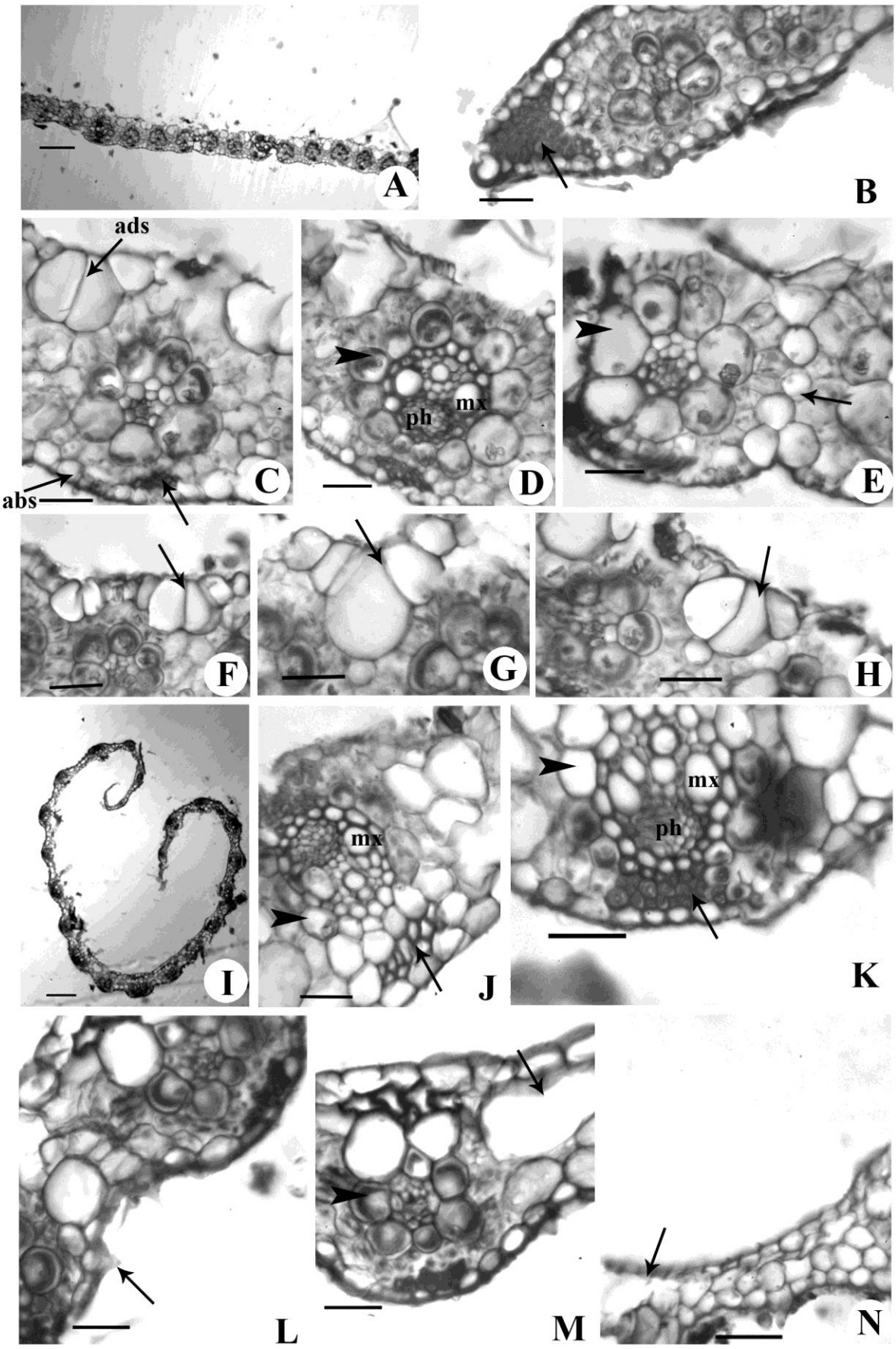

Fig. 162

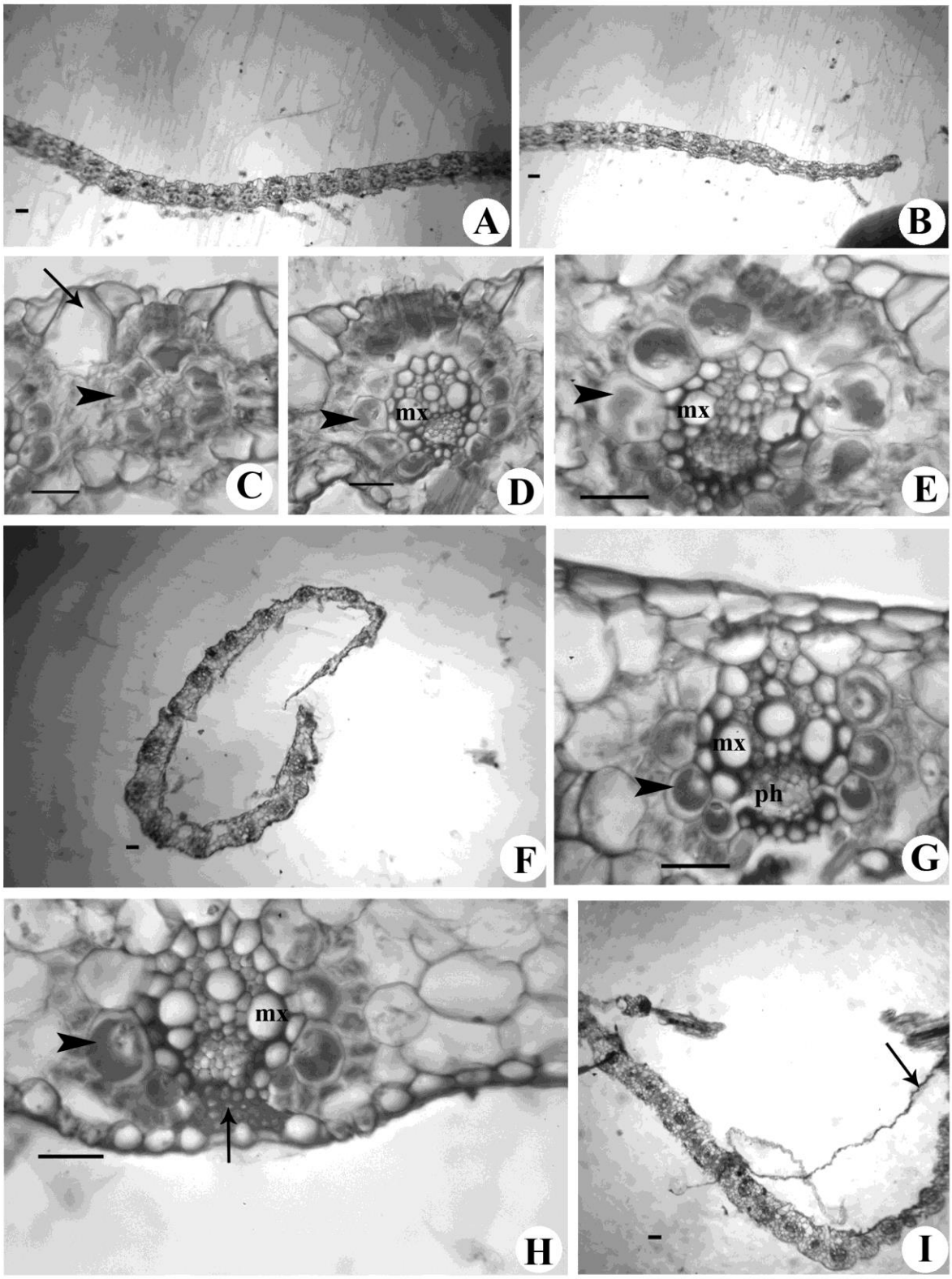

Fig. 163

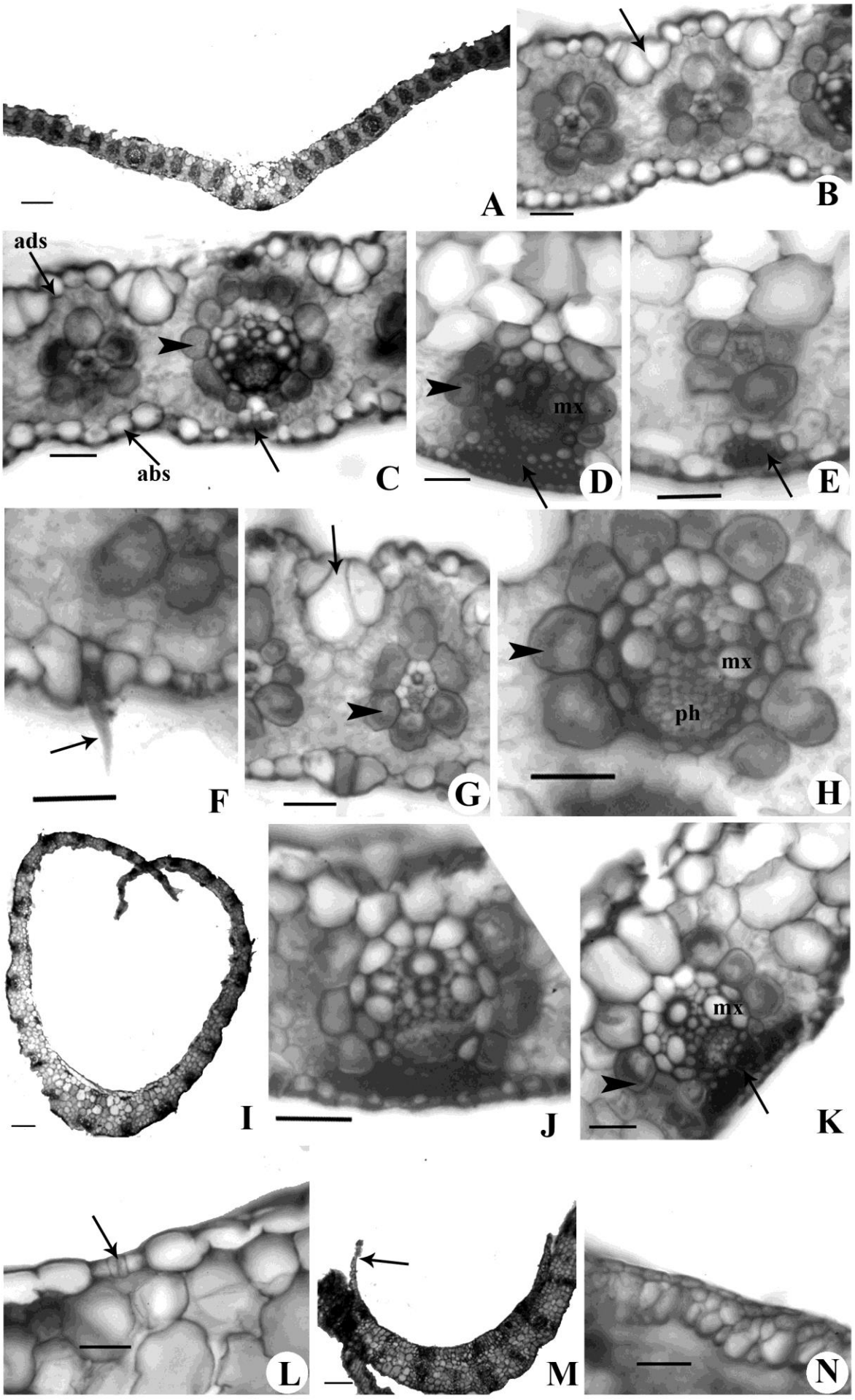

Fig. 164

Cenchrus

42. *Cenchrus biflorus* (Fig. 165)

43. *Cenchrus ciliaris* (Fig. 166)

44. *Cenchrus setigerus* (Fig. 167)

LEAF LAMINA: (Fig. 165 A-G, 166 A-E, 167 A-K)

Outline of the lamina: 'V' shaped, broad angled with irregularly wavy arms in *C. biflorus* and *C. ciliaris* (Fig. 165 A, 166 A), wide angled in *C. setigerus* outwardly curving convex arms (Fig. 167 A). Two halves are symmetrical on either side of the median vascular bundle.

Leaf surfaces show ribs on the vascular bundle and furrows in between vascular bundle in *C. biflorus* and *C. ciliaris* and absent in *C. setigerus.* Furrows present between the vascular bundles on the adaxial surface are shallow, wide and the ribs on the vascular bundles are flat in *C. biflorus* while medium, wide furrows and the ribs on the vascular bundles are triangular in *C. ciliaris.* On the abaxial surface furrows are narrow, deeper, medium and ribs are rounded in *C. biflorus* while shallow furrows and rounded ribs present in *C. ciliaris*.

Keel is semicircular in *C. biflorus* and *C. ciliaris*, 'V' shaped in *C. setigerus* with 3 1st order, 6-7 3rd order in *C. biflorus*, single mediun vascular bundle, 3-4 3rd order and in *C. ciliaris*, single median vascular bundle, 12-14 3rd order in *C. setigerus* and 2-3 2nd order vascular bundles. Sclerenchyma is associated with vascular bundles in form of well developed strands.

Epidermis: Adaxial epidermal surface has extensive groups of large, inflated bulliform cells extending over many vascular bundles except first order vascular bundle in *C. biflorus* (Fig. 165 E), restricted group of large, inflated bulliform cells present in level with the general epidermal surface in *C. ciliaris* and *C. setigerus* (Fig. 166 C, arrow, 167 J, arrow). Adaxial epidermal cells are rectangular to square shaped in *C. biflorus*, barrel shaped in *C. ciliaris* or large, rectangular shaped in *C. setigerus* covered with thin cuticle. Thickened prickle present (Fig. 165 F, arrow). Abaxial epidermal cells are round with outer tangential wall inflated in *C. biflorus*, barrel shaped with thick cuticle in *C. ciliaris, C. setigerus*. Prickels present on abaxial surface (Fig. 165 D, arrow) of *C. biflorus*. Abaxial epidermis has restricted groups of large, inflated bulliform cells present above the level of general epidermis surface in *C. setigerus* (Fig. 167 K, arrow) and prickles in *C. setigerus* (Fig. 167 I, arrow) and stomata in *C. setigerus* (Fig. 167 H, arrow) present on abaxial.

Mesophyll: Irregular, vertically arranged single layered, isodiametric chlorenchyma cells. Compactly arranged homogenous chlorenchymatous cells occupy the major area between the adaxial and abaxial epidermides, chlorenchyma cells continuous

between bundles in *C. biflorus* while incompletely radiating chlorenchyma cells continuous between bundles in *C. ciliaris*, *C. setigerus.* Colourless cells absent.

Vascular bundles: 3-4 1st order vascular bundles regularly arranged from median bundle to marginal bundles in half lamina.

5-6 3rd and 3-4 2nd order bundles in *C. biflorus*, 4-5 3rd and 2-3 2nd order bundles in *C. ciliaris* and *C. setigerus* between consecutive 1st order bundles present. 1st order vascular bundles arranged centrally while 3rd order vascular bundles placed abaxially.

3rd order vascular bundles: (Fig. 165 D, 166 E, 167 D)

Hexagonal with vascular tissue consisting of only a few indistinguishable vascular strands in *C. biflorus* and *C. ciliaris* while xylem and phloem distinguishable strands in *C. setigerus*.

2nd order vascular bundles: Circular (Fig. 165 E, 167 E)

1st order vascular bundles: (Fig. 165 C, 166 D, 167 G)

Shape: Circular

Relationship of phloem cells and the vascular fibres: Phloem adjoins the inner or parenchyma sheath in *C. biflorus* while completely surrounded by thick walled fibers in *C. ciliaris* and *C. setigerus.*

Nature of lysigenous cavity and protoxylem: Enlarged protoxylem vessel present in all species but lysigenous cavity present only in *C. ciliaris.*

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Median vascular bundles: (Fig. 165 G, 167 F)

Shape: Circular in *C. biflorus* and *C. ciliaris*, egg shaped in *C. setigerus*

Relationship of phloem cells and the vascular fibres: Phloem adjoins the inner or parenchyma sheath in *C. biflorus* while completely surrounded by thick walled fibers in *C. ciliaris* and *C. setigerus.*

Nature of lysigenous cavity and protoxylem: Enlarged protoxylem vessel present in all species but lysigenous cavity present only in *C. ciliaris.*

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. 165 D, 166 E arrowhead, 167 D, arrowhead)

Shape: Round

Shape of bundle sheath cell: Elliptical shaped

2nd order vascular bundle's bundle sheath:

Shape: Ellliptical in *C. biflorus*, circular in *C. ciliaris* and *C. setigerus*

Shape of bundle sheath cell: Elliptical shaped

Number of bundle sheath cell: 10-11 in *C. biflorus*, 11-12 in *C. ciliaris*, 17-18 in *C. setigerus*

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast positioned towards inner in *C. biflorus* and *C. ciliaris* or outer in *C. setigerus* tangential wall

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. 165 C, 166 D, 167 G)

Shape: Circular

Extent of bundle sheath around the vascular bundle: Complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 15-16 in *C. biflorus*, 20-22 in *C. ciliaris* and *C. setigerus* parenchyma cells comprise the sheath

Bundle sheath cell shape: Elliptical shaped. Chloroplast positioned towards inner in *C. biflorus* and *C. ciliaris* or outer in *C. setigerus* tangential wall.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Minute subepidermal strands present

Abaxial sclerenchyma: Narrow well developed tall strands

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming well developed round fibrous cap (Fig. 165 B, 166 B, 167 B). Epidermal cells at margin are thin with thick outer tangential wall.

LEAF SHEATH ANATOMY (Fig. 165 H-K, 166- F-K, 167 L-O)

Outline of lamina: 'V'shaped, standard angle in *C. biflorus* (Fig. 165 H, 166 F, 167 L) with outwardly bowed arms, outwardly curving in *C. ciliaris* and *C. setigerus*. Ribs and furrows present. Shallow, wide furrows present between all vascular bundles abaxially.

Epidermis: Adaxial epidermal cells: flat, rectangular with thin cuticle.

Abaxial epidermal cells: flat, rectangular shaped with thick cuticle. Trichomes (Fig. 166 G, arrow), Hooks (Fig. 166 H, arrow) and stomata (Fig. 166 I, arrow) present in *C. ciliaris*.

Restricted groups of large, inflated bulliform cells present above the level of general epidermal surface (Fig. 167 O, arrow) and trichomes (Fig. 167 N, arrow) present in *C. setigerus.*

Ground tissue: Parenchymatous with absence of air cavity.

Vascular bundle:

Arrangement of vascular bundle: 2-3 in *C. biflorus*, 1 in *C. ciliaris*, 3-4 in *C. setigerus* consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: (Fig. 165 I, J, 166 I, J, 167 I, J)

Pentagonal in *C. biflorus*, hexagonal in *C. ciliaris* and circular in *C. setigerus* with vascular tissue consisting of only few indistinguishable vascular elements in *C. biflorus; C. ciliaris* while xylem and phloem distinguishable strands in *C. setigerus*.

2nd order vascular bundle: Elliptical in *C. biflorus* and *C. ciliaris*, circular in *C. setigerus*

1st order vascular bundle: Circular in *C. ciliaris*, *C. biflorus* and *C. setigerus* (Fig. 165 K, 166 K, 167 O) with phloem completely surrounded by thick walled fibers. Enlarged protoxylem vessel present in all species but lysigenous cavity present only in *C. ciliaris.* Circular wide metaxylem vessel element.

Vascular bundle sheath: (Fig. 165 K, 166 K, 167 O)

Shape: Circular

Extent of bundle sheath around the vascular bundle: complete

Number of cells comprising the bundle sheath: 19-20 in *C. biflorus*, 17-18 in *C. ciliaris*, 22-23 in *C. setigerus* parenchyma cells

Bundle sheath cell shape: Elliptical

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of narrow, wide strand on abaxial surface in *C. biflorus* and *C. ciliaris* (Fig. 165 J, arrow), wider strand on abaxial surface above ribs in *C. setigerus*

LIGULE ANATOMY (Fig. 165 L, 166 L, 167 P, Q)

Shape: Ligule attached to the lamina more than half length of it and blunt narrow 'V' shaped at the connection point (Fig. 165 L, 166 L, 167 P)

Anatomy: Two layered (*C. biflorus, C. ciliaris*) and more than three layered (*C. setigerus*) mesophyll cells between adaxial and abaxial surfaces.

Differentiating features:

More than three layered of mesophyll present in ligule…….. *C. setigerus*

Two layered of mesophyll present in ligule

Phloem adjoins the inner or parenchyma sheath in 1st order vascular bundle ……*C. biflorus*

Phloem completely surrounded by thick walled fibers ……. *C. ciliaris*

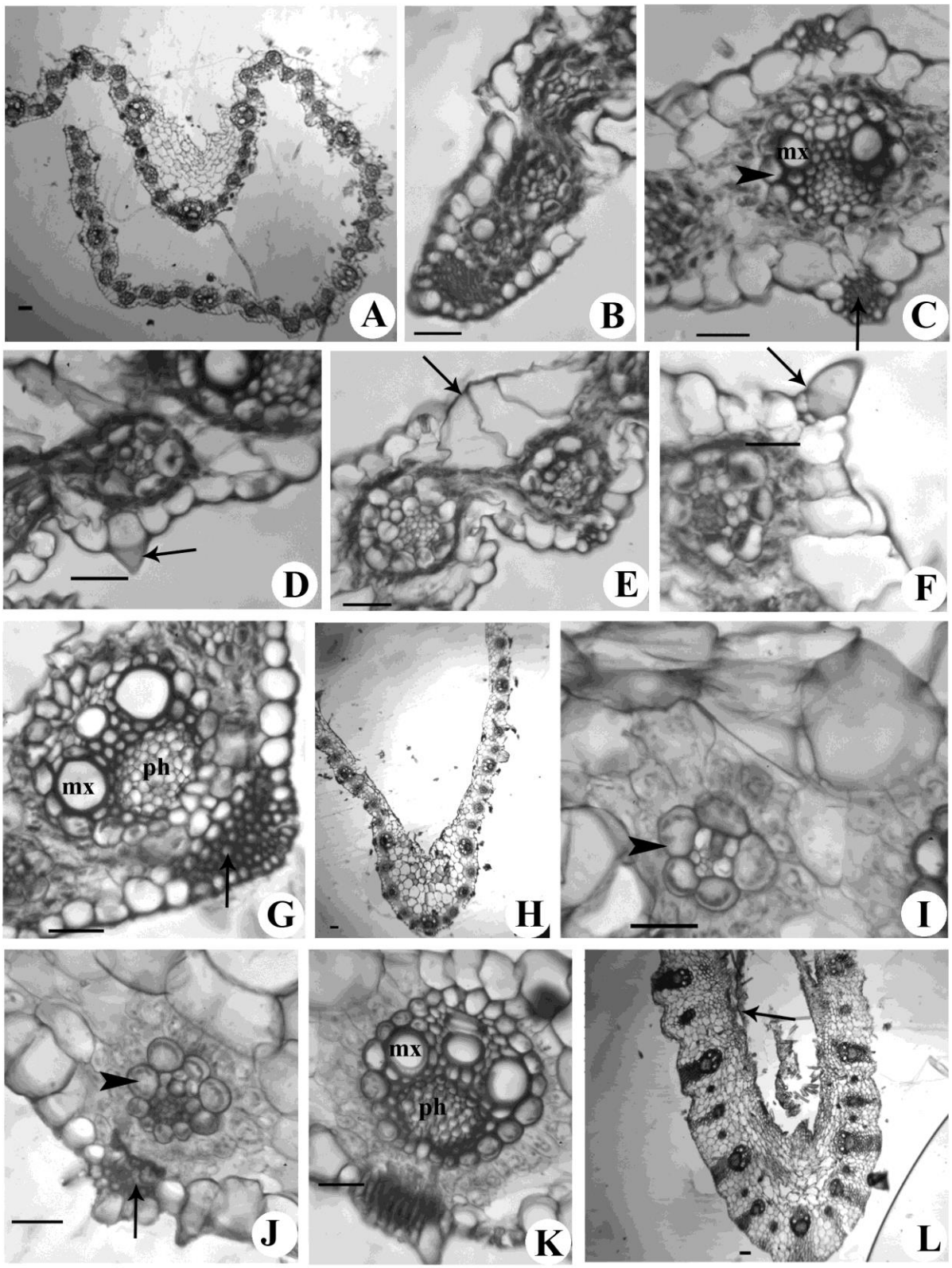

Fig. 165

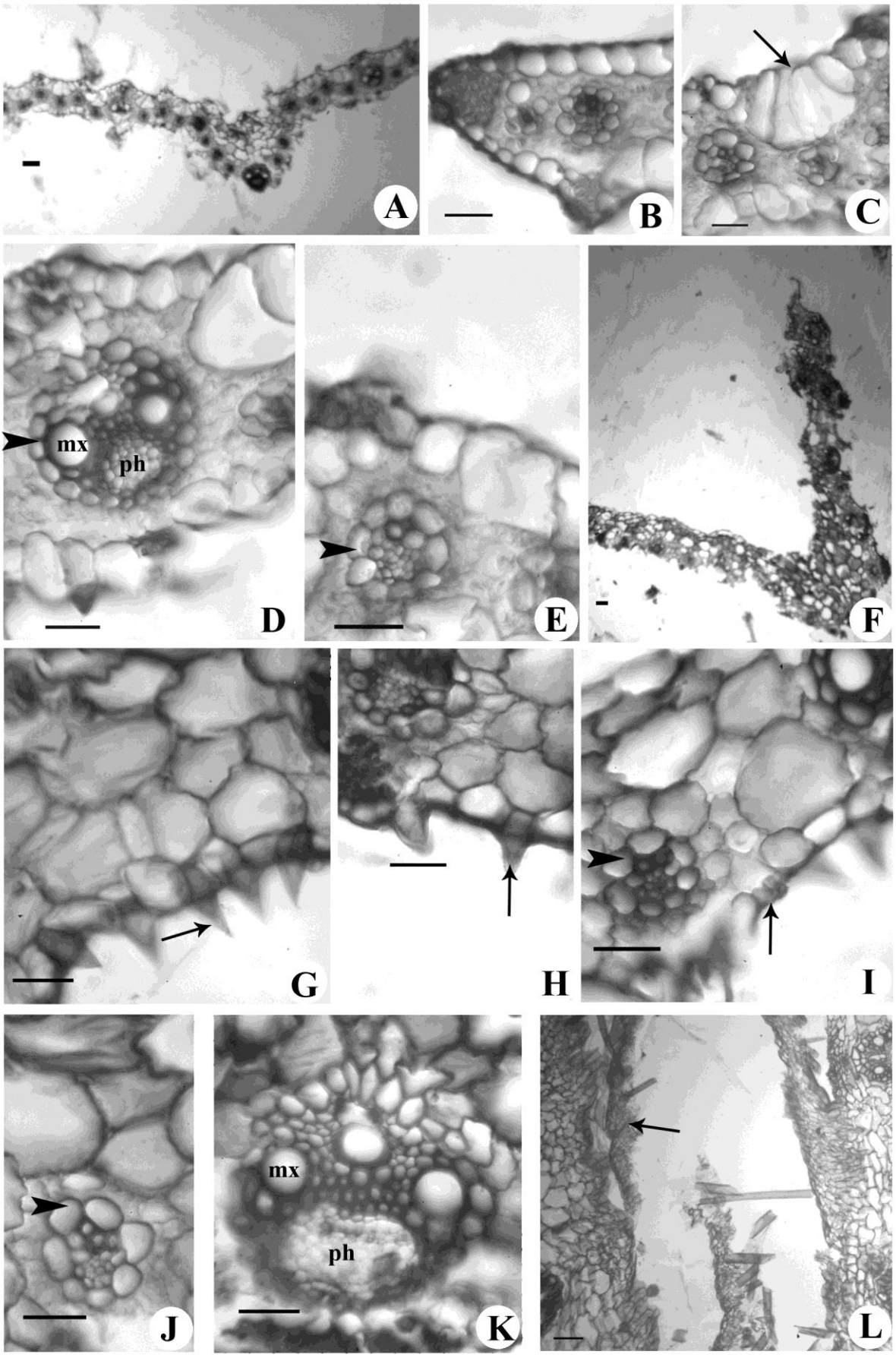

Fig. 166

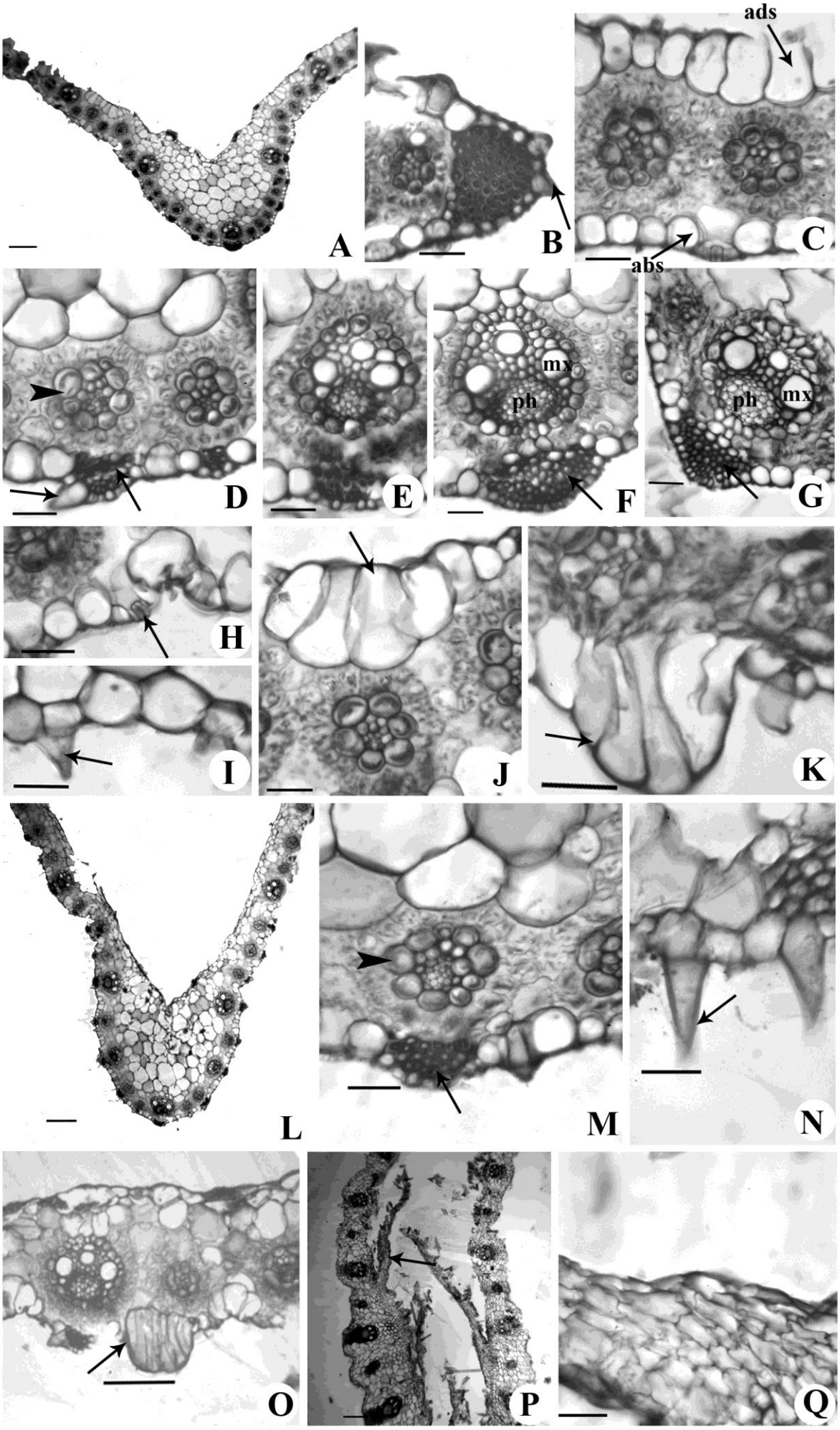

Fig. 167

Digitaria

45. *Digitaria ciliaris* (Fig. 168)

46. *Digitaria granularis* (Fig. 169)

47. *Digitaria longiflora* (Fig. 170)

48. *Digitaria stircta* (Fig. 171)

LEAF LAMINA: (Fig. 168A-F, 169 A-E, 170 A-G, 171 A-G)

Outline of the lamina: Expanded with flat, straight leaf blade in *D. ciliaris*, *D. granularis*, *D. longiflora* and *D. stricta* (Fig. 168 A, 169 A, 170 A, 171 A). Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are absent on the leaf surface.

Keel is well developd in all species except inconspicuous in *D. ciliaris*. Semicircular keel with single median vascular bundle, 3-4 3rd order in *D. granularis*, 2-3 2nd and 5-6 3rd order in *D. longiflora* and 1-2 3rd order in *D. stricta* vascular bundles.

Epidermis: Adaxial epidermal surface has most part of it made up of large, inflated by bulliform cells in *D. ciliaris*, *D. longiflora* and *D. stricta* (Fig. 168 F, 170 G arrow, 171 D) while restricted groups of large, inflated bulliform cells present above the level of general epidermis in *D. granularis* (Fig. 169 F). Abaxial epidermal cells are barrel shaped in *D. granularis* and *D. ciliaris*, rectangular in *D. longiflora*, barrel to rectangular in *D. stricta* covered with cuticle. Small prickles (Fig. 168 B, arrow) and stomata (Fig. 168 C, arrow) in *D. ciliaris*.

Mesophyll: Irregular, vertically arranged chlorenchyma cells occupy the major area between the adaxial and abaxial epidermides. Chlorenchyma cells continuous between bundles. Colourless cells absent.

Vascular bundles: 4-5 1st order in *D. ciliaris*, 3-4 1st order in *D. granularis*, *D. longiflora* and *D. stricta* vascular bundles regularly arrangeed from median bundle to marginal bundles in half lamina. 3-4 3rd order and 2-3 2nd order in *D. ciliaris*, 5-6 3rd order and 3-4 2nd order in *D. granularis*, 8-9 3rd order and 3-4 2nd order in *D. longiflora* and 7-8 3rd order and 2-3 2nd order in *D. stricta* bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally.

3rd order vascular bundles: (Fig. 168 F, 169 F, 170 F, 171 D, E)

Square in *D. ciliaris*, only pentagonal in *D. granularis*, hexagonal in *D. longiflora* and Pentagonal (Fig. 171 D) and square (Fig. 171 E) in *D. stricta* with vascular tissue consisting of only a few indistinguishable vascular element.

2nd order vascular bundles: (Fig. 169 D, 170 D) Elliptical in all species except circular in *D. ciliaris.*

1st order vascular bundles: (Fig. 168 E, 170 E, 171 F)

Shape: Circular in all species except elliptical in *D. granularis.*

Relationship of phloem cells and the vascular fibres: completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity present in all species and protoxylem vessel absent in *D. longiflora*

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Midrib vascular bundles: (Fig. 168 D, 171 G)

Shape: Round in *D. ciliaris* and *D. longiflora*, obovate in *D. granularis*, egg shaped in *D. stricta*

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity present in all species and protoxylem vessel absent in *D. longiflora*

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. 168 F, arrowhead, 169 E arrowhead, 170 F arrowhead, 171 D, E arrowhead)

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath:

Shape: Round in *D. ciliaris* and *D. stricta*, elliptical in *D. granularis* and *D. longiflora*

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 8-9 in *D. ciliaris* and *D. stricta*, 11-12 in *D. granularis*, 14-15 in *D. longiflora*

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast positioned towards near outer tangential wall

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. 168 D)

Shape: Circular in all species except in *D. granularis* elliptical.

Extent of bundle sheath around the vascular bundle: Complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 15-16 in *D. ciliaris*, 17-18 in *D. granularis*, 13-14 in *D. longiflora*, 16-17 in *D. stricta* parenchyma cells

Bundle sheath cell shape: All cells are elliptical and elongated in shape. Chloroplast positioned towards outer tangential wall

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Absent

Abaxial sclerenchyma: Minute subepidermal strands present

Sclerenchyma between bundles: absent

Sclerenchyma in leaf margin: Forming very small pointed fibrous cap (Fig. 171 C, arrow). Epidermal cells at margin are thin with thick outer tangential wall.

LEAF SHEATH ANATOMY (Fig. 168 G-J, 169 F-I, 170 H-K, 171 H-L)

Outline of lamina: V shaped, standard angle with inrolled margins in *D. ciliaris*, *D. granularis*, *D. longiflora* and *D. stricta* (Fig. 168 G, 169 F, 170 H, 171 H). Shallow, wide furrows present on abaxail surface with flat ribs.

Epidermis: Flat, rectangular adaxial epidermal cells covered with thin cuticle.

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle. Restricted groups of large, inflated bulliform cells (Fig. 168 J, arrow) present above the level of general epidermis surface in *D. ciliaris*.

Ground tissue: Parenchymatous ground tissue. All species showed absence of air cavity except *D. granularis* with few big, oval shaped air cavities (Fig. 169 H, arrow).

Vascular bundle:

Arrangement of vascular bundle: 1 in *D. ciliaris*, 3-4 in *D. granularis*, 2-3 in *D. longiflora* and 1-2 in *D. stricta* consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: (Fig. 168 H, 169 I, 170 I, 171 L)

Pentagonal in *D. ciliaris*, *D. longiflora* and *D. stricta*, circular (*D. granularis*) with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundle: (Fig. 169 G, 170 I, 171 L)

Circular in all species except in *D. longiflora* elliptical.

1st order vascular bundle: (Fig. 168 I, 169 H, 170 J, 171 L,J)

Circular in *D. ciliaris* and *D. granularis*, elliptical in *D. longiflora*, circular (Fig. 171 L) and elliptical (Fig. 171 J) in *D. stricta* with phloem completely surrounded by thick walled fibers. Lysigenous cavity and enlarged protoxylem vessel present in *D. ciliaris*, lysigenous cavity absent and protoxylem present in *D. granularis* while lysigenous cavity present and protoxylem present in *D. longiflora* and *D. stricta*. Circular shaped wide metaxylem vessels elements

Vascular bundle sheath: (Fig. 168 I, 169 H arrowhead, 170 J arrowhead, 171 J, arrowhead)

Shape: Round, circular in all species except in *D. stricta* elliptical

Extent of bundle sheath around the vascular bundle: Complete in all species except in *D. granularis*, incomplete and interrupted by sclerenchyma cells abaxially.

Number of cells comprising the bundle sheath: 12-13 in *D. ciliaris*, 11-12 in *D. granularis*, 15-16 in *D. longiflora*, 19-20 in *D. stricta* parenchyma cells.

Bundle sheath cell shape: All cells are elliptical and elongated, smaller than the ground tissue cell.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of subepidermal strand in *D. ciliaris* and *D. granularis*, narrow, taller than wider strand in *D. longiflora* and narrow, straight horizontal strand in *D. stricta* present on abaxial surface.

LIGULE ANATOMY (Fig. 168 K, L, 169 J, K, 170 L, M, 171 M, N)

Shape: Ligule attached to the leaf sheath more than the half width and very broad round shaped at the connection point (Fig. 168 K, 169 J, 170 L, 171 M)

Anatomy: Two layered in *D. ciliaris, D. granularis* and *D. longiflora*, three layered in *D. stricta* mesophyll cells between adaxial and abaxial surfaces (Fig. 168 L, 169 L, 170 M, 171 N).

Differentiating features:

Circular shaped 3rd order vascular bundles in leaf sheath……..... *D. granularis*

Pentagonal shaped 3rd order vascular bundles in leaf sheath

Egg shaped midrib vascular bundle…….……..…. *D. stricta*

Round shaped midrib vascular bundle

Square shaped 3rd order vascular bundles in leaf lamina…… *D. ciliaris*

Angular (penta and hexagonal) shaped 3rd order vascular bundles in leaf lamina……...*D. longiflora*

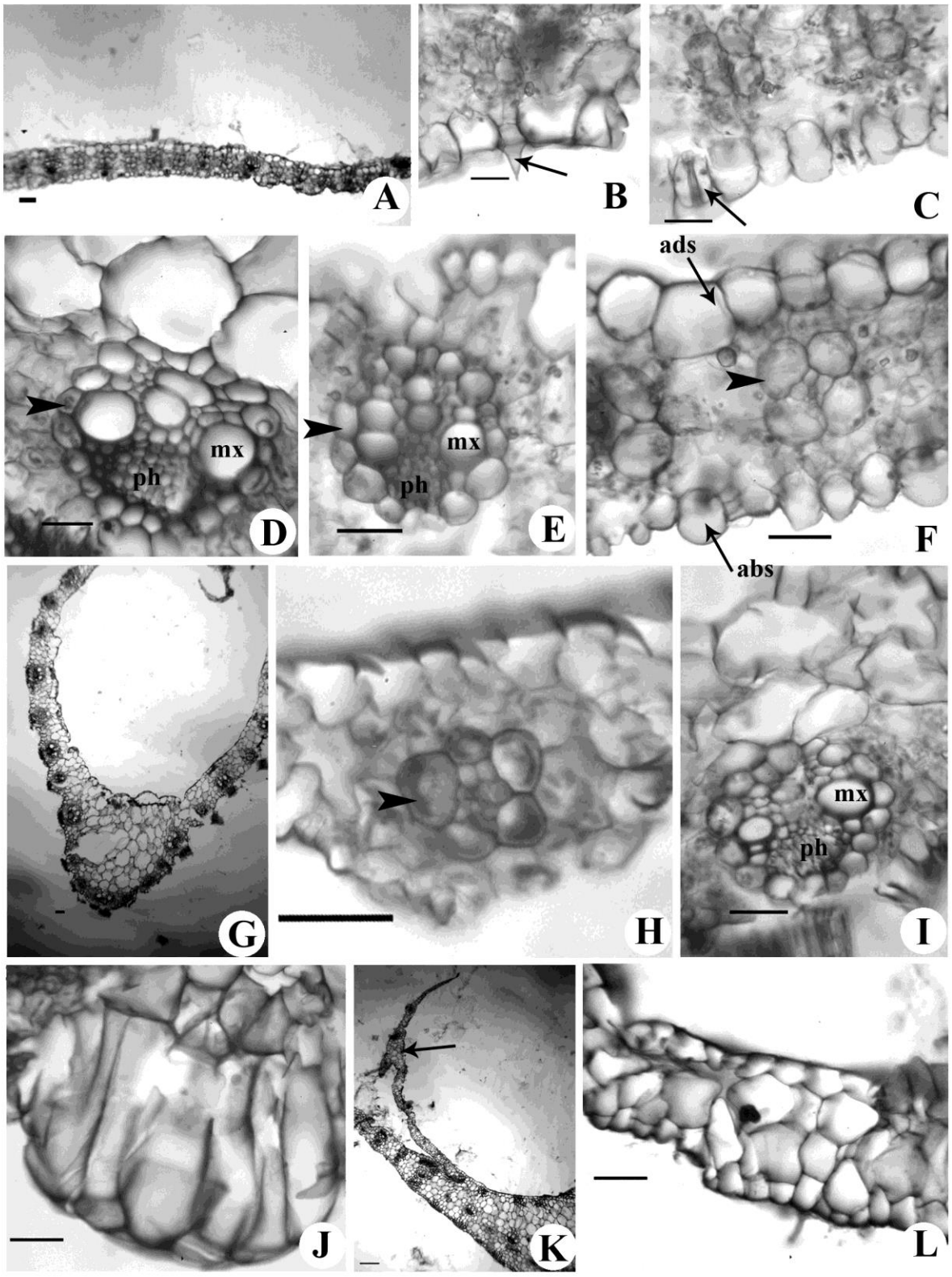

Fig. 168

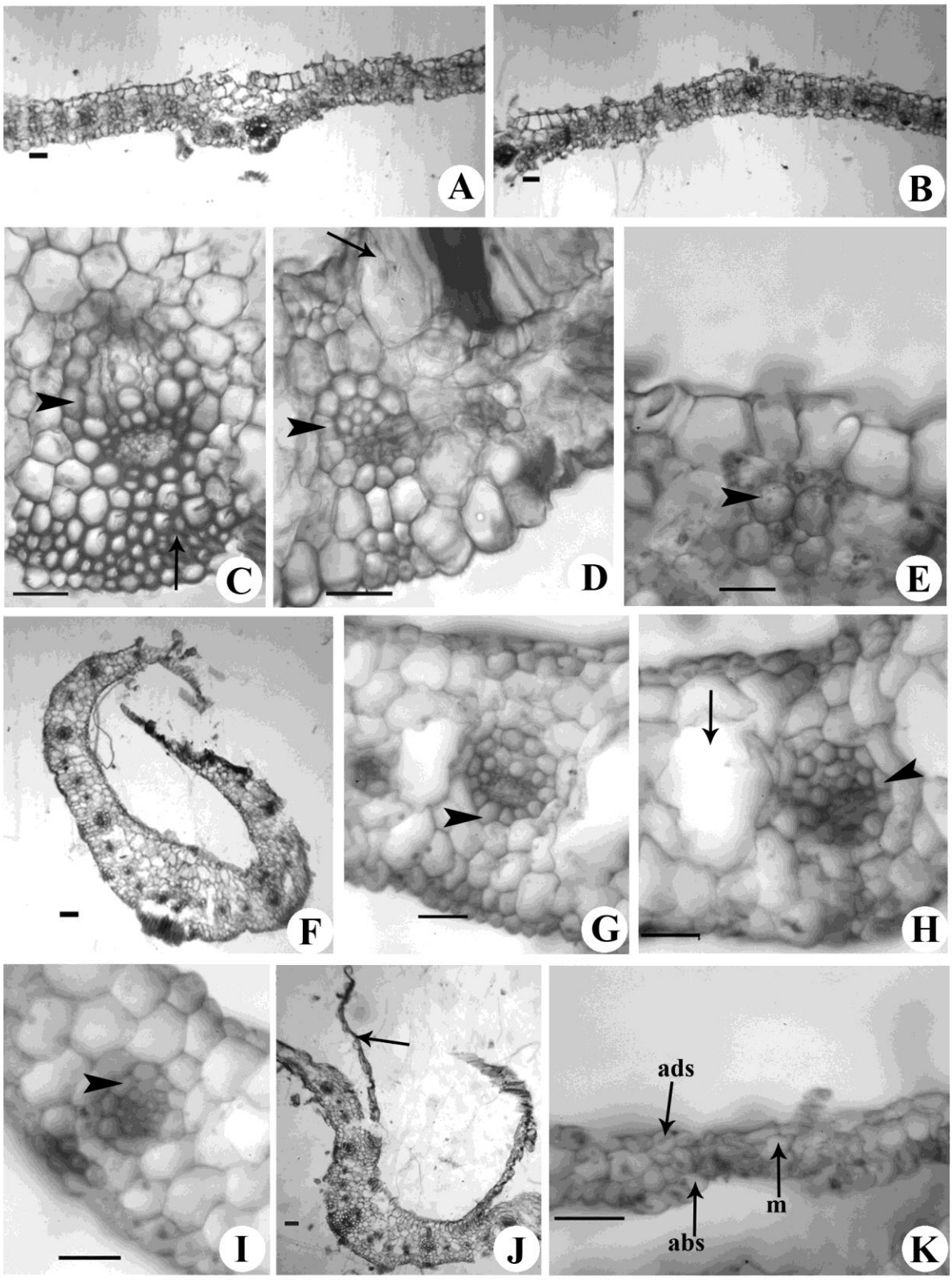

Fig. 169

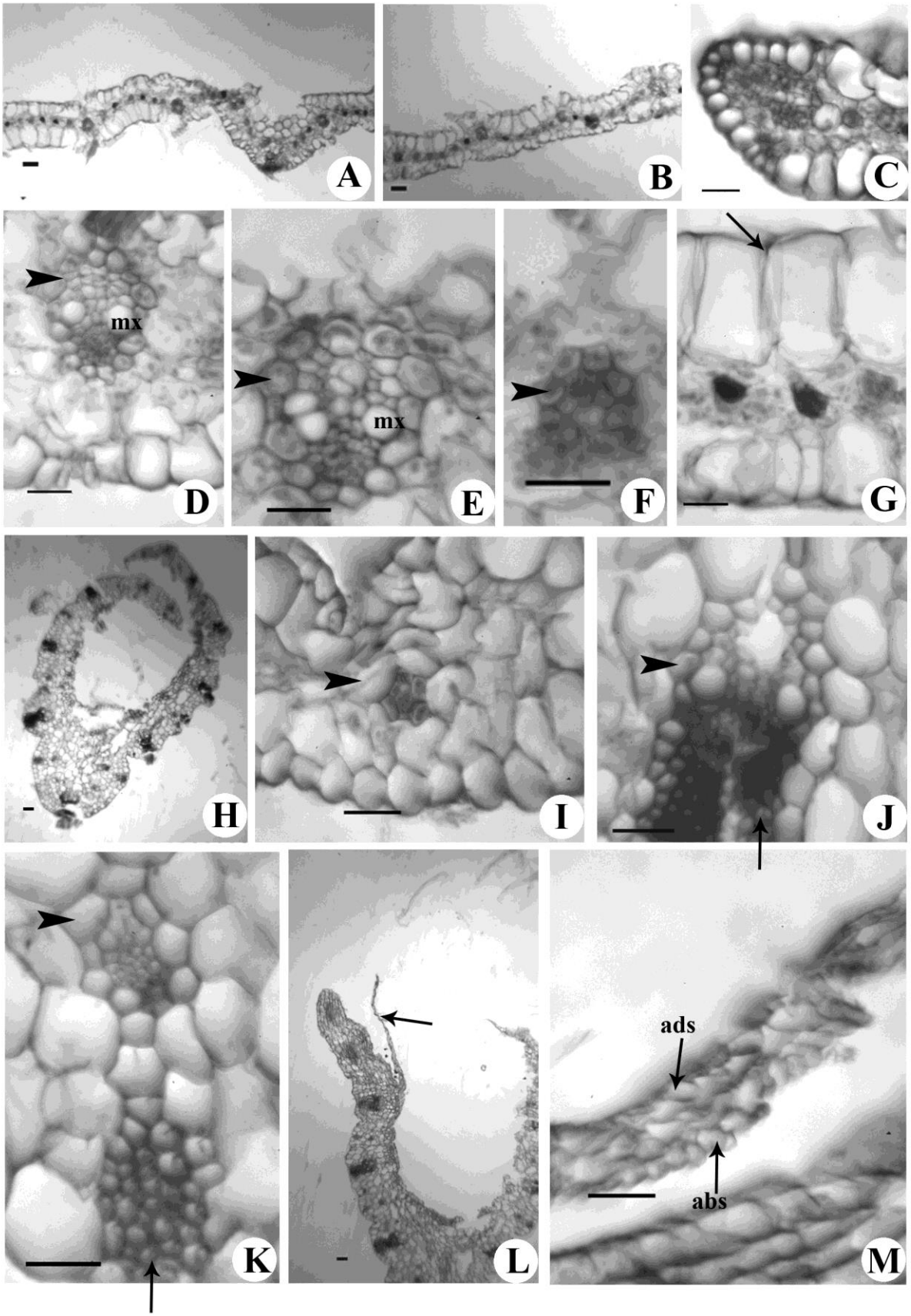

Fig. 170

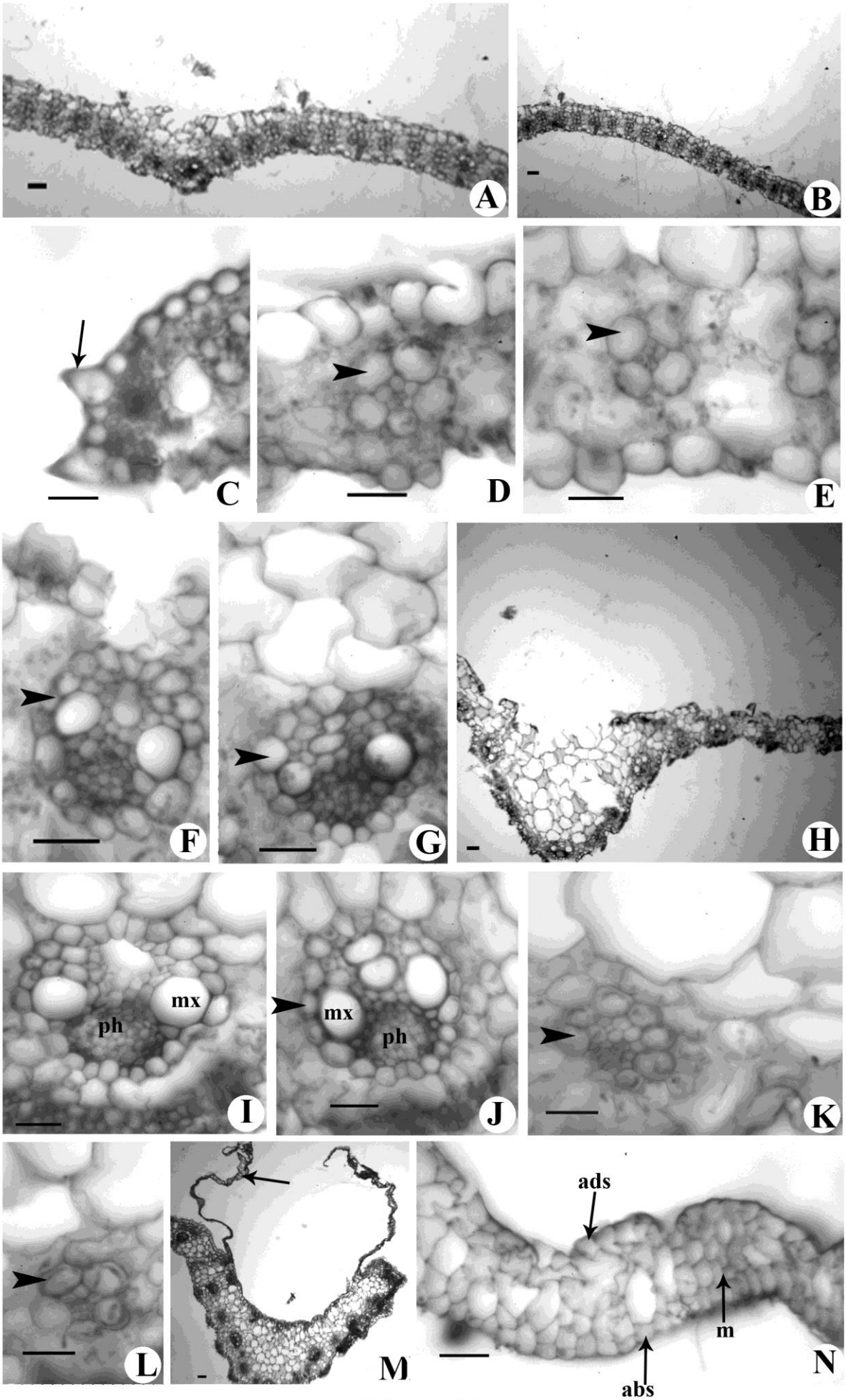

Fig. 171

Echinichloa

49. *Echinichloa colona* (Fig. 172)

50. *Echinochloa crusgalli* (Fig. 173)

51. *Echionochloa stagnina* (Fig. 174)

LEAF LAMINA: (Fig. 172 A-F, 173 A-E, 174 A-E)

Outline of the lamina: 'V' shaped in all species(Fig. 172 A, B, 173 A, B, 174 A, B) with broad angled inrolled margin in *E. colona*, broad angled irregularly wavy arms in *E. crusgalli* and wide angled with straight arms in *E. stagnina*.

Two halves are symmetrical on either side of the median vascular bundle.

Ribs and furrows are absent in all species except present in *E. colona*. Shallow, wide furrows with round ribs present on all vascular bundles.

Keel is well developed, 'U' shaped in *E. colona*, 'V' shaped in *E. crusgalli* and *E. stagnina* with single median vascular bundles, 2 2nd order and 5-6 3rd order in *E. colona*, 4-5 3rd order in *E. crusgalli* and 3-4 3rd order in *E. stagnina* vascular bundles. Small, round parenchyma cells present surrounding the median vascular bundle adaxially. Sclerenchyma is present on abaxial surface associated with vascular bundles in form of strands.

Epidermis: Adaxial epidermal surface has group of small bulliform cells, not associated with colourless cells in *E. colona* (Fig. 172 E, arrow), most part made up of large, inflated bulliform cells in *E. crusgalli* and *E. stagnina* (Fig. 173 D, arrow, 174D arrow). Abaxial epidermal cells barrel to rectangular shaped covered with cuticle. Few cells showed papillae which are wide as epidermal cells in *E. crusgalli* and *E. stagnina* (Fig. 173 D, 174 C, D arrow).

Mesophyll: Incompletely radiate chlorenchyma cells continuous between bundles in *E. colona* while irregular, horizontally arranged chlorenchyma cells occupy the major area between the adaxial and abaxial epidermides. Chlorenchyma cells continuous between bundles. Colourless cells absent.

Vascular bundles: 1st order vascular bundles 4-5 in *E. colona*, 5-6 in *E. crusgalli* and *E. stagnina* regularly arrangeed from median bundle to marginal bundles in half lamina.

5-6 3rd order and 2-3 2nd order in *E. colona*, 7-8 3rd order and 3-4 2nd order in *E. crusgalli*, 6-7 3rd order and 3-4 2nd order in *E. stagnina* bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally.

3rd order vascular bundles: (Fig. 172 E, 173 D, 174 D)

Hexagonal in *E. colona* and *E. crusgalli*, pentagonal in *E. stagnina* with xylem and phloem distinguishable.

2nd order vascular bundles: Elliptical

1st order vascular bundles: (Fig. 172 D, 173 E, 174 C)

Shape: circular in all species except in *E. stagnina* elliptical

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity present and enlarged protoxylem vessel absent in *E. colona*, present in *E. stagnina* and

lysigenous cavity absent and enlarged protoxylem vessel present in *E. crusgalli*.

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Midrib vascular bundles:

Shape: Circular in all species except elliptical in *E. stagnina*

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity present and enlarged protoxylem vessel absent in *E. colona*, present in *E. stagnina* and lysigenous cavity absent and enlarged protoxylem vessel present in *E. crusgalli*.

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Vascular bundle sheath: (Fig.172 E arrowhead, 173 D arrowhead, 174 D arrowhead)

3rd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath:

Shape: Circular

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 9-10 in *E. colona* and *E. stagnina*, 7-8 in *E. crusgalli*

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplasst Positioned towards outer tangential wall

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath:

Shape: circular in all species except in *E. stagnina* elliptical

Extent of bundle sheath around the vascular bundle: Complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 18-19 in *E. colona*, 14-15 in *E. crusgalli*, 15-16 *E. stagnina* parenchyma cells

Bundle sheath cell shape: All cells are elliptical, elongated in shape. Chloroplast concentrated near outer tangential wall

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Absent

Abaxial sclerenchyma: Minute subepidermal strands in *E. colona*, straight horizontal band of strands in *E. stagnina* and absent in *E. crusgalli*

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very small round fibrous cap.

Epidermal cells at margin are thin with thick outer tangential wall (Fig. 172 C, 174 E).

LEAF SHEATH ANATOMY (Fig. 172G-J, 173 F-H, 174 F-H)

Outline of lamina: 'V'shaped standard angle with straight arms in all species (Fig. 172 H, 173 F, 174 F). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavity.

Vascular bundle:

Arrangement of vascular bundle: 2-3 in *E. colona* and *E. crusgalli*, 3-4 in *E. stagnina* consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: (Fig. 172 I, 173 F, 174 F)

Circular in all species except in *E. stagnina* hexagonal with xylem and phloem distinguishable

2nd order vascular bundle: Circular shaped (Fig. 172 H)

1st order vascular bundle: (Fig. 172 J, 173 H, 174 H)

Circular with phloem completely surrounded by thick walled fibers. Lysigenous cavity present and enlarged protoxylem vessel absent in *E. colona*, present in *E. stagnina* and lysigenous cavity absent and enlarged protoxylem vessel present in *E. crusgalli*. Circular wide metaxylem vessels element.

Vascular bundle sheath: (Fig. 172 J arrowhead, 173 H arrowhead, 174 H arrowhead)

Shape: Circular

Extent of bundle sheath around the vascular bundle: Complete

Number of cells comprising the bundle sheath: 18-19 in *E. colona*, 17-18 in *E. crusgalli*, 20-21 in *E. stagnina* parenchyma cells

Bundle sheath cell shape: All cells are elliptical, elongated in shape; cells smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of narrow, straight horizontal abaxial strand.

LIGULE ANATOMY (Fig. 172 K, 173 I, 174 I)

Ligule absent in *E. colona* and *E. crusgalli.*

Shape: Ligule attached to the leaf sheath more than half width and very broad round shaped at the connection point (Fig. 174 I)

Anatomy: Three layered mesophyll cells between adaxial and abaxial surfaces

Differentiating features:

'U' shaped keel ……..……. *E. colona*

'V' shaped keel

Ligule absent, circular shaped 1st order vascular bundles in leaf lamina……..

……*E. crusgalli*

Ligule present, elliptical shaped 1st order vascular bundles in leaf lamina……

……*E. stagnina*

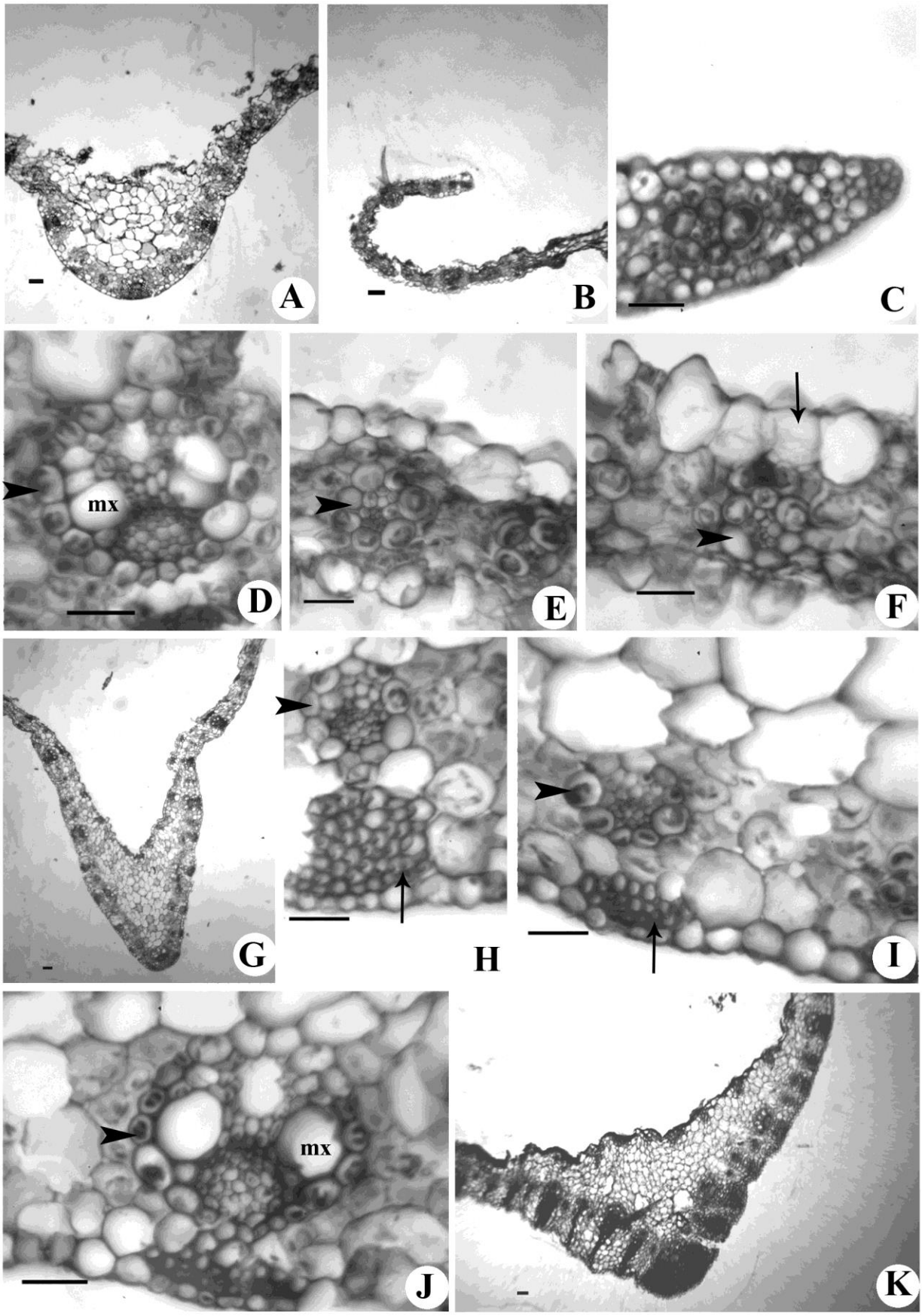

Fig. 172

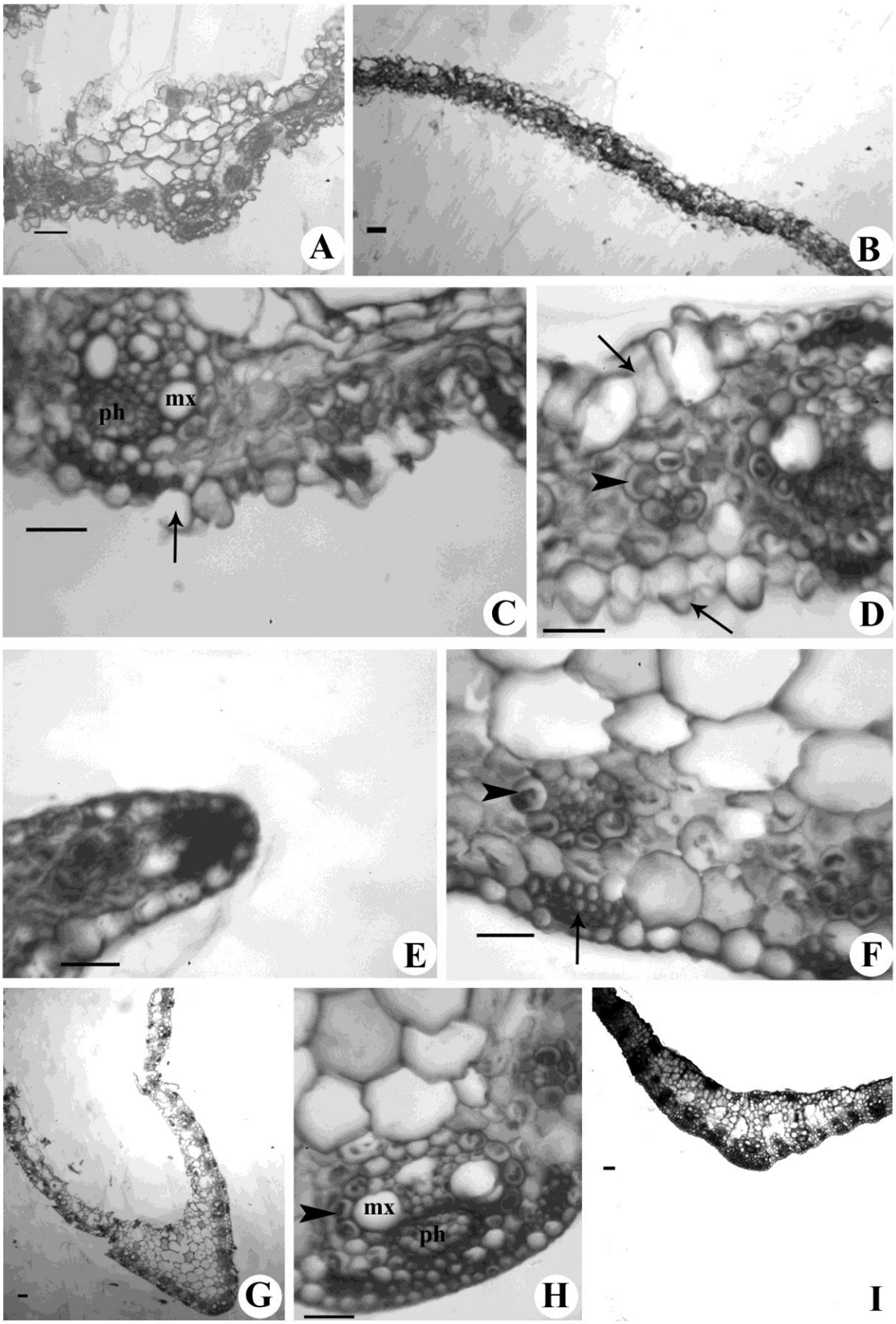

Fig. 174

52. *Eremopogon foveolatus*

LEAF LAMINA: (Fig. 175 A-E)

Outline of the lamina: 'V' shaped, wide angle with outwardly curving arms (Fig. A). Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are absent on the leaf surface.

Keel is well developed, V-shaped with single median vascular bundle. Small, round parenchyma cells present surrounding the median vascular bundle adaxially. Sclerenchyma present on abaxial surface of keel associated with vascular bundles in form of strands.

Epidermis: Adaxial epidermal surface has most of epidermis made up of large, inflated bulliform cells (Fig. C, arrow). Abaxial epidermis surface has small, barrel shaped epidermal cells with thick cuticle. Few epidermal cells has long, balloon shaped papillae (Fig. D, arrow).

Mesophyll: Radiate, single layered, isodiametric chlorenchyma cells completely surrounding bundles. Compact homogenous chlorenchymatous cells occupy the major area between the adaxial and abaxial epidermides. Chlorenchyma cells continuous between bundles. Colourless cells absent.

Vascular bundles: 2-3 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundle. 6-7 3rd order bundles between consecutive larger bundles and 1-2 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally.

3rd order vascular bundles: Hexagonal with vascular tissue consisting of only few indistinguishable vascular elements (Fig. B, C).

2nd order vascular bundles: Circular shaped

1st order vascular bundles: (Fig. E).

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Median vascular bundles:

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 9-10

Nature of bundle sheath (either complete or incomplete): complete

Chloroplast position in bundle sheath cell: Chloroplast concentrated near outer tangential wall

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. E)

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath incomplete, abaxially interrupted by sclerenchyma

Extension of bundle sheath: Broad abaxial extension of the bundle sheath

Number of cells comprising the bundle sheath: 13-14 parenchyma cells comprise the sheath

Bundle sheath cell shape: All cells are elliptical, elongated in shape. Chloroplast concentrated near outer tangential wall.

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Minute strand consisting of only a few subepidermal fibers

Abaxial sclerenchyma: Well developed strand, wider than deep and it follows shape of abaxial rib

Sclerenchyma between bundles: absent

Sclerenchyma in leaf margin: Forming very small pointed fibrous cap. Epidermal cells thin with thick outer tangential wall.

LEAF SHEATH ANATOMY (Fig. 175F-L)

Outline of lamina: V shaped standard angle with inrolled margins (Fig. F). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: big, rectangular (Fig. J, arrow).

Abaxial epidermal cells: small, flat, squarish to round shaped with thick cuticle (Fig. L, arrow).

Ground tissue: Parenchymatous ground tissue, air cavity absent (Fig. G).

Vascular bundle:

Arrangement of vascular bundle: 4-5 consecutive 3rd order vascular bundles between 1st and 2nd order vascular bundle

3rd order vascular bundle: Squarish shaped, vascular tissue consists of only a few distinguishable vascular elements (Fig. L)

2nd order vascular bundle: Elliptical shaped

1st order vascular bundle: Elliptical shaped, phloem completely surrounded by thick walled fibers, lysigenous cavity absent and enlarged protoxylem vessel present, Circular wide metaxylem vessel elements (Fig. I).

Vascular bundle sheath:

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath incomplete, interrupted by sclerenchyma cells extending till abaxial epidermis

Number of cells comprising the bundle sheath: 13-14 parenchyma cells comprise the sheath

Bundle sheath cell shape: All cells are elliptical, elongated in shape; cells smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of well developed broad anchored girder present on abaxial surface (Fig. H, I arrow).

LIGULE ANATOMY (Fig. 175M, N)

Shape: Ligule attached up to ¾ of the lamina and further portion is free and blunt. Ligule broad 'V' shaped at the connection (Fig. M, arrow)

Anatomy: Single layered mesophyll cells between adaxial and abaxial surfaces (Fig. N).

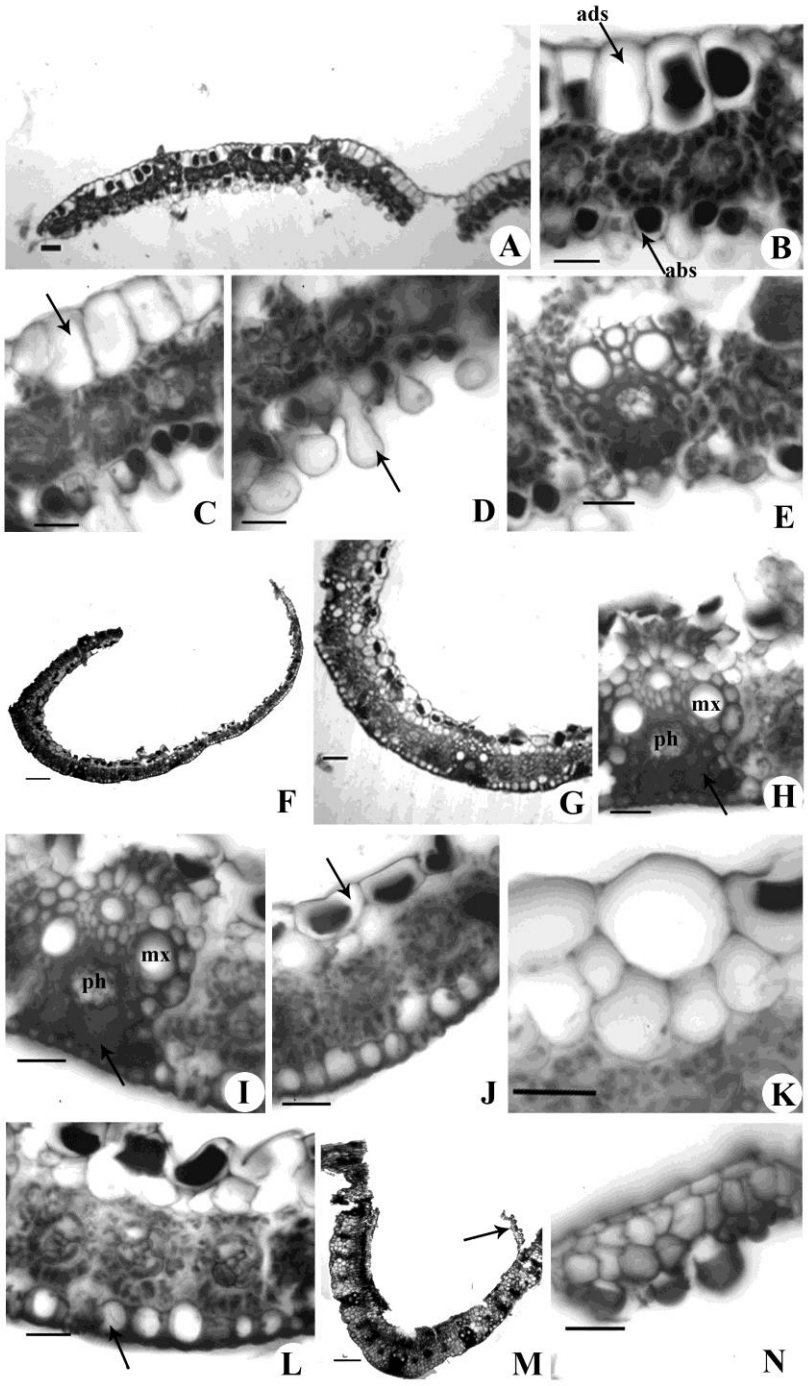

Fig. 175

53. *Eriochloa procera*

LEAF LAMINA: (Fig. 176 A-G)

Outline of the lamina: Expanded with undulating leaf blade (Fig. A, B). Ribs and furrows present on abaxial surface. Shallow and wide furrows present between all vascular bundles. Round ribs present over all vascular bundles. Keel is well developed, V-shaped keel with single median vascular bundle, 3-4 3rd order vascular bundles. Small, round parenchyma cells surrounding the median vascular bundle adaxially. Sclerenchyma present on abaxial surface associated with vascular bundles in form of strands.

Epidermis: Adaxial epidermal surface with fan shaped bulliform cells which occupies ¼-1/2 of the leaf thickness (Fig. E). Abaxial epidermal cells are barrel shaped with thick cuticle.

Mesophyll: Incomplete radiating chlorenchyma cells, continuous between bundles.

Vascular bundles: 3-4 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundles. 7-8 3rd order bundles between consecutive larger bundles and 2-3 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level abaxially.

3rd order vascular bundles: Pentagonal (Fig. F) or hexagonal or square shaped (Fig. G) with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: Elliptical

1st order vascular bundles: (Fig. E)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Phloem adjoins the inner parenchyma cells

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: narrow vessels

Shape of metaxylem vessels: Circular

Median vascular bundles: (Fig. D)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: narrow vessels

Shape of metaxylem vessels: Circular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. F, G arrow)

Shape: Round

Shape of bundle sheath cell: Radial and inner tangential wall straight while outer tangential wall inflated

2nd order vascular bundle's bundle sheath:

Shape: Ellliptical

Shape of bundle sheath cell: Radial and inner tangential wall straight while outer tangential wall inflated

Number of bundle sheath cell: 8-9

Nature of bundle sheath (either complete or incomplete): complete

Chloroplast position in bundle sheath cell: Chloroplast concentrated near outer tangential wall

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. E, D arrowhead)

Shape: Horse shoe shaped

Extent of bundle sheath around the vascular bundle: complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 9-10 parenchyma cells

Bundle sheath cell shape: Cells varying in size having radial and inner tangential wall straight while outer tangential wall inflated. Chloroplast concentrated near outer tangential wall

Mestome/ Inner sheath: Complete sheath present with cells smaller than the outer bundle sheath.

Sclerenchyma:

Adaxial sclerenchyma: Absent

Abaxial sclerenchyma: Minute subepidermal strands present

Sclerenchyma between bundles: absent

Sclerenchyma in leaf margin: Forming well developed pointed cap. Epidermal cells thin with thick outer tangential wall.

LEAF SHEATH ANATOMY (Fig. 176 H-J)

Outline of lamina: 'V' shaped inrolled margins of arms. Ribs and furrows present. Medium, wide furrows present between all vascular bundles on abaxial surface (Fig. H).

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavity.

Vascular bundle:

Arrangement of vascular bundle: 1-2 consecutive 3rd order vascular bundles between 1st and 2nd order vascular bundle

3rd order vascular bundle: Pentagonal with vascular tissue consisting of only few indistinguishable vascular elements (Fig. I)

2nd order vascular bundle: Elliptical shaped

1st order vascular bundle: Elliptical shaped, phloem completely surrounded by thick walled fibers, lysigenous cavity absent and enlarged protoxylem vessel present, Circular narrow metaxylem vessel elements (Fig. J)

Vascular bundle sheath: (Fig. I, J arrowhead,)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Sheath incomplete, interrupted by sclerenchyma cells abaxially

Number of cells comprising the bundle sheath: 8-9 parenchyma cells

Bundle sheath cell shape: Cells of varying size with radial and inner tangential wall straight while outer tangential wall inflated

Mestome/ Inner sheath: Complete sheath present with cells smaller than the outer bundle sheath.

Sclerenchyma: In form of well developed broad, wide and deep girder on abaxial surface.

LIGULE ANATOMY (Fig. 176 K, L)

Shape: Ligule attached to the midrib and few parts of lamina region because it is hairy ligule (Fig. K, arrow)

Anatomy: Two layered mesophyll cells between adaxial and abaxial surfaces (Fig. L)

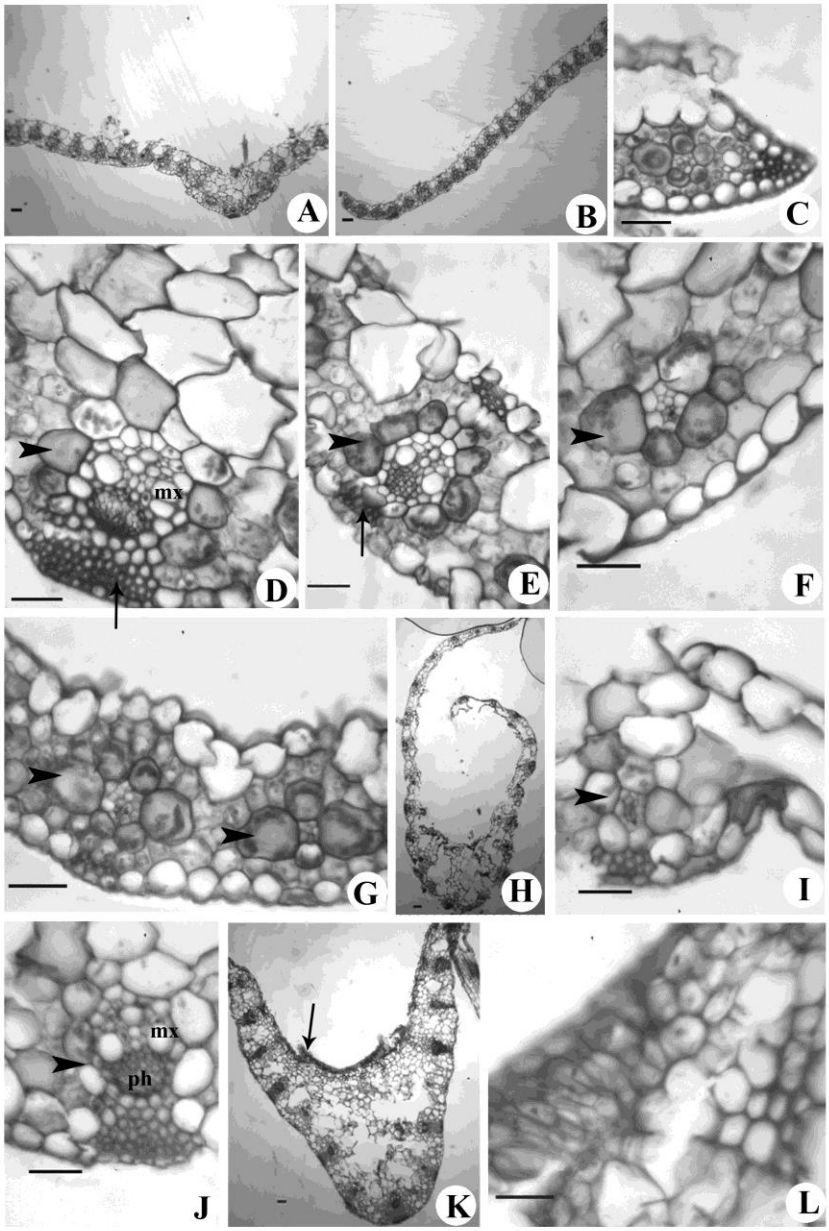

Fig. 176

Oplismenus

54. *Oplismenus burmannii* (Fig. 177)

55. *Oplismenus composites* (Fig. 178)

LEAF LAMINA: (Fig. 177 A-H, 178 A-E)

Outline of the lamina: Expanded with wavy leaf blade (Fig. 177 A, B, 178 A, B). Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are present on the leaf surface. Shallow, wide furrows present between 1st and 2nd order vascular bundles and rounded ribs present on 1st an 2nd order vascular bundles.

Keel is well developed, triangular with single median vascular bundle. Small, round parenchyma cells present surrounding the median vascular bundle adaxially. Sclerenchyma present on abaxial surface associated with vascular bundles in form of strands.

Epidermis: Adaxial epidermal surface has two types of bulliform cells (1) fan shaped (Fig. 177 A, 178 E) in *O. burmannii, O. composites* (2) restricted group of large, inflated bulliform cells present above the level of epidermis in *O. burmannii* (Fig. 177 H, arrow). Long, slender hairs present with sunken bases (Fig. 177 F, arrow, 178 E arrow). Sharp, prickles present (Fig. 177 D, arrow).

Abaxial epidermial cells barrel shaped covered with cuticle. Short, sharp tichomes (Fig. 177 G, arrowhead) and prickles (Fig. 177 G, arrow) present on abaxial surface.

Mesophyll: Irregular, horizontally arranged chlorenchyma cells occupy the major area between the adaxial and abaxial epidermides. Chlorenchyma cells continuous between bundles. Colourless cells absent.

Vascular bundles: 3-4 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundle. 4-5 3rd order bundles between consecutive larger bundles and 8-9 2nd order bundles between consecutive 1st order bundles present. 1st and 2nd order vascular bundles placed abaxially and 3rd order bundles placed centrally.

3rd order vascular bundles: (Fig. 177 D)

Hexagonal with vascular tissue consisting of only few indistinguishable vascular elements

2nd order vascular bundles: Circular shpaed

1st order vascular bundles: (Fig. 177 E, 178 C).

Shape: Circular

Relationship of phloem cells and the vascular fibres: phloem adjoins the inner or parenchyma sheath

Nature of lysigenous cavity and protoxylem: Lysigenous cavity absent and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: narrow vessels

Shape of metaxylem vessels: Circular

Median vascular bundles:

Shape: Circular

Relationship of phloem cells and the vascular fibres: phloem adjoins the inner or parenchyma sheath

Nature of lysigenous cavity and protoxylem: Lysigenous cavity absent and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: narrow vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. 177 D, arrowhead)

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 8-9

Nature of bundle sheath (either complete or incomplete): complete,

Chloroplast position in bundle sheath cell: Chloroplast small and indistinct

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. 177 E, arrowhead, 178 C, arrowhead)

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 9-10 parenchyma cells comprise the sheath

Bundle sheath cell shape: All cells are elliptical and elongated in shape. Chloroplast small and indistinct.

Mestome/ Inner sheath: Complete, inner sheath cells smaller than the outer sheath cell

Sclerenchyma:

Adaxial sclerenchyma: Minute strand in *O. burmannii* or shallow in *O. composites* consisting of only a few subepidermal fibers

Abaxial sclerenchyma: Well developed strand following the abaxial rib

Sclerenchyma between bundles: absent

Sclerenchyma in leaf margin: Forming very small pointed fibrous cap. Epidermal cells thin with thick outer tangential wall.

LEAF SHEATH ANATOMY (Fig. 177 I-L, 178 F-H)

Outline of lamina: Round shaped with inrolled margins (Fig. 177 I, 178 F). Ribs and furrows present on abaxial surface. Shallow, wide furrows present between 1st and 2nd order vascular bundles and rounded ribs present on 1st an 2nd order vascular bundles.

Epidermis: Adaxial epidermal cells flat and rectangular (Fig. 177 L). Restricted group of large, inflated bulliform cells present above the level of epidermis (Fig. 177K) and long slender hair present (Fig. 177 K, arrow) in *O. burmannii*.

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavity in *O. burmannii* but oval shaped air cavities present in *O. composites* (Fig. 178 H)

Vascular bundle:

Arrangement of vascular bundle: One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Hexagonal with vascular tissue consisting of only few indistinguishable vascular elements

2nd order vascular bundle: Circular shaped

1st order vascular bundle: (Fig. 177 J, 178 G) Circular shaped, phloem adjoins inner or parenchyma sheath, lysigenous cavity and enlarged protoxylem vessel present. Circular wide metaxylem vessel element.

Vascular bundle sheath:

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: complete

Number of cells comprising the bundle sheath: 9-10 parenchyma cells

Bundle sheath cell shape: All cells are elliptical, elongated and smaller than the ground tissue cells.

Mestome/ Inner sheath: Complete, inner sheath cells smaller than the outer sheath cell

Sclerenchyma: In form of small, 4-6 fibers strand present on abaxial surface.

LIGULE ANATOMY (Fig. 177 K, L, 178 I)

Shape: Ligule attached to the leaf sheath more than half sheath region and is round shaped at connection point (Fig. 177 K, 178 I)

Anatomy: Single layered mesophyll cells between adaxial and abaxial surfaces

Differentiating features:

Air cavities absent in leaf sheath……..…….…….. *O. burmanii*

Oval shaped air cavities in leaf sheath……..…...……. *O. composites*

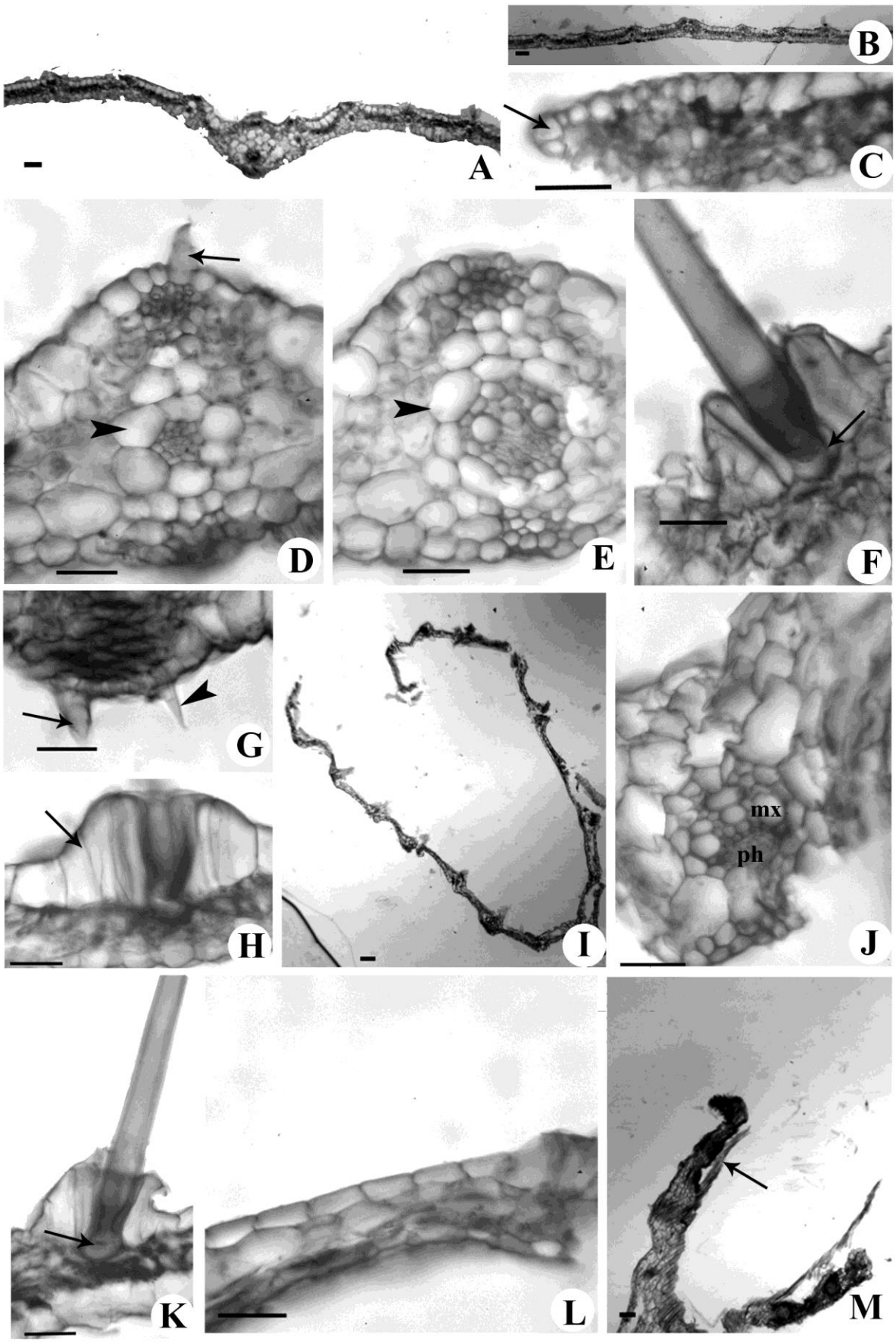

Fig. 177

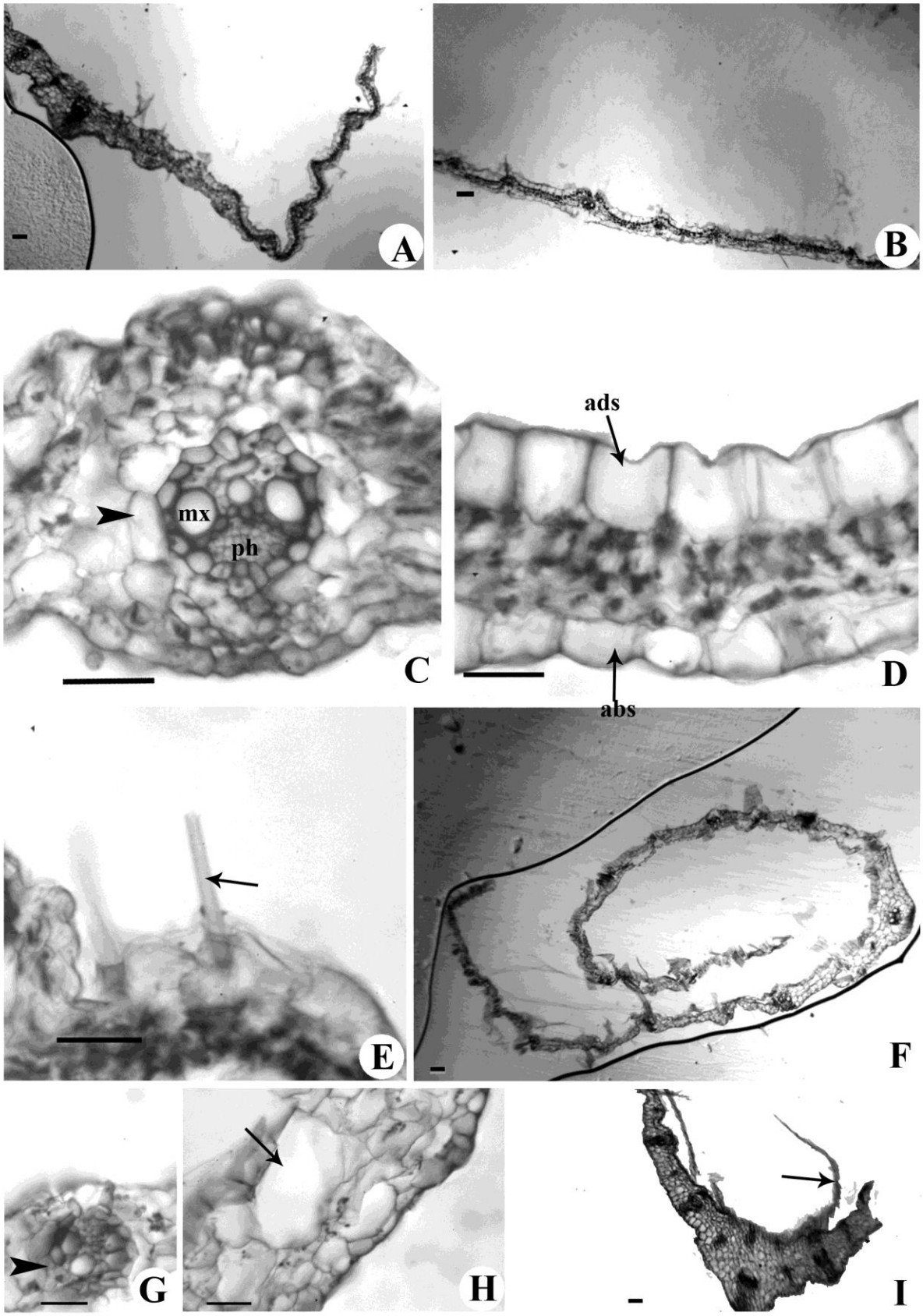

Fig. 178

Panicum

56. *Panicum antidotale* (Fig. 179)

57. *Panicum maximum* (Fig. 180)

58. *Panicum miliaceum* (Fig. 181)

59. *Panicum trypheron* (Fig. 182)

LEAF LAMINA: (Fig. 179 A-J, 180 A-E, 181 A-E, 182 A-H)

Outline of the lamina: Expanded with gently wavy leaf blade (Fig. 179 A, B, 180 A, 181 A) but V' shaped, wide angle with convex shape of the arms in *P. trypheron* (Fig. 182 A, B), two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are present in all species except absent in *P. trypheron*. Shallow, wide furrows present between all vascular bundles and rounded ribs present on all vascular bundles.

Keel is well developed, semicircular in *P. antidotale*, *P. maximum* and *P. miliaceum*, 'V' shaped in *P. trypheron*, with single median vascular bundle in *P. antidotale, P. maximum* and *P. miliaceum* and 4-5 3rd order vascular bundles present in *P. trypheron*. Small, rounded parenchyma cells are present surrounding the median vascular bundle adaxially. Sclerenchyma is present on abaxial surface associated with vascular bundles in form of well developed strands.

Epidermis: Adaxial epidermal surface has fan shaped bulliform cells (Fig. 179 F, 180 E, arrow, 181 F, arrow, 182 E, arrow) with diamond shaped in *P. antidotale* and *P. maximum*, triangular in *P. miliaceum* and large, round in *P. trypheron* shaped central cell. Bulliform cells occupy less than ½ portions in *P. antidotale* and *P. maximum* or ¼ portions in *P. miliaceum* and *P. trypheron* of leaf thickness. Small hook with pointed barb in *P. antidotale* (Fig. 179 I, arrow) on adaxial surface.

Abaxial epidermis has small round to barrel shaped epidermal cells with thick cuticle. Restricted groups of tall and narrow bulliform cells (Fig. 179 F) in which long, slender macrohairs (Fig. 179 G, arrow) with bulbous, sunken base present.

Mesophyll: Radiate, Single layered, isodiametric chlorenchyma cells completely surrounding bundles. Compact homogenous chlorenchymatous cells occupy the major area between the adaxial and abaxial epidermides. Colourless cells absent in *P. miliaceum* and *P. trypheron* while present in *P. antidotale* and *P. maximum* (Fig. 179 E, arrow).Colourles cells smaller than bulliform cells, forming one extension upto abaxial epidermis in *P. antidotale* while in *P. maximum* partially.

Vascular bundles: 6-7 1st order in *P. antidotale*, 8-9 in *P. maximum* and *P. miliaceum*, 3-4 in *P. trypheron* regularly arranged from median bundle to marginal bundle in half lamina. 3-4 3rd order and 2-3 2nd order in *P. miliaceum*, 5-6 3rd order and 3-4 2nd order and 4-5 3rd order and 2-3 2nd order in *P. trypheron* bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally.

3rd order vascular bundles: (Fig. 179 D, 180 D, 181 D, E, 182 C, D, E, G)

Hexagonal in all species except pentagonal (Fig. 182 C, D, G) and square (Fig. 182 E) in *P. trypheron*, with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: Circular shaped (Fig. 181 C)

1st order vascular bundles: (Fig. 179 C, 180 C, 181 B, 182 F).

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers in all species except in *P. trypheron* where phloem adjoins inner or parenchyma cells.

Nature of lysigenous cavity and protoxylem: Enlarged protoxylem vessel present and Lysigenous cavity absent in *P. trypheron*

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: narrow vessels

Shape of metaxylem vessels: Circular

Median vascular bundles: (Fig. 179 J).

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers in all species except in *P. trypheron* where phloem adjoins inner or parenchyma cells.

Nature of lysigenous cavity and protoxylem: Enlarged protoxylem vessel present and Lysigenous cavity absent in *P. trypheron*

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: narrow vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. 179 D, 180 D, 181 D, E, 182 C, D, G arrowhead).

Shape: Round

Shape of bundle sheath cell: Fan shaped in all species. *P. trypheron* has cells towards adaxial side larger than the others.

2nd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Fan shaped in all species but *P. trypheron* has cell towards adaxial side is larger than the others

Number of bundle sheath cell: 8-9 in *P. antidotale* and *P. maximum*, 6-7 in *P. trypheron* and *P. miliaceum*

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast concentrated near inner tangential wall in *P. antidotale* and *P. miliaceum* and outer tangential wall in *P. trypheron* and *P. maximum.*

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. 179 C, 180 C, 181 C, 182 F).

Shape: Elliptical in all species except in *P. antidotale* circular.

Extent of bundle sheath around the vascular bundle: complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 10-11 in *P. antidotale*, 13-14 in *P. maximum*, 9-10 in *P. miliaceum, P. trypheron* parenchyma cells comprise the sheath

Bundle sheath cell shape: Fan shaped, Chloroplast concentrated near inner tangential wall in *P. antidotale* and *P. miliaceum* or near outer tangential wall in *P. trypheron* and *P. maximum*.

Mestome/ Inner sheath: Complete with cells smaller than the outer sheath cells

Sclerenchyma:

Adaxial sclerenchyma: Absent

Abaxial sclerenchyma: Minute strand consisting of only a few subepidermal fibers

Sclerenchyma between bundles: absent

Sclerenchyma in leaf margin: Forming very small round fibrous cap in *P. antidotale, P. miliaceum* and *P. maximum* while pointed fibrous cap in *P. trypheron*. Epidermal cells thin with thick outer tangential wall.

LEAF SHEATH ANATOMY (Fig. 179 K-P, 180 G-I, 181 G-I, 182 I-K)

Outline of lamina: V shaped with standard angle, inrolled margins in *P. antidotale* and *P. maximum* (Fig. 179 K, 180 G) or round with overlapping inrolled margins in *P. miliaceum* and *P. trypheron* (Fig. 181 G, 182 I). Ribs and furrows absent in *P. antidotale, P. maximum* while present in *P. miliaceum, P. trypheron*. Shallow, wide furrows present between all vascular bundles and rounded ribs present on all vascular bundles.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: big, round cells with thick cuticle. Epidermis interrupted by stomata (Fig. 179 O, arrow).

Ground tissue: Parenchymatous with horizontally elongated oval shaped in *P. antidotale* and *P. maximum* or round shaped in *P. miliaceum* air cavity. Air cavity absent in *P. trypheron*.

Vascular bundle:

Arrangement of vascular bundle: 1 in *P. antidotale* and *P. maximum*, 2 in *P. miliaceum* and *P. trypheron* consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: (Fig. 179 L, 180 H, 182 J)

Hexagonal in *P. antidotale* and *P. miliaceum*, elliptical in *P. maximum* and square in *P. trypheron* vascular bundle with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundle: Circular shaped

1st order vascular bundle: (Fig. 179 N, 180 G, 181 I, 182 K)

Circular shaped in all species except in *P. maximum* elliptical with phloem completely surrounded by thick walled fibers. Lysigenous cavity and enlarged protoxylem vessel present in all species except *P. trypheron* with an absence of lysigenous cavity. Circular narrow metaxylem vessels elements.

Vascular bundle sheath: (Fig. 182 K)

Shape: Round in all species except in *P. maximum* elliptical.

Extent of bundle sheath around the vascular bundle: Complete in all species except *P. antidotale* with incomplete vascular bundle, abaxially interrupted by sclerenchyma cells.

Number of cells comprising the bundle sheath: 10-11 in *P. antidotale*, 12-13 in *P. maximum*, 7-8 in *P. miliaceum* and 9-10 in *P. trypheron* parenchyma cells.

Bundle sheath cell shape: Fan shaped with cells smaller than the ground tissue.

Mestome/ Inner sheath: Complete with cells smaller than the outer sheath cell in *P. antidotale* and *P. maximum* or incomplete, innerrupted by sclerenchyma cells on abaxial side in *P. miliaceum* and *P. trypheron.*

Sclerenchyma: In form of well developed broad and wide girder in *P. antidotale* and *P. maximum* (Fig. 179 N, arrow, 180 I, arrow) while straight horizontal abaxial band in *P. miliaceum* and *P. trypheron* (Fig. 182, I arrow).

LIGULE ANATOMY (Fig. 179 P, Q, 180 J, K, 181 J, K, 182 L, M)

Shape: Ligule attached to the leaf sheath more than the half width and very broad round connection point (Fig. 179 Q, 180 J, 181 J, 182 L).

Anatomy: Two layered in all species except in *P. antidotale* single layered, mesophyll cells between adaxial and abaxial surfaces (Fig. 179 P, 180 K, 181 K, 182 M).

Differentiating features:

'V' shaped leaf blade…….…… *P. trypheron*

Expanded leaf blade

Colourless cells absent…..…….…… *P. miliaceum*

Colourless cells present

Hexagonal shaped 3rd order vascular bundles in leaf sheath…..……

……...*P. antidotalae*

Elliptical shaped 3rd order vascular bundles in leaf sheath…….

…….....*P. maximum*

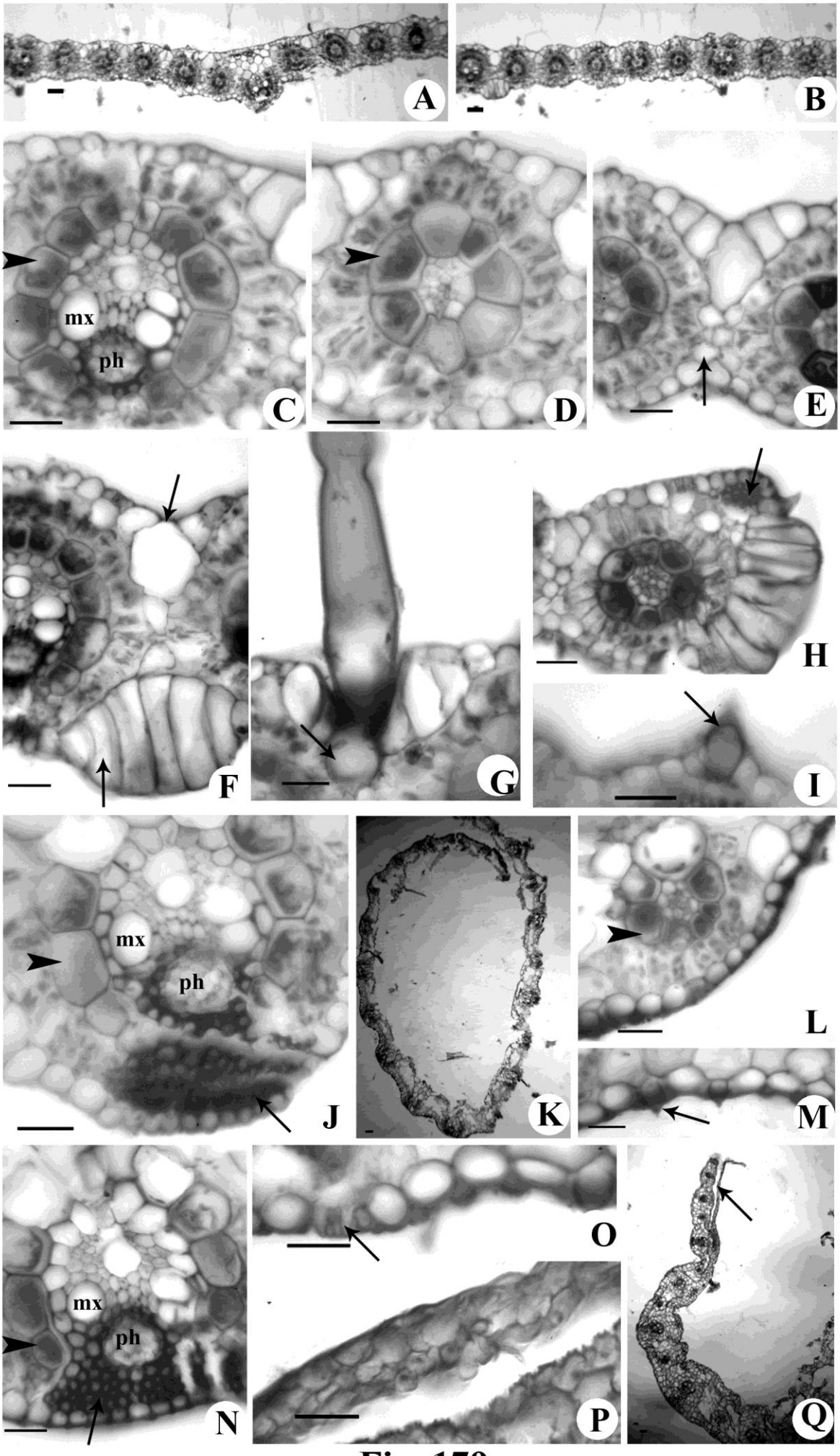

Fig. 179

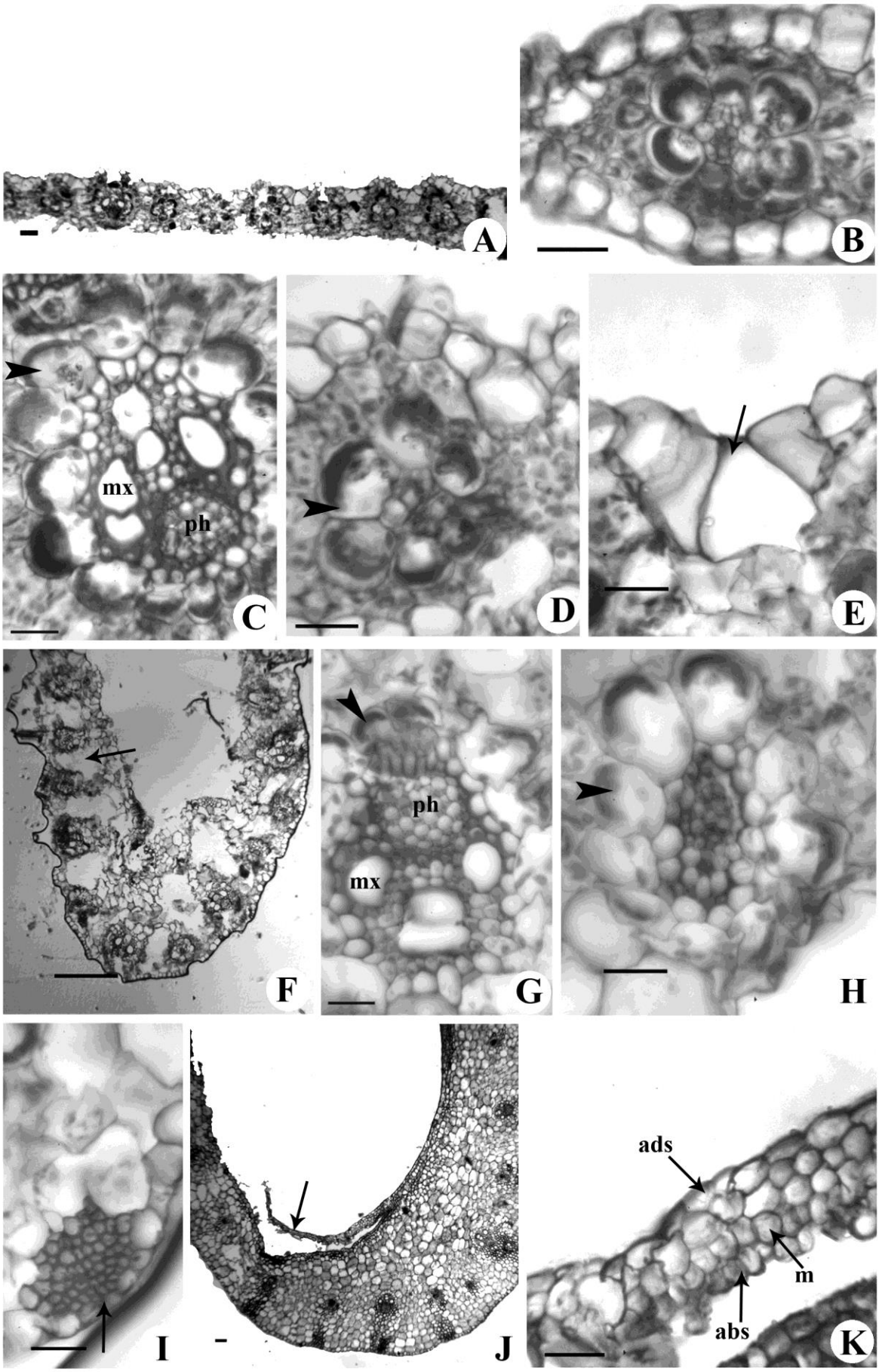

Fig. 180

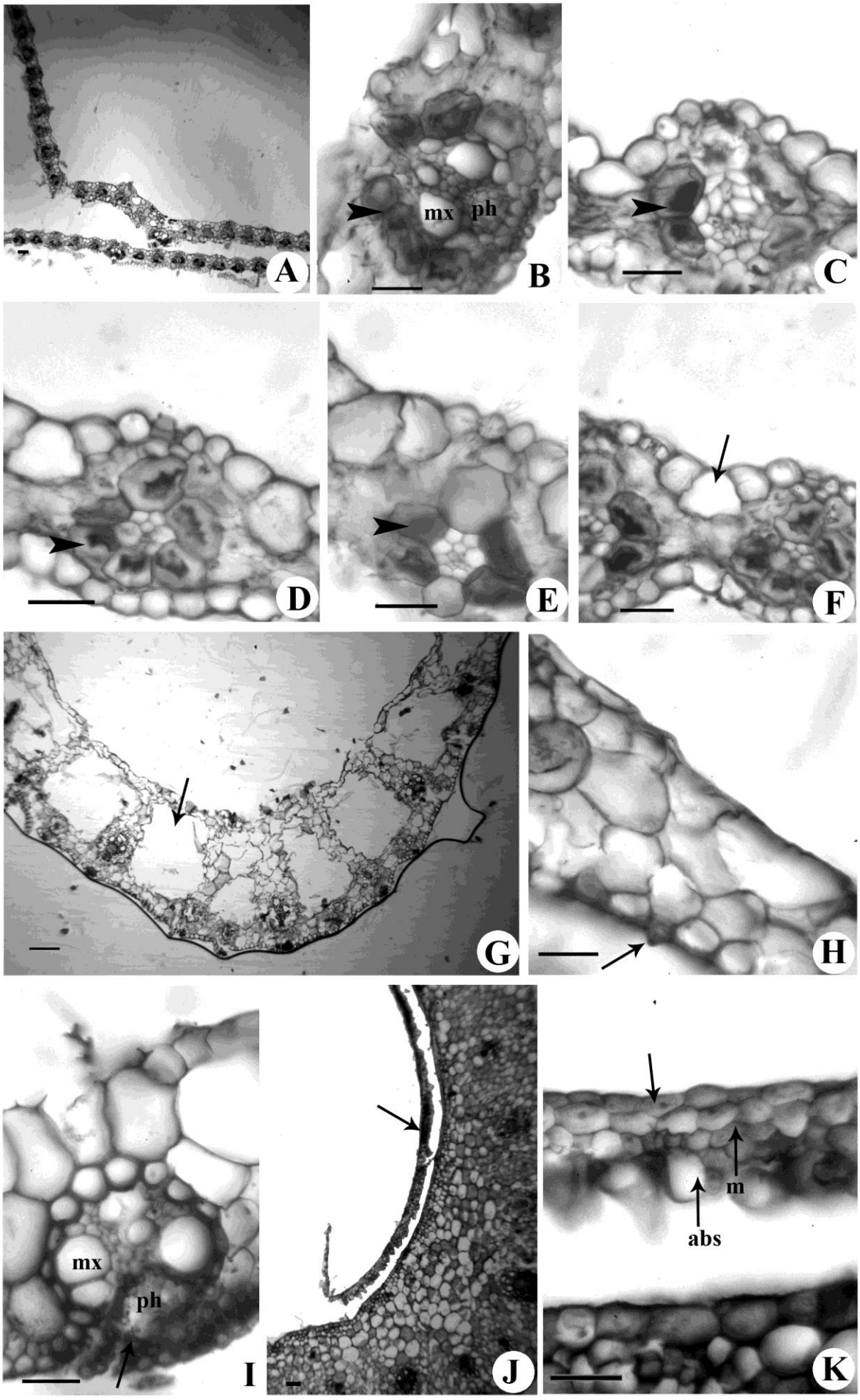

Fig. 181

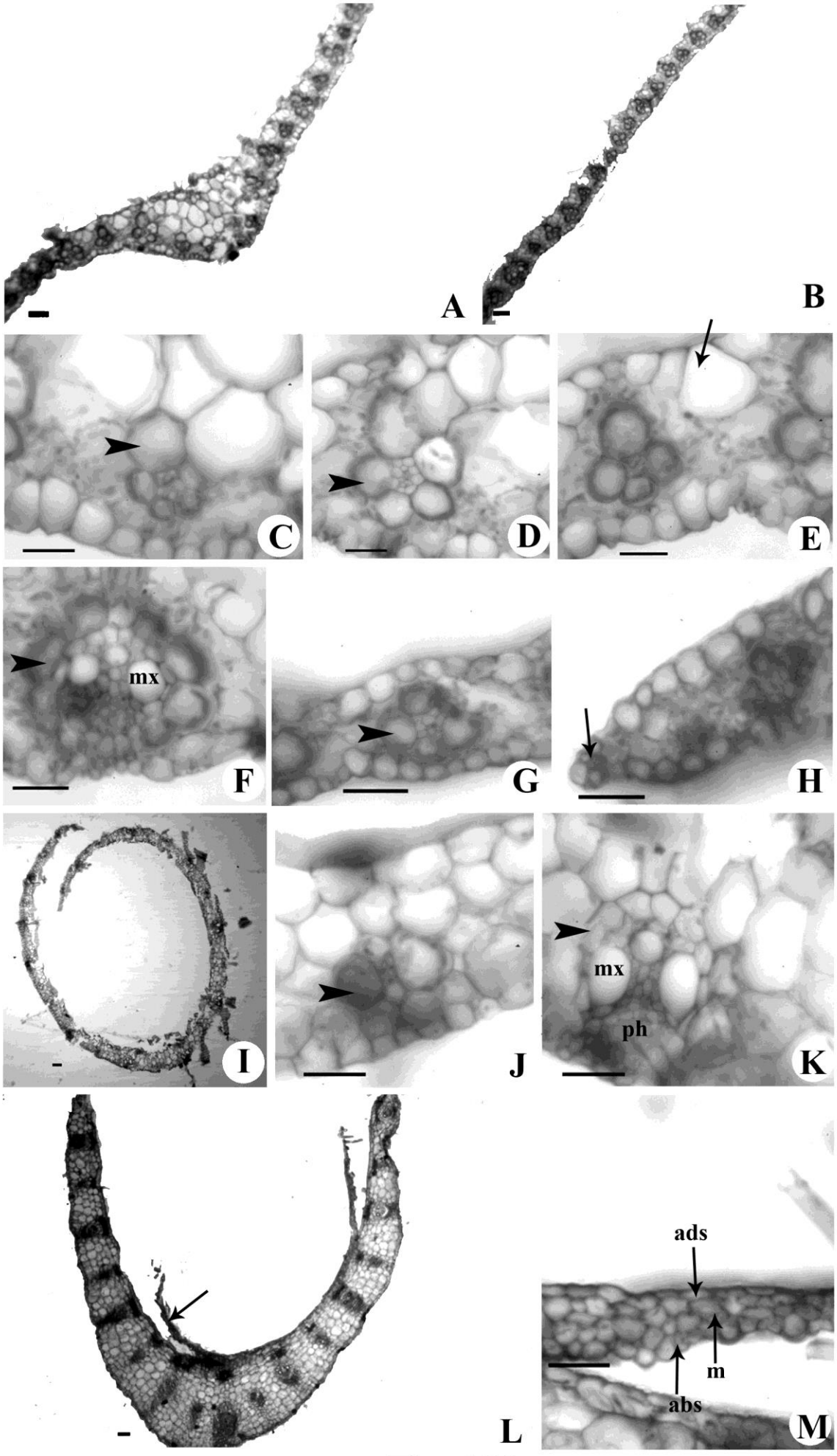

Fig. 182

Paspalidium

60. *Paspalidium flavidum* (Fig. 183)

61. *Paspalidium geminatum* (Fig. 184)

LEAF LAMINA: (Fig. 183 A-G, 184 A-F)

Outline of the lamina: 'V' shaped, wide angled in *P. flavidum* or standard angled in *P. geminatum* with outwardly curving, convex arms (Fig. 183 A, B, 184 A, B). Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are absent on the leaf surface.

Keel is well developed, V-shaped with single median vascular bundle. In *P. flavidum* small, round parenchyma cells present surrounding the median vascular bundle adaxially. In *P. geminatum* leaves are terete so parenchyma may be developed but is not specifically in association with the midrib. Sclerenchyma present on abaxial surface associated with vascular bundles in form of strands.

Epidermis: Adaxial epidermal surface mostly made up of bulliform cells (Fig. 183 C), epidermal cells shows papillae in which it is wide as epidermal cell (Fig. 183 D, arrow, 184 B, arrow). Stomata is present (Fig. 183 E, arrow). Abaxial epidermis has big, barrel to square shaped epidermal cells covered with thick cuticle. Long, slender macrohairs present.

Mesophyll: *P. flavidum* has radiate, single layered, isodiametric chlorenchyma cells completely surrounding bundles. Compactly arranged homogenous chlorenchyma cells occupy the major area between the adaxial and abaxial epidermides. *P. geminatum* has irregular, chlorenchyma arranged in 'U' shaped manner and cells occuping the major area between the adaxial and abaxial epidermides. Chlorenchyma cells continuous between bundles. Colourless cells absent.

Vascular bundles: 4-5 1st order vascular bundle in *P. flavidum* or 2-3 in *P. geminatum* regularly arranged from median bundle to marginal bundle vascular bundles in half lamina.

5-7 3rd order vascular bundle in *P. flavidum* or 4-5 in *P. geminatum* arranged between consecutive larger bundles and 2-3 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally in *P. flavidum* while abaxially placed in *P. geminatum.*

3rd order vascular bundles: (Fig. 183 C, D, E, 184 E)

Hexagonal (Fig. 183 C, D) and elliptical (Fig. 183 E) in *P. flavidum* or circular in *P. geminatum* (Fig. 184 E) with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: Elliptical shaped

1st order vascular bundles: (Fig. 183 G, 184 D)

Shape: Elliptical in *P. flavidum*, circular in *P. geminatum*

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Median vascular bundles: (Fig. 183 F)

Shape: Elliptical in *P. flavidum*, circular in *P. geminatum*

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. 183 C, D, E, 184 E)

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath:

Shape: Elliptical

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 9-10

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast positioned towards the outer tangential wall

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. 183 G, 184 D)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 15-16 in *P. flavidum*, 20-21 in *P. geminatum* parenchyma cells

Bundle sheath cell shape: All cells are elliptical, elongated in shape. Chloroplast positioned towards the outer tangential wall

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Absent

Abaxial sclerenchyma: Well developed strand, wider than deep

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very small with pointed fibrous cap. Epidermal cells at margin are thin with thick outer tangential wall.

LEAF SHEATH ANATOMY (Fig. 183 H-L, 184 G-J)

Outline of lamina: V shaped, narrow angled with inrolled margins in *P. flavidum* (Fig. 183 H) while round shaped, with inrolled margins in *P. geminatum* (Fig. 184 G). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular (Fig. 184 J)

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with vertically oval shaped air cavity in both species (Fig. 183 I, arrow, Fig. 184 G, arrow).

Vascular bundle:

Arrangement of vascular bundle: 3 (*P. flavidum*) or 3-4 (*P. geminatum*) consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: (Fig. 183 K)

Hexagonal in *P. flavidum*, circular in *P. geminatum* with vascular tissue consisting of only a few indistinguishable vascular element.

2nd order vascular bundle: Elliptical shaped

1st order vascular bundle: (Fig. 183 J, 184 H, I)

Obovate in *P. flavidum* or diamond shaped in *P. geminatum* with phloem completely surrounded by thick walled fibers. Lysigenous cavity and enlarged protoxylem vessel present. Circular wide metaxylem vessels present

Vascular bundle sheath: (Fig. 183 J, 184 H).

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Complete

Number of cells comprising the bundle sheath: 23-24 in *P. flavidum*, 34-35 in *P. geminatum* parenchyma cells

Bundle sheath cell shape: All cells are elliptical and elongated in shape; cells smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of straight horizontal band on abaxial surface.

LIGULE ANATOMY (Fig. 183M, N, 184 K, L)

Shape: Ligule attached to the lamina more than half length of it and blunt narrow "V" shaped at the connection point in *P. flavidum* (Fig. 183 M) while attached to the midrib and few parts of lamina region because its is hairy ligule in *P. geminatum* (Fig. 184 K).

Anatomy: Two layered in *P. flavidum* or three layered in *P. geminatum* mesophyll cells between adaxial and abaxial surfaces (Fig. 183 N, 184 L).

Differentiating features:

'V' shaped in outline of leaf sheath, radiate arrangement of mesophyll cells, two layered mesophyll present in ligule…….…….…….*P. flavidum*

Round shaped in outline of leaf sheath, irregularly arranged mesophyll cells, two layered mesophyll present in ligule……...……..…….. *P. geminatum*

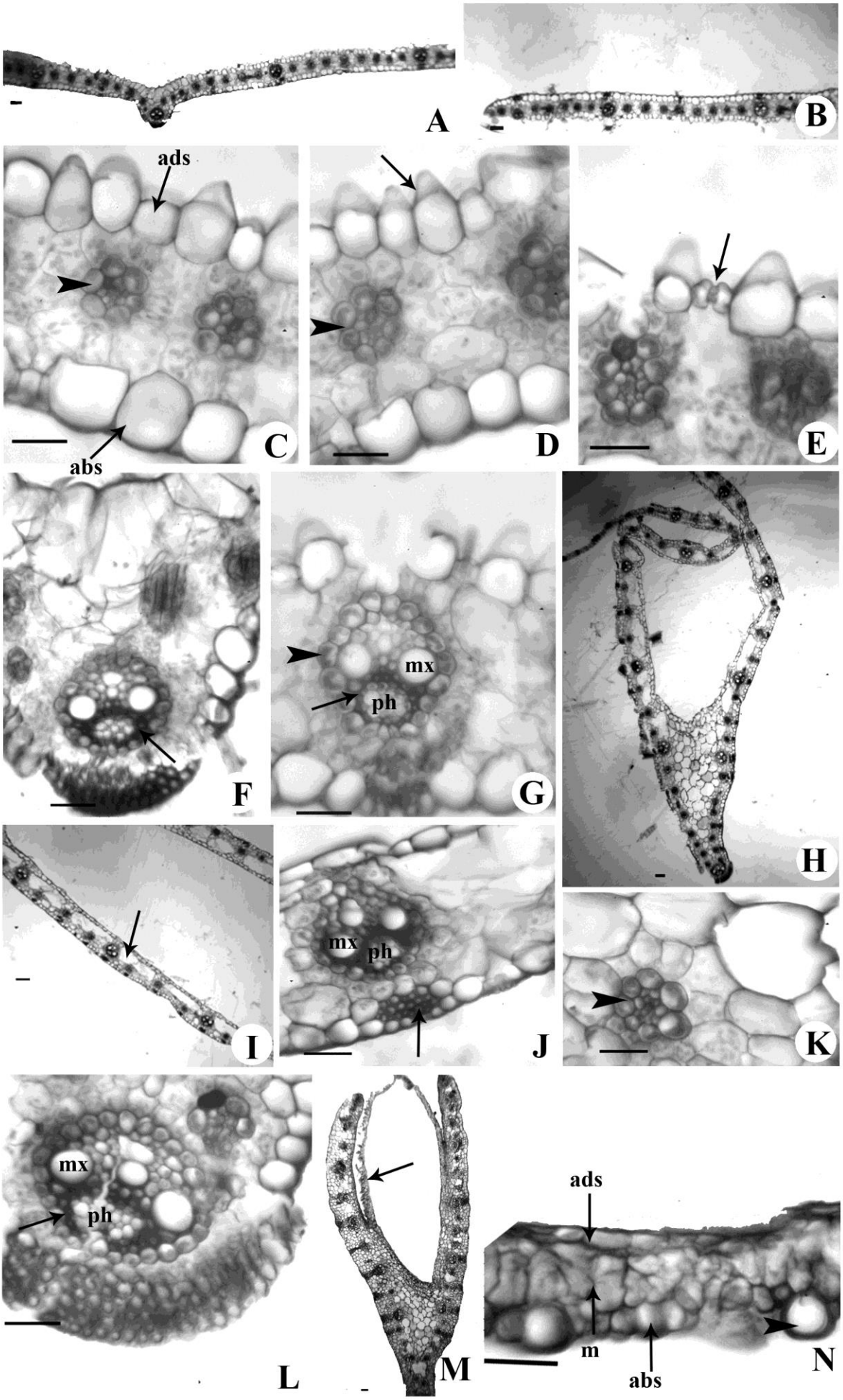

Fig. 183

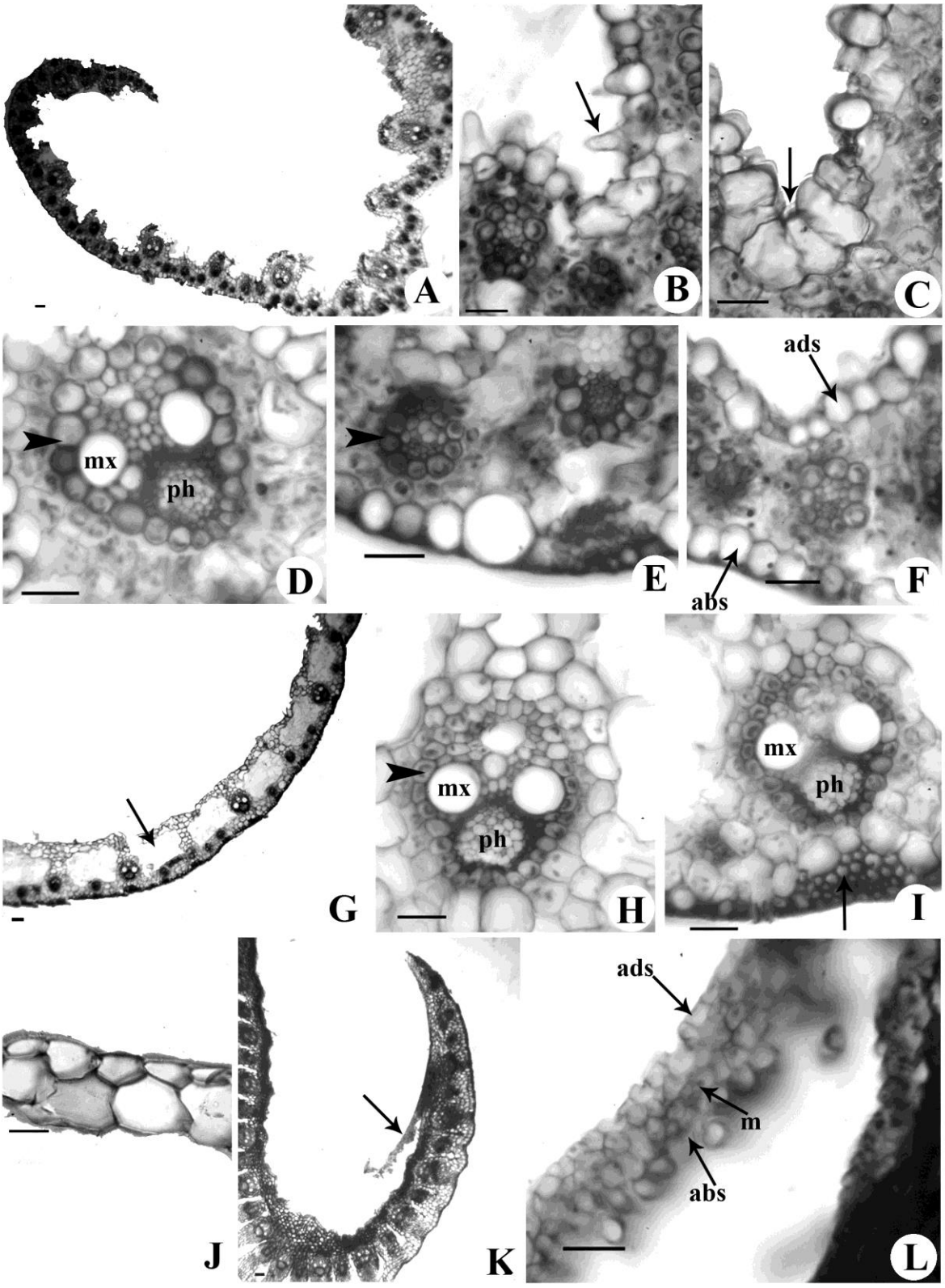

Fig. 184

62. *Paspalum scorbiculatum*

LEAF LAMINA: (Fig. 185 A-G)

Outline of the lamina: Expanded with flat, straight leaf blade (Fig. A).Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows present on the leaf surface. Shallow, wide furrows present between all vascular bundles. Keel is inconspicuous.

Epidermis: Adaxial epidermal surface has most part of epidermis made up of bulliform cells (Fig. C, arrow), epidermal cells shows long, pointed papillae (Fig. D, arrow). Abaxial epidermial cells large, barrel to square shaped covered with thick cuticle.

Mesophyll: Irregular, vertically arranged chlorenchyma cells occuping the major area between the adaxial and abaxial epidermides. Chlorenchyma cells continuous between bundles. Colourless cells absent.

Vascular bundles: 3-4 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundle. 4-5 3rd order bundles between consecutive larger bundles and 2-3 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally.

3rd order vascular bundles: Hexagonal (Fig. E) with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: Elliptical shaped (Fig. D)

1st order vascular bundles: (Fig. E)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Median vascular bundles:

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. E)

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath:

Shape: Elliptical

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 12-13

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast positioned towards the outer tangential wall

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. E, arrowhead)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 17-18 parenchyma cells

Bundle sheath cell shape: All cells are elliptical, elongated in shape. Chloroplast positioned towards the outer tangential wall

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Minute subepidermal strands present

Abaxial sclerenchyma: Well developed strand, wider than deep

Sclerenchyma between bundles: absent

Sclerenchyma in leaf margin: Forming well developed pointed fiberous cap (Fig. B). Epidermal cells at margin are thin with thick outer tangential wall.

LEAF SHEATH ANATOMY (Fig. 185 F-G)

Outline of lamina: Round with inrolled margins (Fig. F). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavity.

Vascular bundle:

Arrangement of vascular bundle: 2 consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Hexagonal (Fig. G) with vascular tissue consisting of only few indistinguishable vascular elements

2nd order vascular bundle: Elliptical shaped

1st order vascular bundle: Elliptical shaped with phloem completely surrounded by thick walled fibers. Lysigenous cavity and enlarged protoxylem vessel present. Circular wide metaxylem vessels present.

Vascular bundle sheath: (Fig. G, arrowhead)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Complete

Number of cells comprising the bundle sheath: 20-21 parenchyma cells

Bundle sheath cell shape: All cells are elliptical and elongated in shape; cells smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of straight horizontal abaxial band.

LIGULE ANATOMY (Fig. 185 H)

Shape: Ligule attached to the half width of the leaf sheath region and it is round shaped at the connection point (Fig. H, arrow)

Anatomy: Two layered mesophyll cells between adaxial and abaxial surfaces

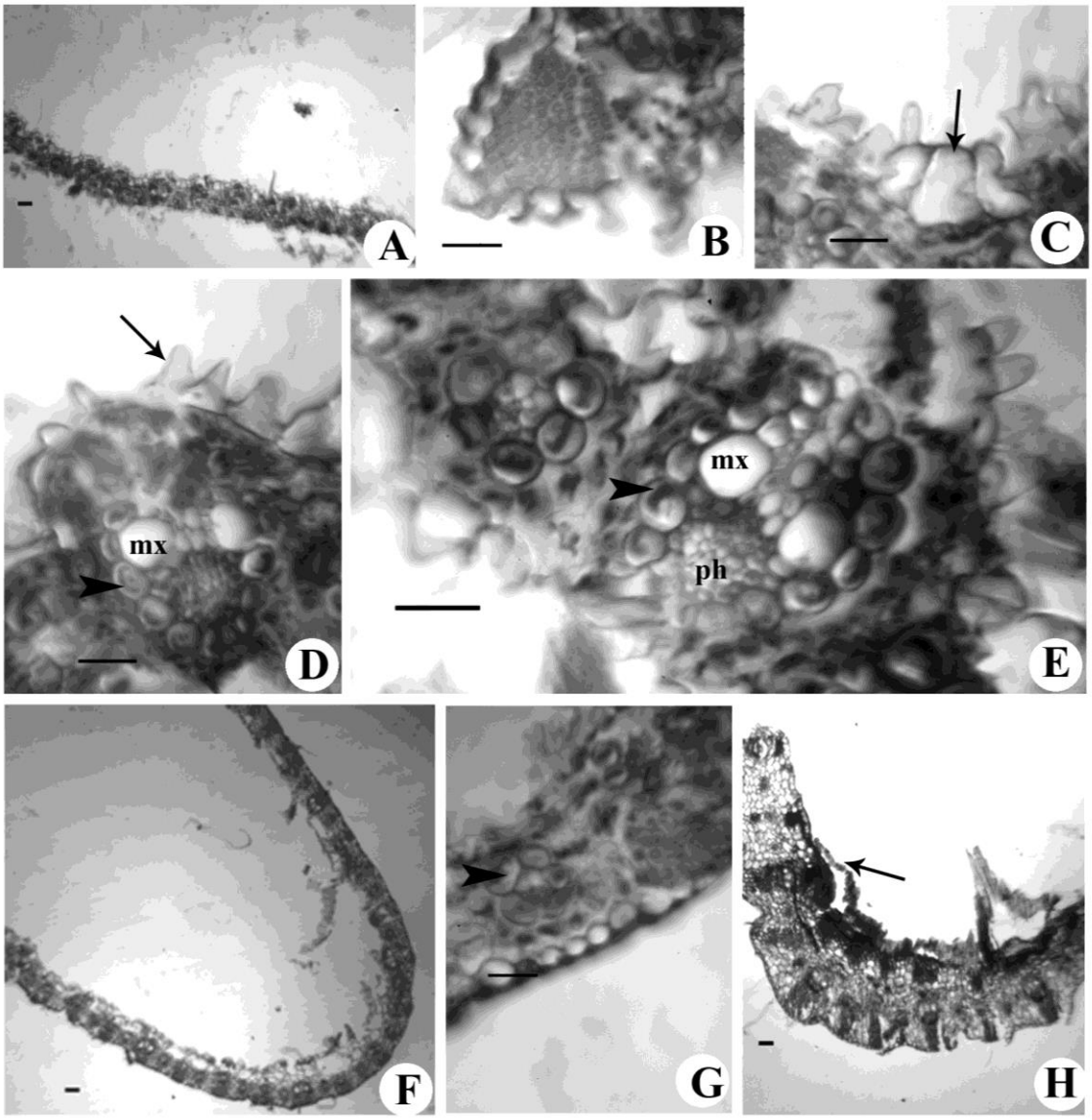

Fig. 185

63. *Pennisetum setosum*

LEAF LAMINA: (Fig. 186 A-F)

Outline of the lamina: 'U' shaped (Fig. A). Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are present on abaxial surface of leaf.Shallow, wide furrows present between 1st and 2nd order vascular bundles and triangular ribs present.

Keel is well developed, U-shaped with 3 median vascular bundle, 5-6 3rd order vascular bundles. Parenchyma cells associated with vascular bundles. Sclerenchyma abaxially associated with vascular bundles in form of strands.

Epidermis: Adaxial epidermal surface has fan shaped bulliform cells (Fig. E, arrow), present at the base of furrows. Hook with sharp burb (Fig. F, arrow). Abaxial epidermis has big, barrel to square shaped epidermal cells covered with thick cuticle.

Mesophyll: Incompletely radiate chlorenchyma present. Colourless cells absent.

Vascular bundles: 3-4 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundle. 3-4 3rd order bundles between consecutive larger bundles and 1-2 2nd order bundles between consecutive 1st order bundles present. All are placed abaxially.

3rd order vascular bundles: Hexagonal shaped (Fig. D) with xylem and phloem distinguishable.

2nd order vascular bundles: Circular shaped

1st order vascular bundles: (Fig. C)

Shape: Obovate

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Median vascular bundles: (Fig. D)

Shape: Obovate

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig.D, arrowhead)

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath:

Shape: Elliptical

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 7-8

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast positioned towards the outer tangential wall

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. C, arrowhead)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 26-28 parenchyma cells

Bundle sheath cell shape: All cells are elliptical and elongated in shape. Chloroplast positioned towards the outer tangential wall

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Well developed triangular shaped strand followed ribs

Abaxial sclerenchyma: Well developed strand, wider than deep

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming pointed very small fiberous cap (Fig. B). Epidermal cells at margin are thin with thick outer tangential wall.

LEAF SHEATH ANATOMY (Fig. 186 G-J)

Outline of lamina: Round shaped with inrolled margins (Fig. G). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular (Fig. J)

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with vertically oval shaped air cavity (Fig. H, J arrow).

Vascular bundle:

Arrangement of vascular bundle: 1 consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Circular shaped, xylem and phloem disitnguishable

2nd order vascular bundle: Circualr shaped

1st order vascular bundle: Circualr shaped with phloem completely surrounded by thick walled fibers. Lysigenous cavity and enlarged protoxylem vessel present. Circular wide metaxylem vessels present (Fig. I).

Vascular bundle sheath: (Fig. I).

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Complete

Number of cells comprising the bundle sheath: 20-21 parenchyma cells

Bundle sheath cell shape: All cells are elliptical and elongated in shape; cells smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of straight horizontal band on abaxial surface.

LIGULE ANATOMY (Fig. 186 K)

Shape: Ligule is attached to the midrib and few parts of lamina region because its is hairy ligule (Fig. K, arrow)

Anatomy: Three layered mesophyll cells between adaxial and abaxial surfaces (Fig. L).

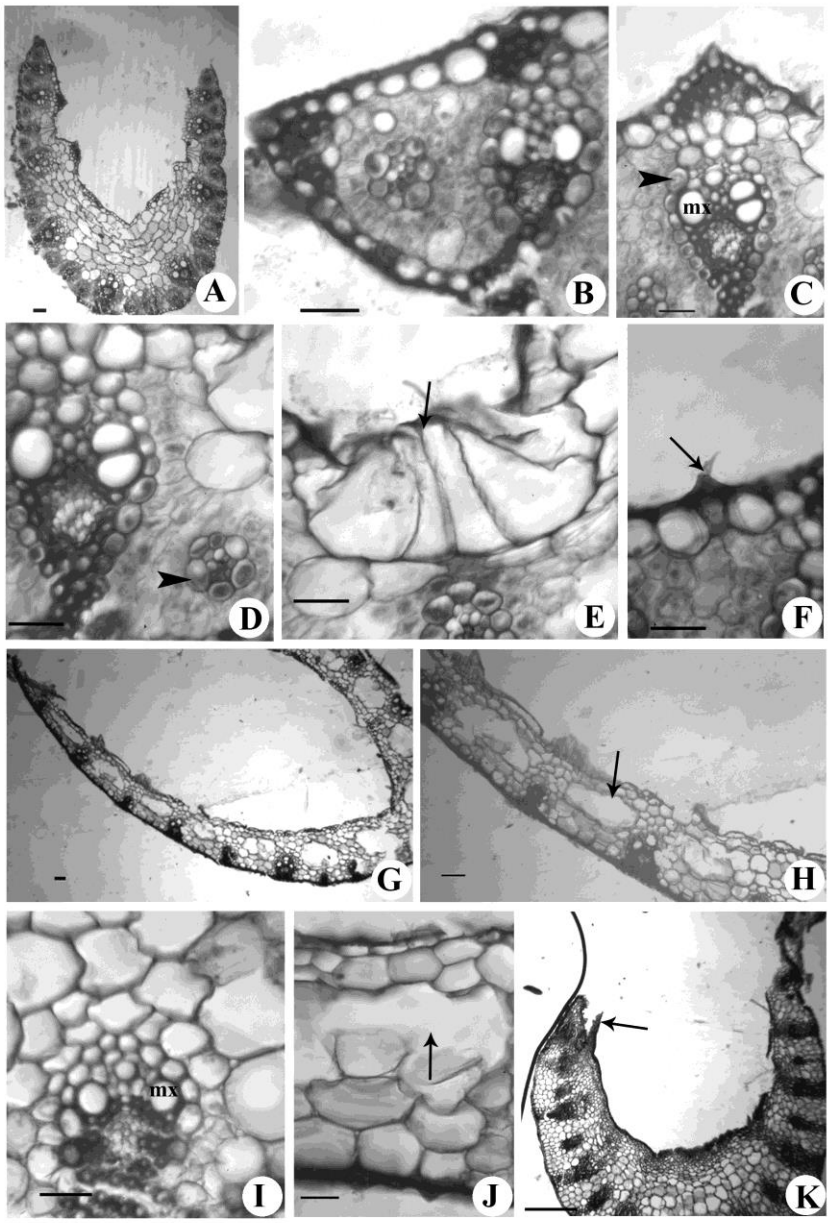

Fig. 186

Setaria

64. *Setaria glauca* (Fig. 187)

65. *Setaria tomentosa* (Fig. 188)

66. *Setaria verticillata* (Fig. 189)

LEAF LAMINA: (Fig. 187 A-D, 188 A-F, 189 A-H)

Outline of the lamina: Expanded with flat, stiraght leaf blade in *S. glauca* and *S. tomentosa* (Fig. 187 A, 188 A) while distinctly wavy leaf blade in *S. verticillata* (Fig. 189 A, B).Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are absent on the leaf surface.

Keel is well developed, V-shaped with single median vascular bundle in *S. glauca*, single median vascular bundle, 5-6 3rd order vascular bundles in *S. tomentosa* and *S. verticillata*. Parenchyma cells associated with vascular bundles. Sclerenchyma abaxially associated with vascular bundles in form of strands.

Epidermis: Adaxial epidermal surface has most part of epidermis made up of bulliform cells in *S. glauca* and *S. verticillata* (Fig. 187 A, 189 A) while restricted gruoup of large, inflated bulliform cells in *S. tomentosa* (Fig. 188 B). Epidermal cells have long, pointed papillae in *S. glauca* (Fig. 187 D, arrow). Long slender hairs with bulbous base sunken in bulliform cells in *S. tomentosa* (Fig. 188 C). Prickles in *S. verticillata* (Fig. 189 F, arrow).

Abaxial epidermis has big, barrel to square shaped epidermal cells covered with thick cuticle. Restricted group of large, inflated bulliform cells in *S. tomentosa* and *S. verticillata* (Fig. 188 B, arrow, 189 G, arrow).

Mesophyll: Irregular, vertically arranged chlorenchyma cells occuping the major area between the adaxial and abaxial epidermides in *S. glauca* and *S. verticillata*, incompletely radiate chlorenchyma in *S. tomentosa*. Chlorenchyma cells continuous between bundles. Colourless cells absent.

Vascular bundles: 3-4 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundle. 10-11 3rd order in *S. glauca*, 12-13 3rd order in *S. tomentosa*, 11-12 3rd order in *S. verticillata* bundles and 3-4 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally.

3rd order vascular bundles: (Fig. 187 B, 188 B, 189 C)

Hexagonal with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: Circular in *S. glauca* and *S. tomentosa*, elliptical in *S. verticillata*

1st order vascular bundles: (Fig. 187 C, 188 E, 189 D)

Shape: Circular in all species except in *S. verticillata* elliptical

Relationship of phloem cells and the vascular fibres: Phloem adjoins inner or parenchyma sheath cell

Nature of lysigenous cavity and protoxylem: Lysigenous cavity absent and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Median vascular bundles: (Fig. 188 D, 189 E)

Shape: Circular in all species except in *S. verticillata* elliptical

Relationship of phloem cells and the vascular fibres: Phloem adjoins inner or parenchyma sheath cell

Nature of lysigenous cavity and protoxylem: Lysigenous cavity absent and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. 187 B, 188 F arrowhead, 189 C, H arrowhead)

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath:

Shape: Elliptical

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 8-9 in *S. glauca* and *S. tomentosa*, 13-14 in *S. verticillata*

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast positioned towards the outer tangential wall

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. 187 C arrowhead, 188 E arrowhead, 189 K, L arrowhead)

Shape: Circular in all species except in *S. verticillata* elliptical

Extent of bundle sheath around the vascular bundle: Complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 14-15 in *S. glauca*, 19-20 in *S. tomentosa, S. verticillata* parenchyma cells

Bundle sheath cell shape: All cells are elliptical and elongated in shape. Chloroplast positioned towards the outer tangential wall

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Absent in *S. glauca* and *S. tomentosa*, Minute subepidermal, 4-6 fibers strands present in *S. verticillata*

Abaxial sclerenchyma: Minute subepidermal strands present

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming well developed with pointed fibrous cap in all species (Fig. 187 B). Epidermal cells at margin are thin with thick outer tangential wall.

LEAF SHEATH ANATOMY (Fig. 187 E-I, 188 G, K, 189 I-L)

Outline of lamina: Round shaped inrolled margins in *S. glauca* (Fig. 187 E), V shaped with narrow angle in *S. tomentosa* or standard angle in *S. verticillata* with inrolled margins (Fig. 188 E, 189 I). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle. Interrupted by stomata (Fig. 187 F, arrow, 189 J, arrow). Restricted gruoup of tall, narrow, inflated bulliform cells in *S. tomentosa* (Fig. 188 I, arrow).

Ground tissue: Parenchymatous with oval shaped air cavity in *S. glauca* (Fig. 187 E) or absence of air cavity in *S. tomentosa* and *S. verticillata*.

Vascular bundle:

Arrangement of vascular bundle: 4-5 consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: (Fig. 187 F, I, 188 H, 189 K)

Hexagonal in all species except circular in *S. tomentosa* with vascular tissue consisting of only few indistinguishable vascular elements

2nd order vascular bundle: Elliptical shaped (Fig. 187 H)

1st order vascular bundle: (Fig. 187 G, arrowhead, 188 J, K, 189 L)

Elliptical with phloem completely surrounded by thick walled fibers. Lysigenous cavity and enlarged protoxylem vessel present. Circular wide metaxylem vessels present

Vascular bundle sheath: (Fig. 187 G, arrowhead, 188 J, K arrowhead, 189 L arrowhead)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Incomplete, abaxially interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 17-18 in *S. glauca* and *S. verticillata*, 20-22 in *S. tomentosa* parenchyma cells

Bundle sheath cell shape: All cells are elliptical and elongated in shape and cells smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of straight horizontal band girder in *S. glauca* and *S. verticillata* or well developed in *S. tomentosa* on abaxial surface (Fig. 187 H arrow, 188 K).

LIGULE ANATOMY (Fig. 187 J, K, 188 L, M, 189 M, N)

Shape: Ligule attached to the half width of the leaf sheath region and it is round shaped at the connection point in all species (Fig. 187 J, 188 L, 189 M)

Anatomy: Two layered in *S. tomentosa* and *S. verticillata*, three layered in *S. glauca* mesophyll cells between adaxial and abaxial surfaces (Fig. 187 K, 188 M, 189 N). Few cells of abaxial surface showed sclerenchyma cells in *S. glauca* and *S. tomentosa* (Fig. 187 K, arrowhead, 188 M).

Differentiating features:

Oval shaped air cavities in leaf sheath……..……..……. *S. glauca*

Air cavities absent

Elliptical shaped 1st order vascular bundles……...……..…….. *S. verticillata*

Circular shaped 1st order vascular bundles……..……*S. tomentosa*

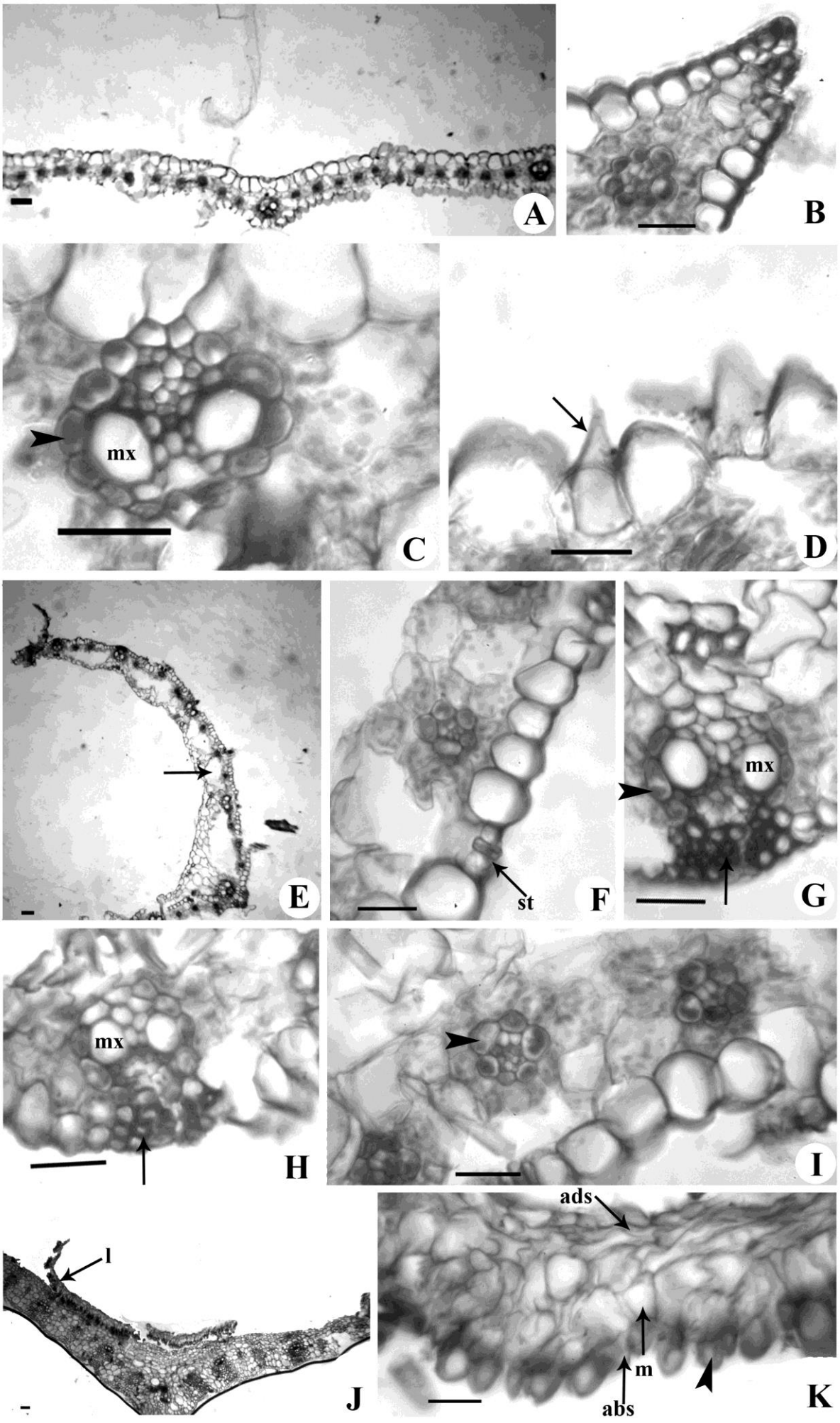

Fig. 187

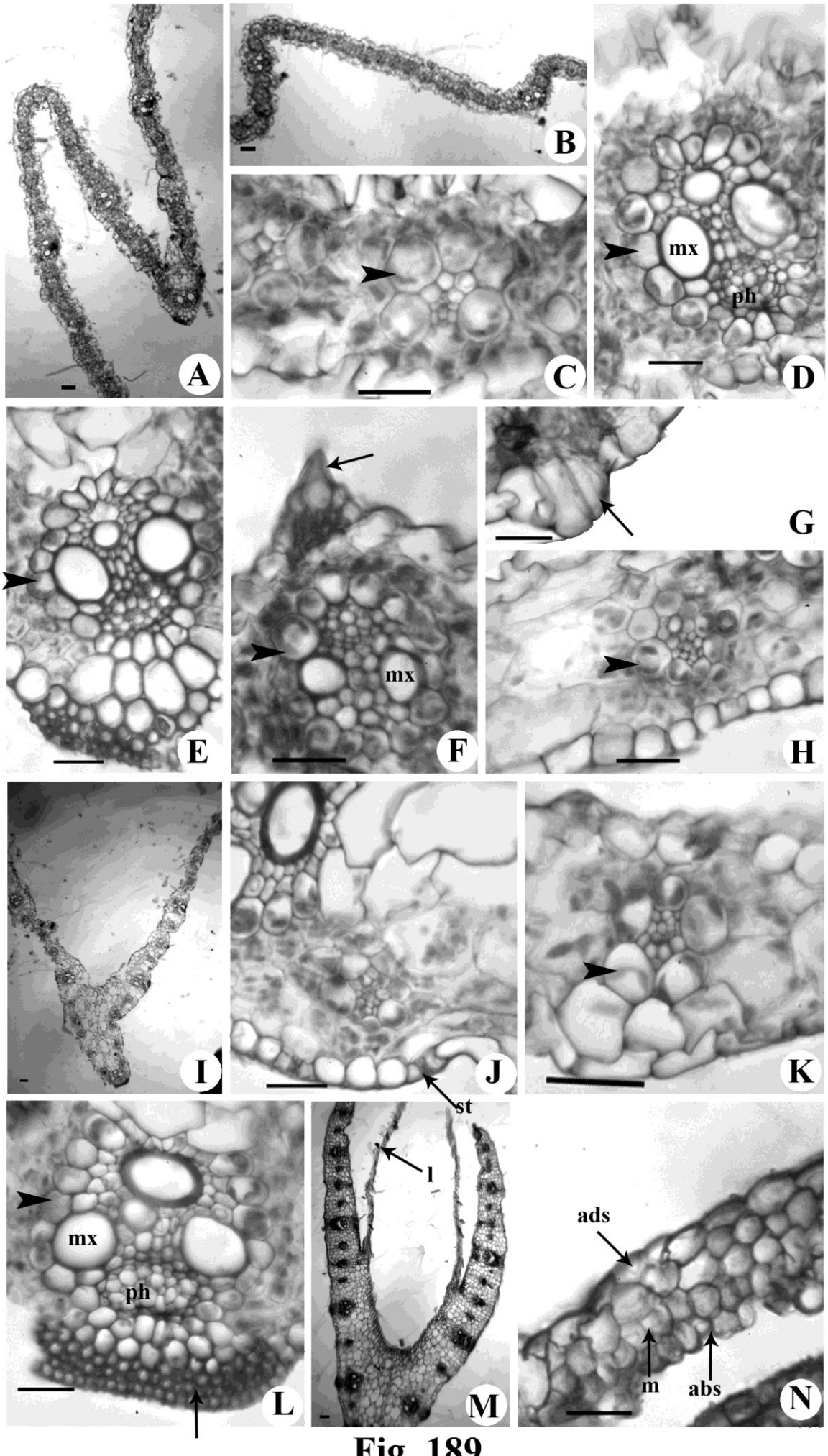

Fig. 189

67. *Isachne globosa*

LEAF LAMINA: (Fig. 190 A-D)

Outline of the lamina: Expanded with distinctly wavy leaf blade (Fig. A).Two halves symmetrical on either side of the median vascular bundle. Ribs and furrows are present on the leaf surface. Deep, wide furrows present between all vascular bundles and triangular ribs with pointed apex present over all vascular bundles. Keel is inconspicuous.

Epidermis: Adaxial epidermal surface has no bulliform cells (Fig. A), epidermal cells are small, barrel shaped covered with cuticle. Abaxial epidermis has small, barrel to square shaped epidermal cells covered with thick cuticle.

Mesophyll: Incompletely radiating chlorenchyma cells present. Colourless cells absent.

Vascular bundles: 2-3 1st order vascular bundles regularly arranged from median bundle to marginal bundle in half lamina. 4-5 3rd order bundles between consecutive larger bundles and 1-2 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally.

3rd order vascular bundles: Circular shaped (Fig. B) with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: Elliptical shaped (Fig. C)

1st order vascular bundles: (Fig. D)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Phloem adjoins inner or parenchyma sheath cell

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. B, arrrowhead)

Shape: Round

Shape of bundle sheath cell: Cells are large with outer tangential wall thick

2nd order vascular bundle's bundle sheath: (Fig. C, arrow)

Shape: Elliptical

Shape of bundle sheath cell: Cells are large with outer tangential wall thick

Number of bundle sheath cell: 8-9

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Translucent

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. D)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 13-14 parenchyma cells

Bundle sheath cell shape: Cells are large with outer tangential wall thick. Chloroplast translucent

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Minute subepidermal, 4-6 fibers strands present

Abaxial sclerenchyma: Minute subepidermal strands present

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming well developed with very pointed fibrous cap. Epidermal cells at margin are thin with thick outer tangential wall.

LEAF SHEATH ANATOMY (Fig. 190 E, F)

Outline of lamina: V shaped, standard angle with inrolled margins (Fig. E). Ribs and furrows present. Shallow, wide furrows present between all vascular bundles.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with oval shaped air cavity (Fig. E, arrow).

Vascular bundle:

Arrangement of vascular bundle: 1 consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Circular shaped with vascular tissue consisting of only few indistinguishable vascular elements

2nd order vascular bundle: Elliptical shaped

1st order vascular bundle: Elliptical shaped with phloem completely surrounded by thick walled fibers. Lysigenous cavity and enlarged protoxylem vessel present. Circular wide metaxylem vessels present (Fig. F)

Vascular bundle sheath: (Fig. F, arrow)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Incomplete, abaxially interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 15-16 parenchyma cells

Bundle sheath cell shape: Cells are large with outer tangential wall thick; cells smaller than the ground tissue.

Mestome/ Inner sheath: Absent

Sclerenchyma: In form of straight horizontal abaxial band.

LIGULE ANATOMY (Fig. 190 G, H)

Shape: Ligule attached to the half width of the leaf sheath region and it is round shaped at the connection point (Fig. G, arrow)

Anatomy: Three layered mesophyll cells between adaxial and abaxial surfaces (Fig. H)

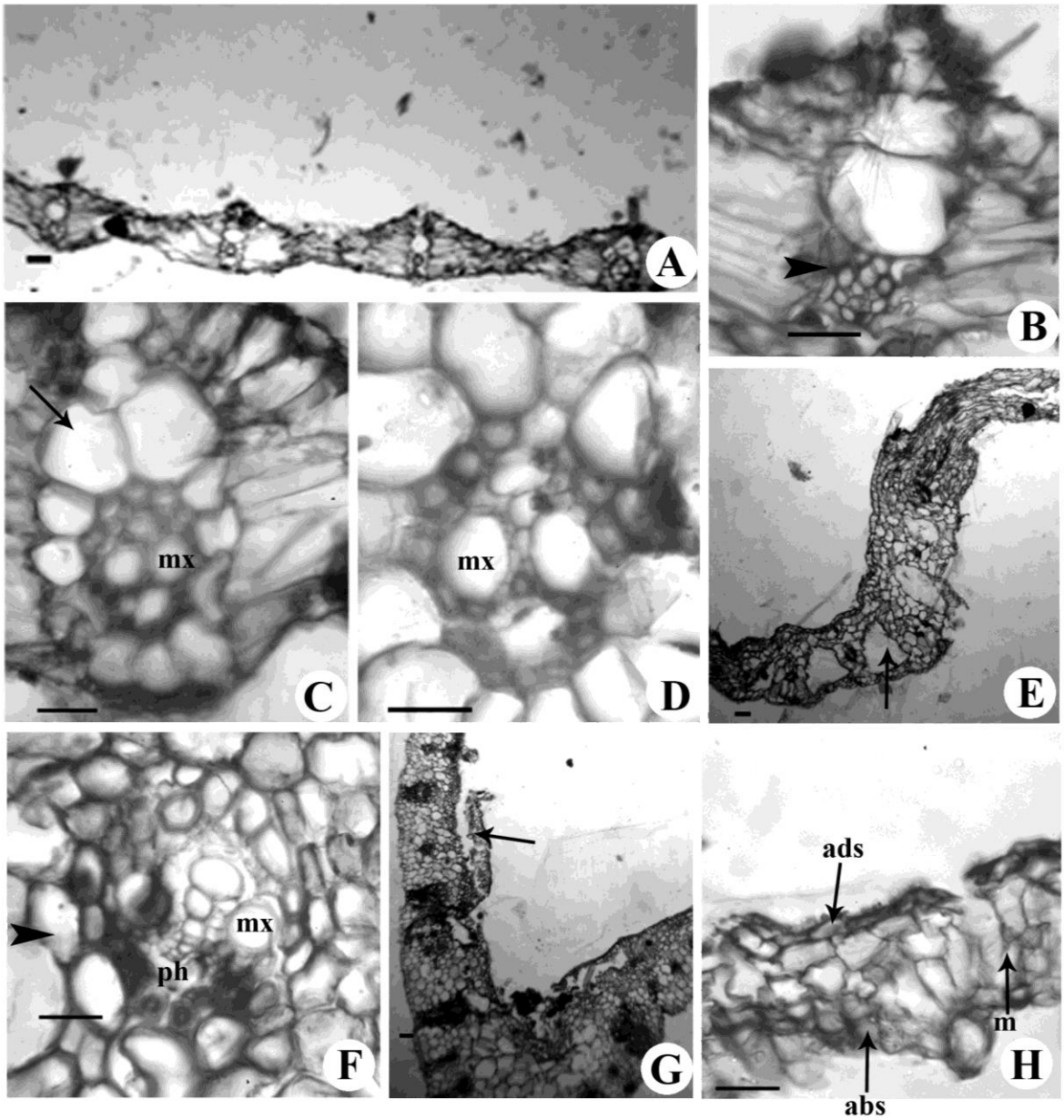

Fig. 190

Aristida

68. *Aristida adscensionis* (Fig. 191)

69. *Aristida funiculata* (Fig. 192)

LEAF LAMINA: (Fig. 191 A-D, 192 A-D)

Outline of the lamina: 'V' shaped, standard angle with concave arms forming heart shape in both species (Fig. 191 A, 192 A).Two halves are symmetrical on either side of the median vascular bundle.

Ribs and furrows are present surface of leaf. Shallow, wide furrows with rounded ribs present over all vascular bundle.

Keel is well developed, V-shaped with single median vascular bundle. Small, parenchyma associated with median vasucalr bundle. Sclerenchyma present on abaxial surface associated with vascular bundles in form of strands.

Epidermis: Adaxial epidermal surface has no bulliform cells in *A. adscensionis* or fan shaped bulliform cells in *A. funiculata* (Fig. 192 C, arrow). Small, barrel shaped epidermal cells covered with thick cuticle. Abaxial epidermal cells are barrel to square shaped covered with thick cuticle.

Mesophyll: Irregular, horizontally arranged chlorenchyma cells occuping the major area between the adaxial and abaxial epidermides. Chlorenchyma cells continuous between bundles. Colourless cells absent.

Vascular bundles: 1-2 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundle. 2-3 3rd order bundles between consecutive larger bundles and 1-2 2nd order bundles between consecutive 1st order bundles present. Vascular bundles arranged at different level. 1st and 2nd order vascular bundles placed centrally while 3rd order vascular bundles placed abaxially.

3rd order vascular bundles: (Fig. 191 D, 192 C)

Circular with xylem and phloem disitnguishable

2nd order vascular bundles: Circular shaped

1st order vascular bundles: (Fig. 191 B, 192 D)

Shape: Circular

Relationship of phloem cells and the vascular fibres: Phloem adjoins inner or parenchyma sheath

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Median vascular bundles: (Fig. 191 C)

Shape: Circular

Relationship of phloem cells and the vascular fibres: Phloem adjoins inner or parenchyma sheath

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. 191 D arrowhead, 192 C arrowhead)

Shape: Round

Shape of bundle sheath cell: Cells elliptical and elongated

2nd order vascular bundle's bundle sheath:

Shape: Elliptical

Shape of bundle sheath cell: Cells elliptical and elongated

Number of bundle sheath cell: 11-12 in *A. adscensionis*, 7-8 in *A. funiculata*

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Translucent

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. B)

Shape: Circular

Extent of bundle sheath around the vascular bundle: Incomplete, abaxially interrupted by sclerenchyma cells

Extension of bundle sheath: Broad abaxial extension present

Number of cells comprising the bundle sheath: 11-12 in *A. adscensionis*, 9-10 in *A. funiculata* parenchyma cells.

Bundle sheath cell shape: All cells are elliptical and elongated in shape. Chloroplast translucent

Mestome/ Inner sheath: Complete, cells smaller than outer sheath cell

Sclerenchyma:

Adaxial sclerenchyma: Absent

Abaxial sclerenchyma: Well developed strand (Fig. 191 C, D arrow, 192 D, arrow)

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very small with very pointed fibrous cap. Epidermal cells at margin are with thick outer tangential wall.

LEAF SHEATH ANATOMY (Fig. 191E-G, 192 E-G)

Outline of lamina: Round shaped with inrolled margins (Fig. 191 E, 192 E). Ribs and furrows absent in *A. adscensionis* while present in *A. funiculata* in which shallow, wide furrows present over 1st and 2nd order vascular bundles.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with round shaped air cavity present in *A. adscensionis* (Fig. 191 F, arrow) while absence of air cavity in *A. funiculata*.

Vascular bundle:

Arrangement of vascular bundle: 3-4 consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Circular with xylem and phloem disitnguishable

2nd order vascular bundle: Elliptical shaped

1st order vascular bundle: (Fig. 191 G, 192 H)

Circualr with phloem completely surrounded by thick walled fibers. Lysigenous cavity and enlarged protoxylem vessel present. Circular wide metaxylemvessels present.

Vascular bundle sheath: (Fig. 191 G, 192 H).

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Incomplete, abaxially interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 14-15 in *A. adscensionis*, 10-11 in *A. funiculata* parenchyma cells

Bundle sheath cell shape: All cells are elliptical and elongated in shape and cells smaller than the ground tissue.

Mestome/ Inner sheath: Complete, cells smaller than outer sheath cell

Sclerenchyma: In form of straight horizontal girder on abaxial surface (Fig. 191 G, arrow).

LIGULE ANATOMY (Fig. 191H, I, 192 H, I)

Shape: Ligule is attached to the midrib and few parts of lamina region because its is hairy ligule in both species (Fig. 191 H, 192 H)

Anatomy: Single layered mesophyll cells between adaxial and abaxial surfaces in both species (Fig. 191 I, 192 I).

Differentiating features:

Round shaped air cavities present in leaf sheath, ribs and furrows absent in leaf sheath ……..……*A. adscensionis*

Air cavities absent, shallow furrows present in leaf sheath…….*A. funiculata*

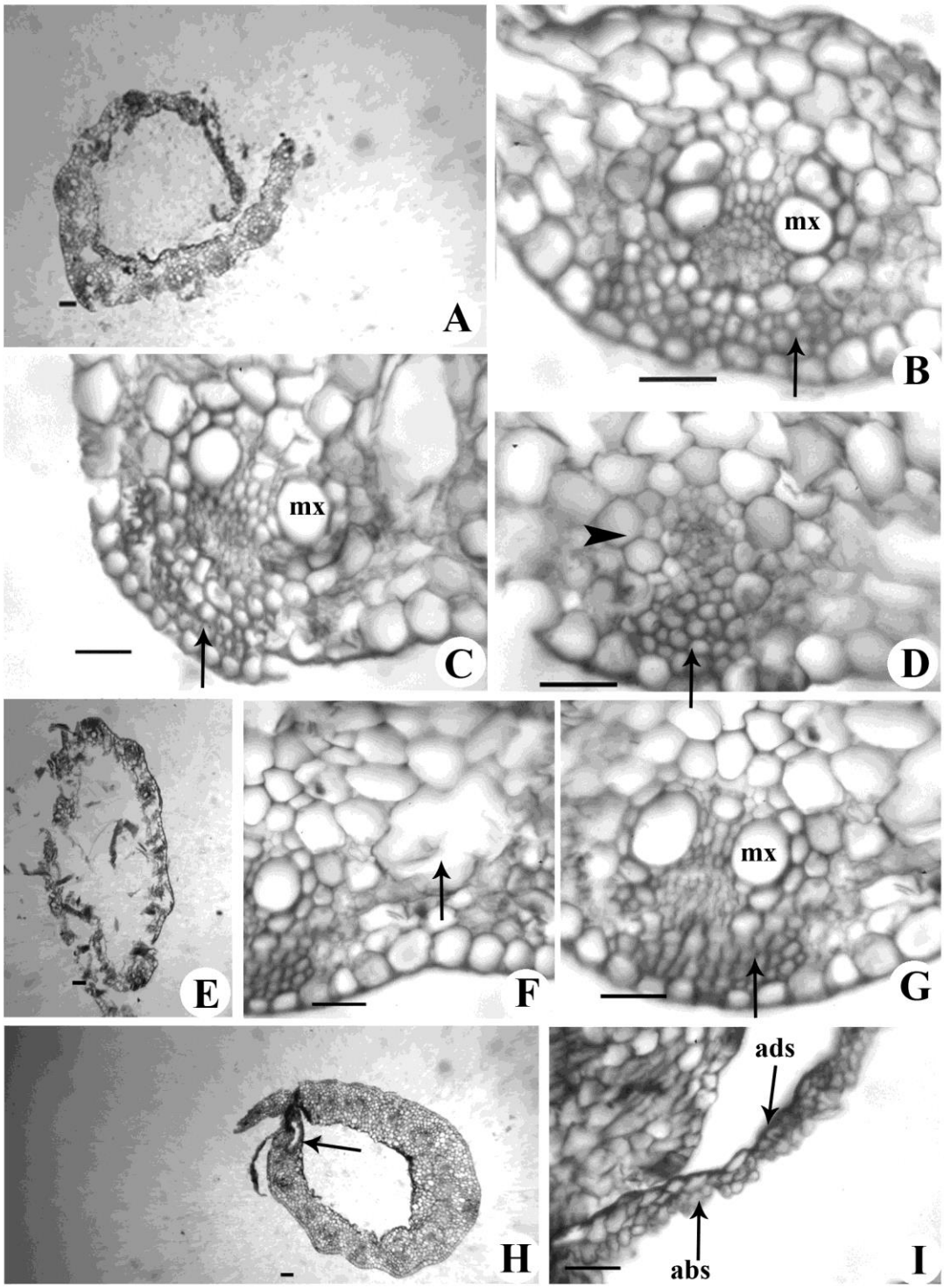

Fig. 191

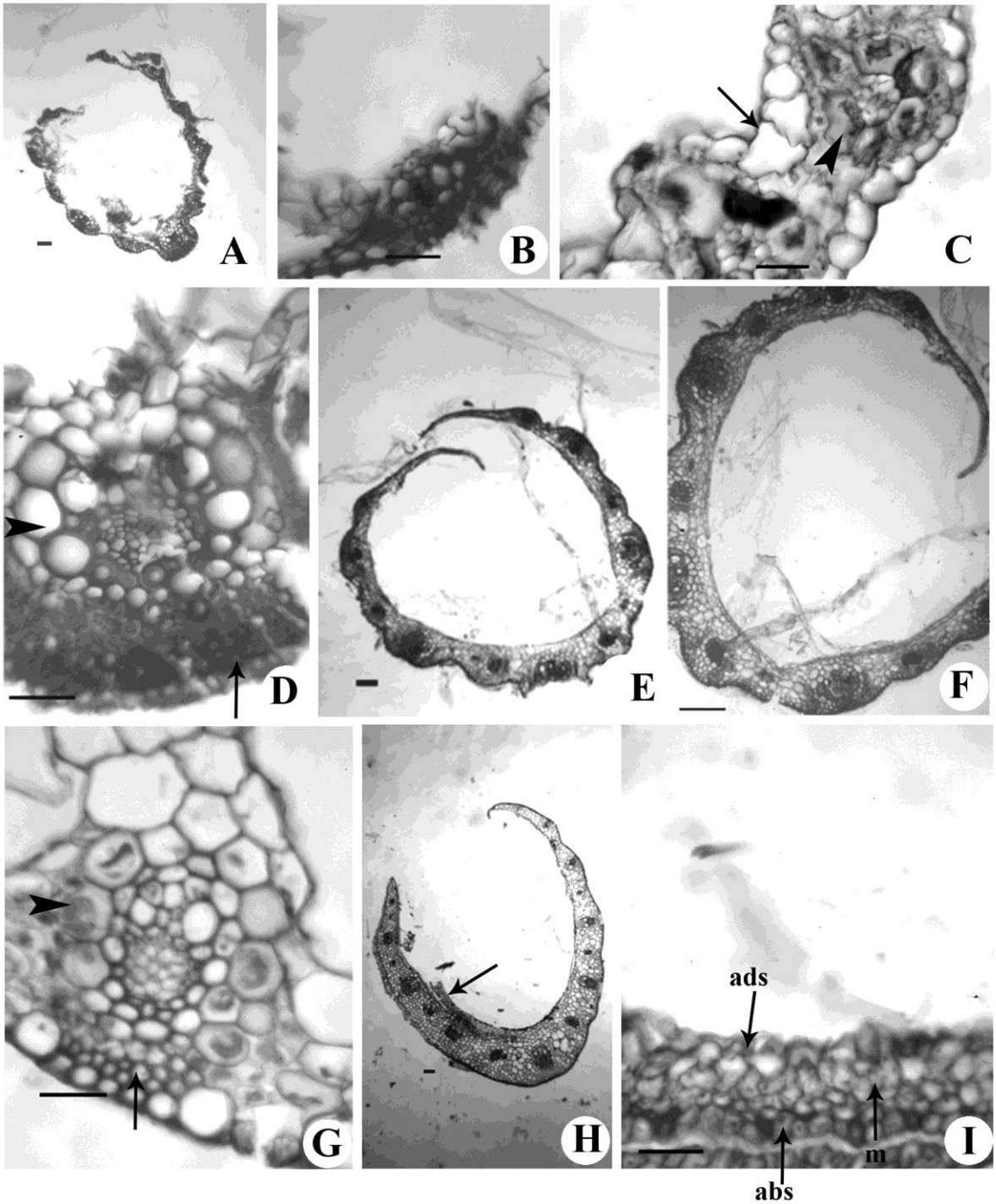

Fig. 192

70. *Perotis indica*

LEAF LAMINA: (Fig. 193 A-E)

Outline of the lamina: Expanded with flat leaf blade (Fig. A). Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are present on the leaf surface. Very shallow furrows present on abaxial surface. Keel is inconspicuous.

Epidermis: Adaxial epidermal surface has fan shaped bulliform cells (Fig. E, arrow), epidermal cells are small, barrel shaped covered with cuticle. Abaxial epidermal cells are small, barrel to square shaped covered with thick cuticle.

Mesophyll: Incompletely radiate chlorenchyma cells present. Colourless cells absent.

Vascular bundles: 4-5 1st order vascular bundles regularly arranged from median bundle to marginal bundle in half lamina. 6-7 3rd order bundles between consecutive larger bundles and 1-2 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally.

3rd order vascular bundles: Pentagonal (Fig. C) with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: Elliptical shaped

1st order vascular bundles: (Fig. D)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Phloem adjoins inner or parenchyma sheath cell

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Shape of metaxylem vessels: Angular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. D, arrowhead)

Shape: Horse shoe shaped

Shape of bundle sheath cell: Fan shaped

2nd order vascular bundle's bundle sheath:

Shape: Horse shoe shaped

Shape of bundle sheath cell: Fan shaped

Number of bundle sheath cell: 6-7

Nature of bundle sheath (either complete or incomplete): Incomplete, abaxially interrupted by sclerenchyma cells.

Chloroplast position in bundle sheath cell: Chloroplast fills entire lumen of cell

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath:

Shape: Horse shoe shaped

Extent of bundle sheath around the vascular bundle: Incomplete, abaxially interrupted by sclerenchyma cells.

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 6-7 parenchyma cells

Bundle sheath cell shape: Fan shaped

Mestome/ Inner sheath: Complete, cells are smaller than the outer sheath cell

Sclerenchyma:

Adaxial sclerenchyma: Absent

Abaxial sclerenchyma: Well developed wide girder present (Fig. C, D, B)

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very pointed cap. Epidermal cells at margin are thin with thick outer tangential wall.

LEAF SHEATH ANATOMY (Fig. 193 F-H)

Outline of lamina: Round shaped with inrolled margins (Fig. F). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with round shaped air cavity (Fig. F, arrow).

Vascular bundle:

Arrangement of vascular bundle: 2 consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Pentagonal and vascular tissue consisting of only a few distinguishable vascular elements (Fig. H, arrowhead)

2nd order vascular bundle: Elliptical shaped

1st order vascular bundle: Elliptical shaped with phloem completely surrounded by thick walled fibers. Lysigenous cavity and enlarged protoxylem vessel present. Circular narrow metaxylem vessels present (Fig. G)

Vascular bundle sheath: (Fig. G)

Shape: Horse shoe shaped

Extent of bundle sheath around the vascular bundle: Incomplete, abaxially interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 7-8 parenchyma cells

Bundle sheath cell shape: Fan shaped cells smaller than the ground tissue.

Mestome/ Inner sheath: Complete, cells are smaller than the outer sheath cell

Sclerenchyma: In form of straight horizontal band on abaxial surface (Fig. G, arrow).

LIGULE ANATOMY (Fig. 193 H, I)

Shape: Ligule attached to the lamin upto 1/3 length of it and than free, blunt, narrow, 'V' shaped at the point of connection (Fig. H, arrow)

Anatomy: Singel layered mesophyll cells between adaxial and abaxial surfaces (Fig. I)

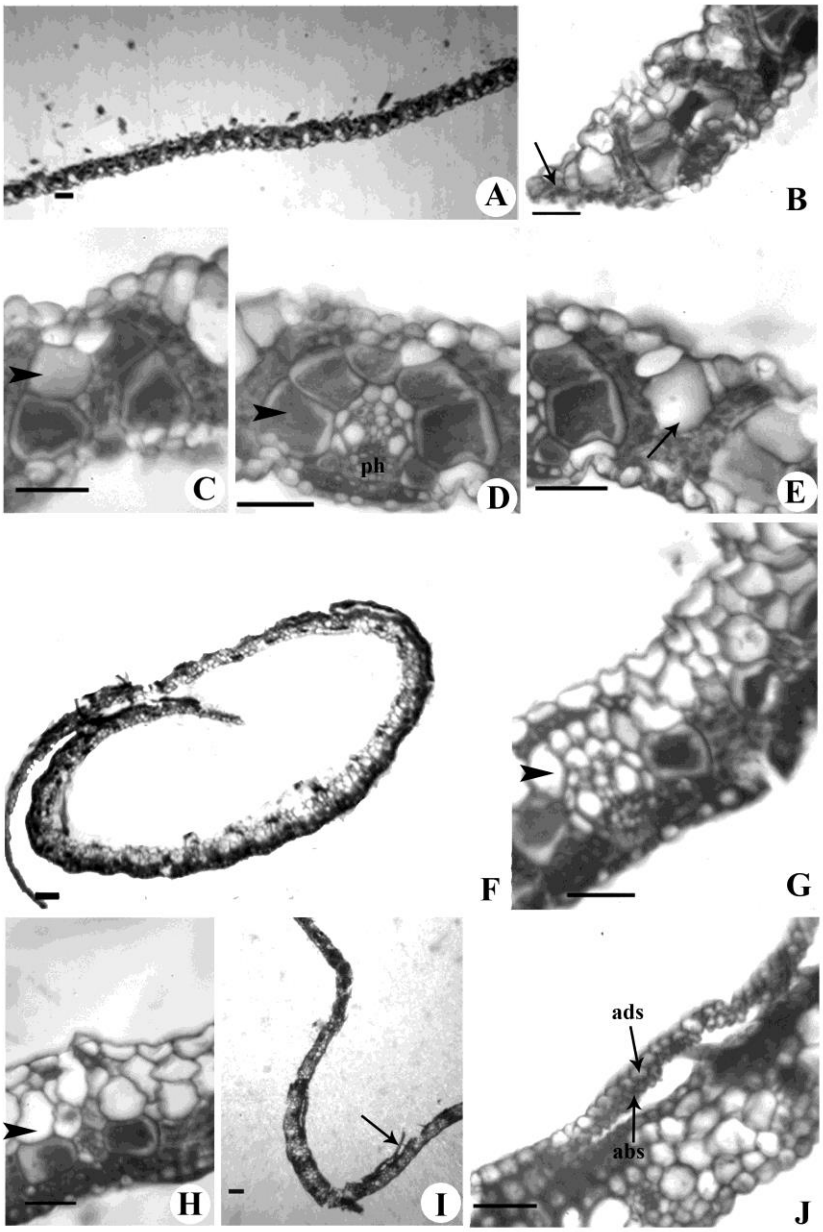

Fig. 193

Chloris

71. *Chloris barbata* (Fig. 194)

72. *Choris montana* (Fig. 195)

73. *Chloris virgata* (Fig. 196)

LEAF LAMINA: (Fig. 194 A-H, 195 A-E, 196 A-F)

Outline of the lamina: 'V' shaped in all species (Fig. 194 A, 195 A, 195 A), broad angled with concave arms in *C. barbata*, convex arms in *C. montana* or standard angled with straight arms in *C. virgata*.

Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows absent in *C. montana*, *C. virgata* while present in *C. barbata*. Shallow, wide furrows with rounded ribs present over all vascular bundle.

Keel is well developed, V-shaped with single median vascular bundle, 5-6 3rd order vascular bundles. Small, parenchyma associated with median vascular bundle. Sclerenchyma present on abaxial surface associated with vascular bundles in form of strands.

Epidermis: Adaxial epidermal surface has fan shaped bulliform cells in all species (Fig. 194 F, arrow, 195 C, arrow, 196 B, arrow) in which central cell is diamond shape in *C. barbata* (Fig. 194 G, arrow), inflated round in *C. montana* or shield shape in *C. virgata*.

Abaxial epidermal cells are barrel to square shaped covered with thick cuticle. Epidermal cells have papillae in all species (Fig. 194 D, arrow, 195 D, arrow, 196 E, arrow)

Mesophyll: Incompletely radiate chlorenchyma cells present in *C. barbata* or radiate, single layered, isodiametric cells completely surrounding bundles in *C. montana* and *C. virgata*. Compactly arranged homogenous chlorenchymatous cells occuping the major area between the adaxial and abaxial epidermides in *C. montana* and *C. virgata*. Chlorenchyma cells continuous between bundles. Colourless cells absent.

Vascular bundles: 3-4 1st order vascular bundles in *C. barbata* and *C. virgata* or 2-3 in *C. montana*, regularly arranged from median bundle to marginal bundle in half lamina. 4-5 3rd order bundles between consecutive larger bundles and 2-3 2nd order bundles between consecutive 1st order bundles present. Vascular bundles placed at different level. 1st and 2nd order vascular bundles placed centrally while 3rd order vascular bundles placed abaxially.

3rd order vascular bundles: (Fig. 194 E, 195 B, C, 196 C)

Hexagonal in *C. barbata* and *C. virgata* while pentagonal in *C. montana* with xylem and phloem distinguishable.

2nd order vascular bundles: Circular shaped

1st order vascular bundles: (Fig. 194 B, 196 D)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely surrounded by sclerenchyma fibers

Nature of lysigenous cavity and protoxylem: Enlarged protoxylem vessel present in all species and lysigenous cavity present only in *C. virgata*

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Shape of metaxylem vessels: Circular

Median vascular bundles: (Fig. 195 D)

Shape: Circualr in all species except in *C. barbata* elliptical

Relationship of phloem cells and the vascular fibres: Completely surrounded by sclerenchyma fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity absent and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig.194 E arrowhead, 195 B arrowhead, 196 C, E arrowhead)

Shape: Round

Shape of bundle sheath cell: Outer tangential wall inflated; radial and inner tangential wall straight

2nd order vascular bundle's bundle sheath:

Shape: Circualr in all species except in *C. barbata* elliptical

Shape of bundle sheath cell: Outer tangential wall inflated; radial and inner tangential wall straight

Number of bundle sheath cell: 7-8 in *C. barbata* and *C. montana*, 8-9 in *C. virgata*

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast fills lumen of cell

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. 194 B, 196 D arrowhead)

Shape: Circualr in all species except in *C. barbata* elliptical

Extent of bundle sheath around the vascular bundle: Incomplete, abaxially interrupted by sclerenchyma cells in *C. barbata* and *C. montana* or complete in *C. virgata*

Extension of bundle sheath: Broad abaxial extension present in *C. barbata* and *C. montana* or absent in *C. virgata*

Number of cells comprising the bundle sheath: 9-10 in *C. barbata* and *C. montana*, 15-16 in *C. virgata* parenchyma cells

Bundle sheath cell shape: Outer tangential wall inflated; radial and inner tangential wall straight. Chloroplast fills lumen of cell.

Mestome/ Inner sheath: Complete, cells smaller than outer sheath cell. Gradation in cell size towards abaxial side seen only in *C. virgata.*

Sclerenchyma:

Adaxial sclerenchyma: Absent

Abaxial sclerenchyma: Well developed strand in *C. barbata*, minute subepidermal strands in *C. montana* and *C. virgata*

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very small with very pointed fibrous cap in *C. barbata* (Fig. 194 C, arrow), only pointed cap in *C. montana*, *C. virgata* (Fig. 195 D, 196 F). Epidermal cells at margin are thin with thick outer tangential wall.

LEAF SHEATH ANATOMY (Fig. 194 I-K, 195 F-H, 196 G-K)

Outline of lamina: Round shaped with inrolled margins in *C. barbata* (Fig. 194 I), 'V' shaped with inrolled margins in *C. montana* and *C. virgata* (Fig. 195 F, 196 G). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavity.

Vascular bundle:

Arrangement of vascular bundle: 2-3 consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: (Fig. 194 K, 195 G, 196 I)

Hexagonal with xylem and phloem distinguishable.

2nd order vascular bundle: Elliptical in all species except in in *C. virgata* circular

1st order vascular bundle: (Fig. 194 J, 195 H, 196 H, K)

Elliptical in all species except in in *C. virgata* circular with phloem completely surrounded by thick walled fibers. Lysigenous cavity and enlarged protoxylem vessel present. Circular wide metaxylem vessels present.

Vascular bundle sheath: (Fig. 194 J, K arrowhead, 195 H, G arrowhead, 196 H, K arrowhead,).

Shape: Circular in all species except in *C. barbata* elliptical

Extent of bundle sheath around the vascular bundle: Incomplete, abaxially interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 10-11 in *C. montana* and *C. barbata*, 14-15 in *C. virgata* parenchyma cells

Bundle sheath cell shape: Outer tangential wall inflated; radial and inner tangential wall straight and cells smaller than the ground tissue.

Mestome/ Inner sheath: Complete, cells smaller than outer sheath cell.

Sclerenchyma: In form of straight horizontal girder in *C. montana* and *C. barbata* (Fig. 194 K, arrow) or well developed girder in *C. virgata* (Fig. 196 M) on abaxial surface.

LIGULE ANATOMY (Fig. 194 L, M, 195 I, J, 196 L, M)

Shape: Ligule is attached to the half width of the leaf sheath region and it is round shaped at the connection point in *C. barbata* (Fig. 194 H) or attached to the lamina upto the half length of it and is free and 'V' shaped at the connection point in *C. montana* and *C. virgata* (Fig. 195 I, 196 L).

Anatomy: Two layered in *C. barbata* and *C. montana* or three layered in *C. virgata* mesophyll cells between adaxial and abaxial surfaces (Fig. 194 M, 195 J, 196 M).

Differentiating features:

Round shaped ligule……...…… *C. barbata*

'V' shaped ligule

Central cell of bulliform cell is inflated round ……..……. *C. montana*

Central cell of bulliform cell is shield shape……*C. virgata*

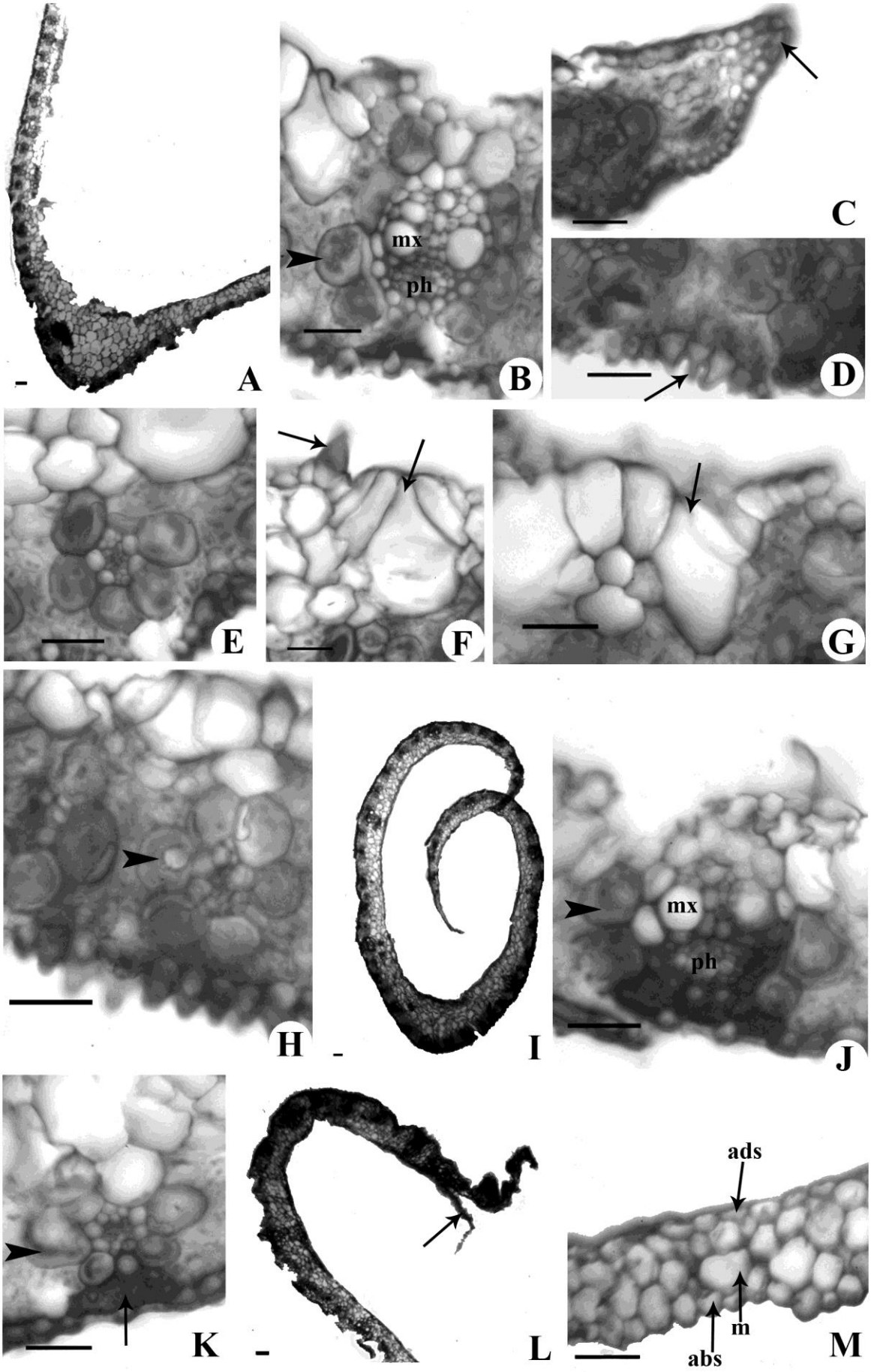

Fig. 194

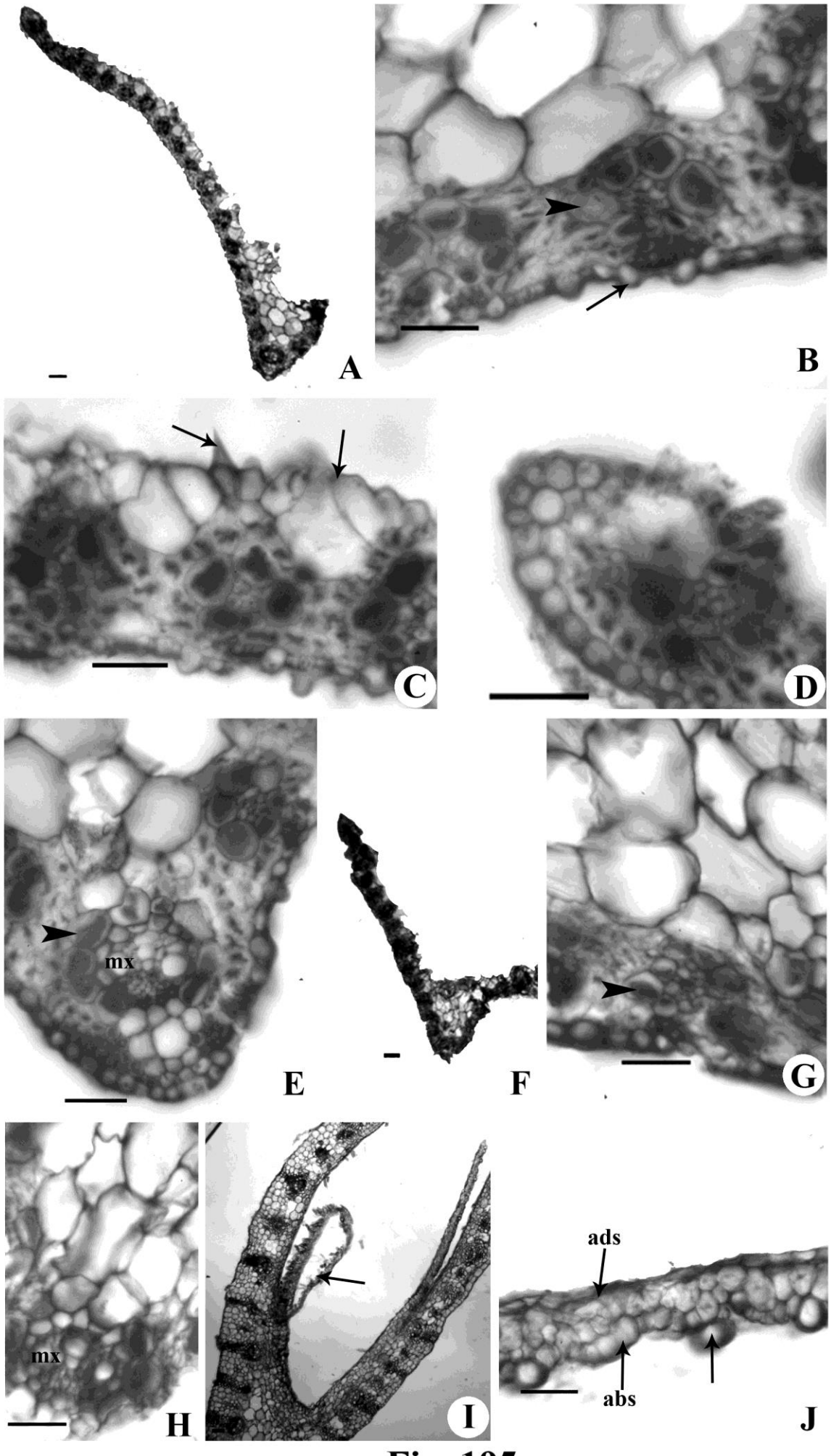

Fig. 195

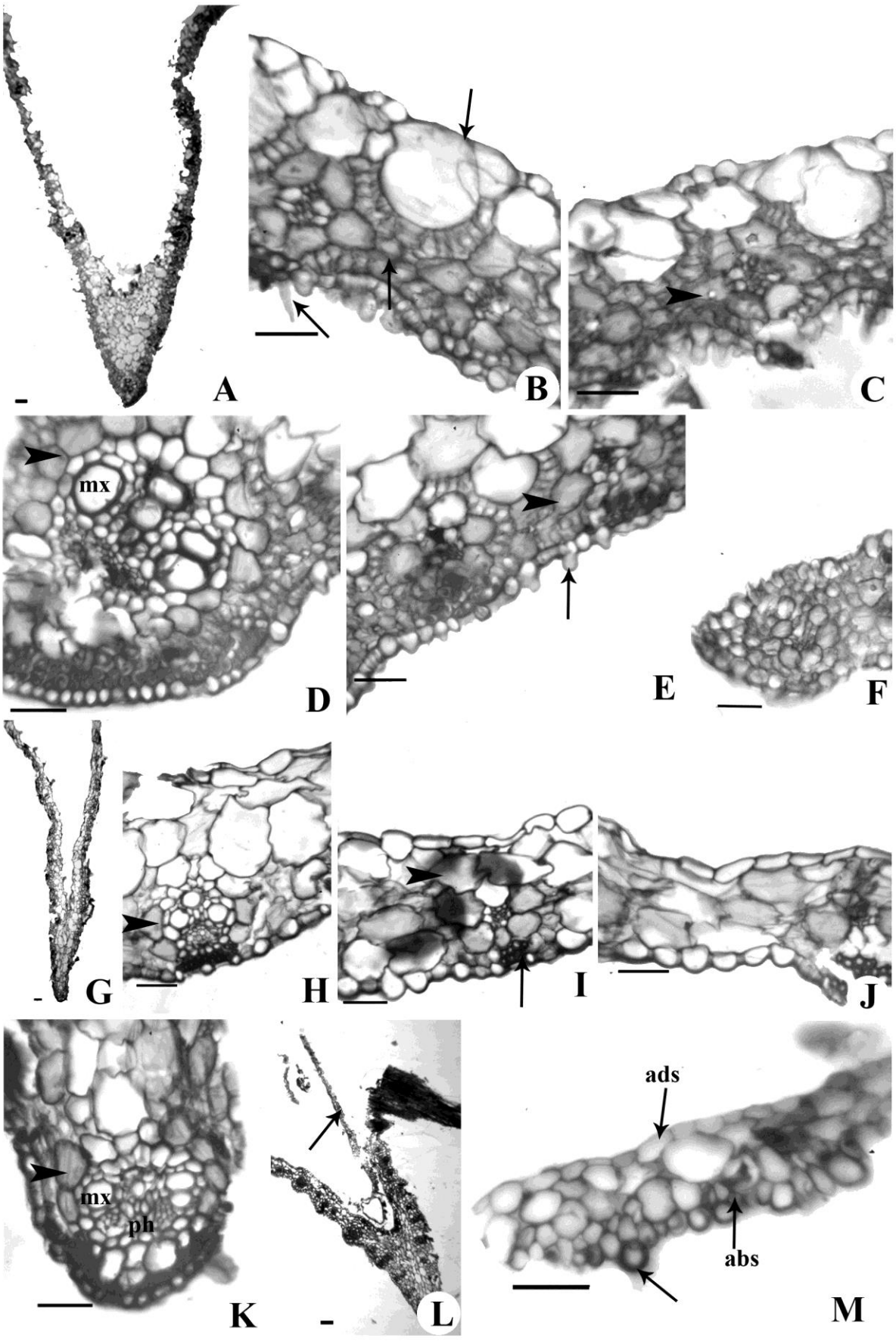

Fig. 196

74. *Cynodon dactylon*

LEAF LAMINA: (Fig. 197 A-E)

Outline of the lamina: Expanded with undulating leaf blade (Fig. A). Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are present on the leaf surface. Shallow, narrow furrows between all vascular bundles and flat ribs present over all vascular bundles. Keel is inconspicuous.

Epidermis: Adaxial epidermal surface has fan shaped bulliform cells (Fig. B, arrow) in which central cell is elongated with parallel sides. Epidermal cells showed pointed prickles (Fig. E, arrow). Abaxial epidermal cells are small, barrel to square shaped covered with thick cuticle.

Mesophyll: Incompletely radiate chlorenchyma cells present. Colourless cells present (Fig. E) which is smaller than bulliform cells and with one extension.

Vascular bundles: 1-2 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundle. 3-4 3rd order bundles between consecutive larger bundles and 1-2 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally.

3rd order vascular bundles: Triangular (Fig. B) with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: Circular shaped (Fig. D)

1st order vascular bundles: (Fig. C)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely covered by sclerenchyma cells

Nature of lysigenous cavity and protoxylem: Lysigenous cavity absent and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Shape of metaxylem vessels: Angular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. B, arrrowhead)

Shape: Triangular

Shape of bundle sheath cell: Fan shaped

2nd order vascular bundle's bundle sheath: (Fig. D, arrowhead)

Shape: Triangular

Shape of bundle sheath cell: Fan shaped

Number of bundle sheath cell: 8-9

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Translucent

Mestome/ Inner sheath: Complete, cells are smaller than outer sheath cells

1st order vascular bundle's bundle sheath: (Fig. C, arrowhead)

Shape: Triangular

Extent of bundle sheath around the vascular bundle: Complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 13-14 parenchyma cells

Bundle sheath cell shape: Fan shaped

Mestome/ Inner sheath: Complete and cells are smaller than the outer sheath cell

Sclerenchyma:

Adaxial sclerenchyma: Minute subepidermal strands present

Abaxial sclerenchyma: subepidermal strands present

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very pointed cap. Epidermal cells at margin are thin with thick outer tangential wall.

LEAF SHEATH ANATOMY (Fig. 197 F-I)

Outline of lamina: Round with inrolled margins (Fig. F). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous ground tissue, parenchyma cells contain starch grains (Fig. I, arrow), air cavity absent.

Vascular bundle:

Arrangement of vascular bundle: 1 consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Pentagonal with vascular tissue consisting of only few indistinguishable vascular elements

2nd order vascular bundle: Elliptical shaped

1st order vascular bundle: Elliptical with phloem completely surrounded by thick walled fibers. Lysigenous cavity and enlarged protoxylem vessel present. Circular narrow metaxylem vessels present (Fig. H).

Vascular bundle sheath: (Fig. G, H arrowhead)

Shape: Elliptical shaped

Extent of bundle sheath around the vascular bundle: Incomplete, abaxially interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 8-9 parenchyma cells

Bundle sheath cell shape: Fan shaped and cells smaller than the ground tissue.

Mestome/ Inner sheath: Complete, cells are smaller than the outer sheath cell

Sclerenchyma: In form of straight horizontal abaxial band.

LIGULE ANATOMY (Fig. 197 J, K)

Shape: Ligule attached to the lamin upto 1/3 length of it and then free, blunt, narrow, 'V' shaped at the point of connection (Fig. J, arrow)

Anatomy: Three layered mesophyll cells between adaxial and abaxial surfaces (Fig. K).

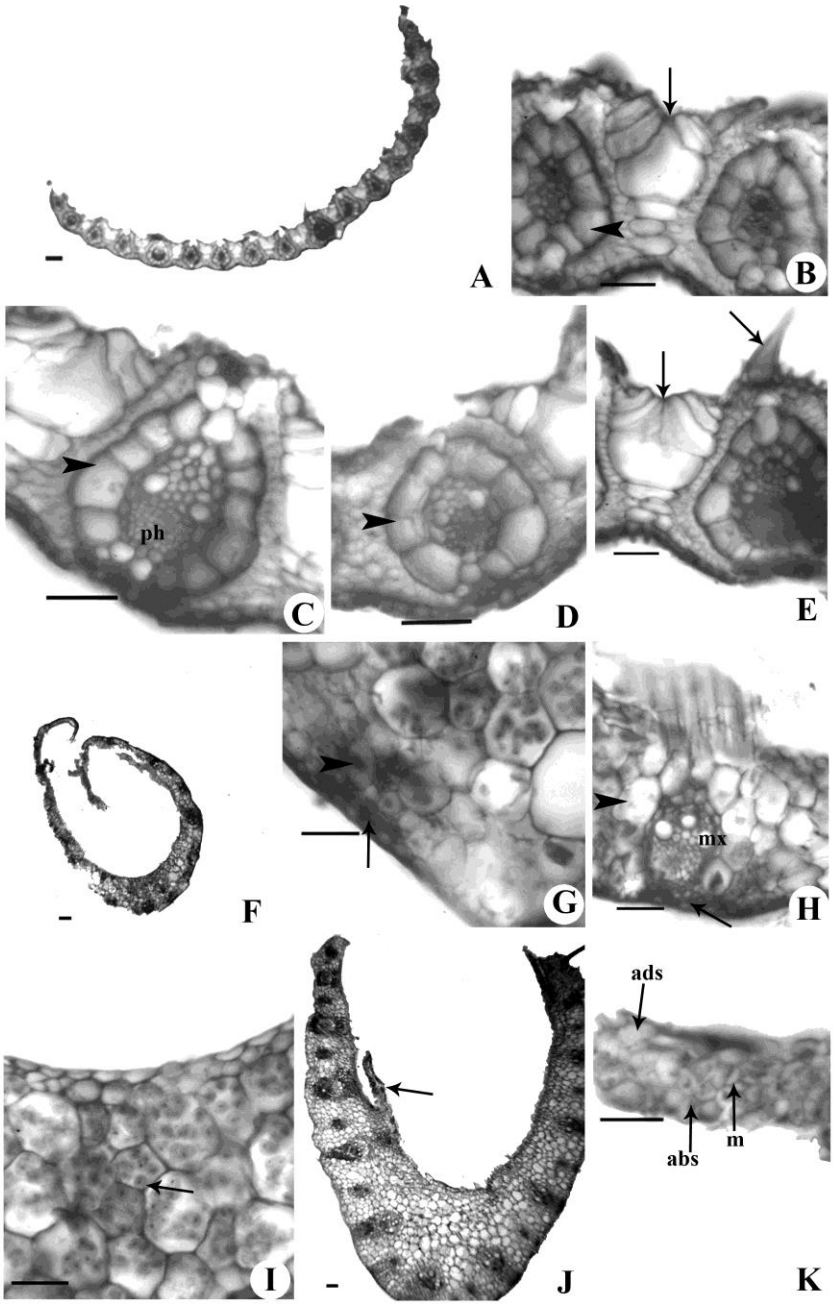

Fig. 197

75. *Melanocenchris jaequemontii*

LEAF LAMINA: (Fig. 198 A-F)

Outline of the lamina: Expanded with undulating leaf blade (Fig. A). Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are present on the leaf surface. Medium, narrow furrows between all vascular bundles and rounded ribs present over all vascular bundles. Keel is inconspicuous.

Epidermis: Adaxial epidermal surface has fan shaped bulliform a cell (Fig. B, arrow) in which central cell is dimond shaped. Epidermal cells showed pointed, curved prickles (Fig. D). Abaxial epidermal cells are small, barrel to square shaped covered with thick cuticle.

Mesophyll: Incompletely radiate chlorenchyma cells present. Colourless cells present (Fig. E) which is smaller than bulliform cells and with one extension.

Vascular bundles: 1-2 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundle. 3-4 3rd order bundles between consecutive larger bundles and 1-2 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally.

3rd order vascular bundles: Hexagonal (Fig. E) with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: Circular shaped

1st order vascular bundles: (Fig. C)

Shape: Round

Relationship of phloem cells and the vascular fibres: Completely covered by sclerenchyma cells

Nature of lysigenous cavity and protoxylem: Lysigenous cavity absent and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Shape of metaxylem vessels: Angular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Fan shaped

2nd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Fan shaped

Number of bundle sheath cell: 8-9

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Translucent

Mestome/ Inner sheath: Complete and cells are smaller than outer sheath cells

1st order vascular bundle's bundle sheath: (Fig. C, arrowhead)

Shape: Triangular

Extent of bundle sheath around the vascular bundle: Complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 8-9 parenchyma cells

Bundle sheath cell shape: Fan shaped

Mestome/ Inner sheath: Complete and cells are smaller than the outer sheath cell

Sclerenchyma:

Adaxial sclerenchyma: Minute subepidermal strands present

Abaxial sclerenchyma: subepidermal strands present

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very pointed cap. Epidermal cells at margin are thin with thick outer tangential wall (Fig. B).

LEAF SHEATH ANATOMY (Fig. 198 G, H)

Outline of lamina: Round shaped with inrolled margins (Fig. G). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavity.

Vascular bundle:

Arrangement of vascular bundle: 1 consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Hexagonal with vascular tissue consisting of only few indistinguishable vascular elements

2nd order vascular bundle: Circular shaped

1st order vascular bundle: Circular shaped with phloem completely surrounded by thick walled fibers. Lysigenous cavity and enlarged protoxylem vessel present. Circular narrow metaxylem vessels present.

Vascular bundle sheath:

Shape: Circular shaped

Extent of bundle sheath around the vascular bundle: Complete

Number of cells comprising the bundle sheath: 8-9 parenchyma cells

Bundle sheath cell shape: Fan shaped and cells smaller than the ground tissue.

Mestome/ Inner sheath: Complete, cells are smaller than the outer sheath cell

Sclerenchyma: In form of straight horizontal band on abaxial surface.

LIGULE ANATOMY (Fig. 198 I)

Shape: Ligule attached to the midrib and few parts of lamina region because it is hairy ligule.

Anatomy: Two layered mesophyll cells between adaxial and abaxial surfaces (Fig. I).

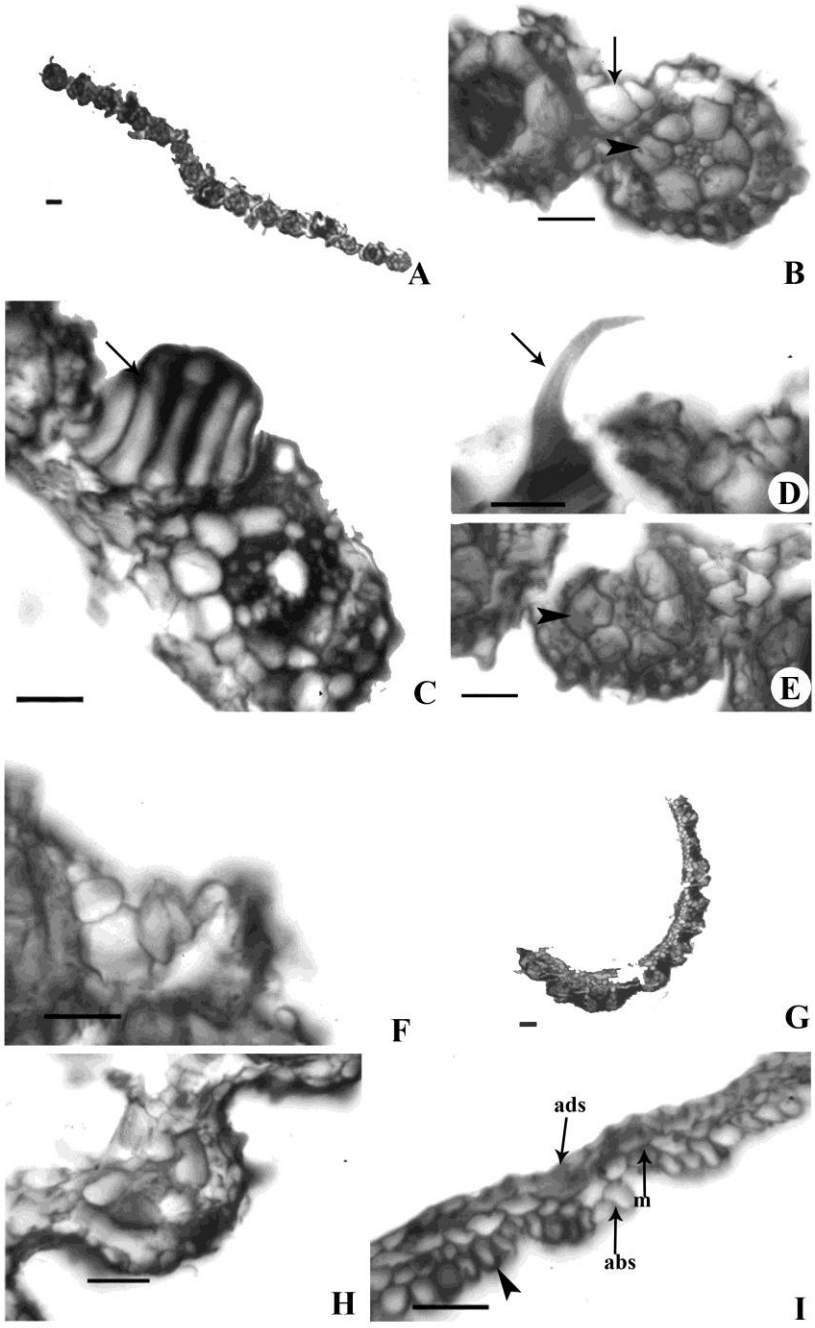

Fig. 198

76. *Oropetium villosulum*

LEAF LAMINA: (Fig. 199 A-F)

Outline of the lamina: Expanded with undulating leaf blade (Fig. A). Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are present on the leaf surface. Medium, narrow furrows between all vascular bundles and rounded ribs present over all vascular bundles. Keel is inconspicuous.

Epidermis: Adaxial epidermal surface has fan shaped bulliform cell (Fig. E, arrow) in which central cell is dimond shaped. Epidermal cells showed pointed, curved prickles (Fig. F). Few epidermal cells have papillae, one papillae per cell (Fig. E, arrow). Abaxial epidermal cells are small, barrel to square shaped covered with thick cuticle.

Mesophyll: Incompletely radiate chlorenchyma cells present. Colourless cells present (Fig. E) which is smaller than bulliform cells and with one extension.

Vascular bundles: 1-2 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundle. 2-3 3rd order bundles between consecutive larger bundles and 1-2 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally.

3rd order vascular bundles: Hexagonal (Fig. C) with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: Circular shaped

1st order vascular bundles: (Fig. D)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely covered by sclerenchyma cells

Nature of lysigenous cavity and protoxylem: Lysigenous cavity absent and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Shape of metaxylem vessels: Circular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. C, F arrowhead)

Shape: Round

Shape of bundle sheath cell: Fan shaped

2nd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Fan shaped

Number of bundle sheath cell: 7-8

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Translucent

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. D, arrowhead)

Shape: Circular

Extent of bundle sheath around the vascular bundle: Complete
Extension of bundle sheath: Absent
Number of cells comprising the bundle sheath: 8-9 parenchyma cells
Bundle sheath cell shape: Fan shaped
Mestome/ Inner sheath: Complete and cells are smaller than the outer sheath cell

Sclerenchyma:

Adaxial sclerenchyma: Minute subepidermal strands present
Abaxial sclerenchyma: subepidermal strands present
Sclerenchyma between bundles: Absent
Sclerenchyma in leaf margin: Forming very pointed cap. Epidermal cells at margin are thin with thick outer tangential wall (Fig. B).

LEAF SHEATH ANATOMY (Fig. 199 G-I)

Outline of lamina: V shaped, narrow angle with inrolled margins (Fig. G). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular
Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with absene of air cavity.

Vascular bundle: (Fig. H, I arrowhead)

Arrangement of vascular bundle: 1 consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle
3rd order vascular bundle: Hexagonal with vascular tissue consisting of only few indistinguishable vascular elements (Fig. H)
2nd order vascular bundle: Circular shaped
1st order vascular bundle: Elliptical with phloem completely surrounded by thick walled fibers. Lysigenous cavity and enlarged protoxylem vessel present. Circular narrow metaxylem vessels present (Fig. I).

Vascular bundle sheath:

Shape: Circular shaped
Extent of bundle sheath around the vascular bundle: Complete
Number of cells comprising the bundle sheath: 10-11 parenchyma cells
Bundle sheath cell shape: Fan shaped and cells smaller than the ground tissue.
Mestome/ Inner sheath: Complete and cells are smaller than the outer sheath cell.

Sclerenchyma: In form of straight horizontal abaxial band.

LIGULE ANATOMY (Fig. 199J, K)

Shape: Ligule attached to the midrib and few parts of lamina region because it is hairy ligule (Fig. J, arrow)

Anatomy: Two layered mesophyll cells between adaxial and abaxial surfaces (Fig. K).

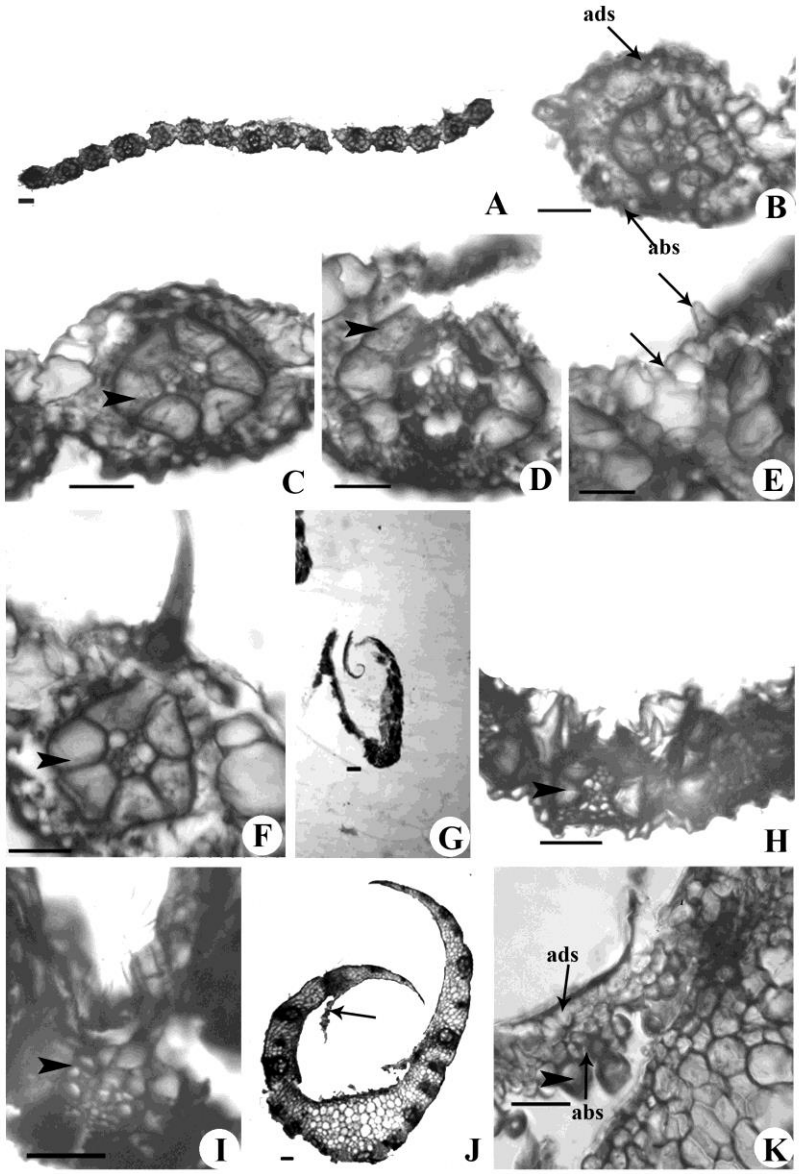

Fig. 199

77. *Schoenefeldia gracilis*

LEAF LAMINA: (Fig. 200 A-E)

Outline of the lamina: V shaped, wide angle with straight arms (Fig. A).Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are present on the leaf surface. Medium, narrow furrows between all vascular bundles and rounded ribs present over all vascular bundles.

Keel is well developed, V-shaped keel with single median vascular bundle, 3-4 3rd order vascular bundles. Small, round parenchyma cells are present surrounding the median vascular bundle adaxially. Sclerenchyma on abaxial surface associated with vascular bundles in form of girders.

Epidermis: Adaxial epidermal surface has fan shaped bulliform cells (Fig. E, arrow) in which central cell is shield shpaed. Epidermal cells showed pointed, curved prickles (Fig. D). Abaxial epidermal cells are small, barrel to square shaped covered with thick cuticle.

Mesophyll: Radiate, single layered, isodiametric chlorenchyma cells completely surrounding bundles. Compact homogenous chlorenchymatous cells occupy the major area between the adaxial and abaxial epidermides. Chlorenchyma cells continuous between bundles. Colourless cells present (Fig. E) which are smaller than bulliform cells and with one extension.

Vascular bundles: 1-2 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundle. 4-5 3rd order bundles between consecutive larger bundles and 2-3 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed abaxially.

3rd order vascular bundles: Hexagonal (Fig. D) with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: Circular shaped

1st order vascular bundles: (Fig. C)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely covered by sclerenchymatous fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Shape of metaxylem vessels: Circular

Median vascular bundle:

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely covered by sclerenchymatous fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. D, arrowhead)

Shape: Round

Shape of bundle sheath cell: Fan shaped

2nd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Fan shaped

Number of bundle sheath cell: 6-7

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast positioned towards inner tangential wall

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. C, arrowhead)

Shape: Circular

Extent of bundle sheath around the vascular bundle: Incomplete, adaxially interrupted by parenchyma cell and abaxially interrupted by sclerenchyma cells

Extension of bundle sheath: Broad well developed girder present towards abaxial side

Number of cells comprising the bundle sheath: 8-9 parenchyma cells

Bundle sheath cell shape: Fan shaped

Mestome/ Inner sheath: Complete and cells are smaller than the outer sheath cell

Sclerenchyma:

Adaxial sclerenchyma: Minute subepidermal strands present

Abaxial sclerenchyma: Well developed girder, wider than deep

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very small rounded cap. Epidermal cells at margin are thin with thick outer tangential wall (Fig. B).

LEAF SHEATH ANATOMY (Fig. 200 F-I)

Outline of lamina: U shaped with inrolled margins (Fig. F). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavity.

Vascular bundle:

Arrangement of vascular bundle: 2-3 consecutive 3rd order vascular bundles between 1st and 2nd order vascular bundle

3rd order vascular bundle: Hexagonal with vascular tissue consisting of only few indistinguishable vascular elements

2nd order vascular bundle: Elliptical shaped (Fig. I)

1st order vascular bundle: Elliptical with phloem completely surrounded by thick walled fibers. Lysigenous cavity and enlarged protoxylem vessel present. Circular narrow metaxylem vessels present (Fig. G)

Vascular bundle sheath: (Fig. G, H, I arrowhead)

Shape: Horse shoe shaped

Extent of bundle sheath around the vascular bundle: Incomplete, abaxially interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 8-9 parenchyma cells

Bundle sheath cell shape: Fan shaped and cells smaller than the ground tissue.

Mestome/ Inner sheath: Complete and cells are smaller than the outer sheath cell

Sclerenchyma: In form of well developed girder on abaxial surface (Fig. H, arrow).

LIGULE ANATOMY (Fig. 200 J, K)

Shape: Ligule attached to the midrib and few parts of lamina region because it is hairy ligule (Fig. J, arrow)

Anatomy: Two layered mesophyll cells between adaxial and abaxial surfaces, few cells have prescence of sclerenchyma (Fig. K, arrowhead).

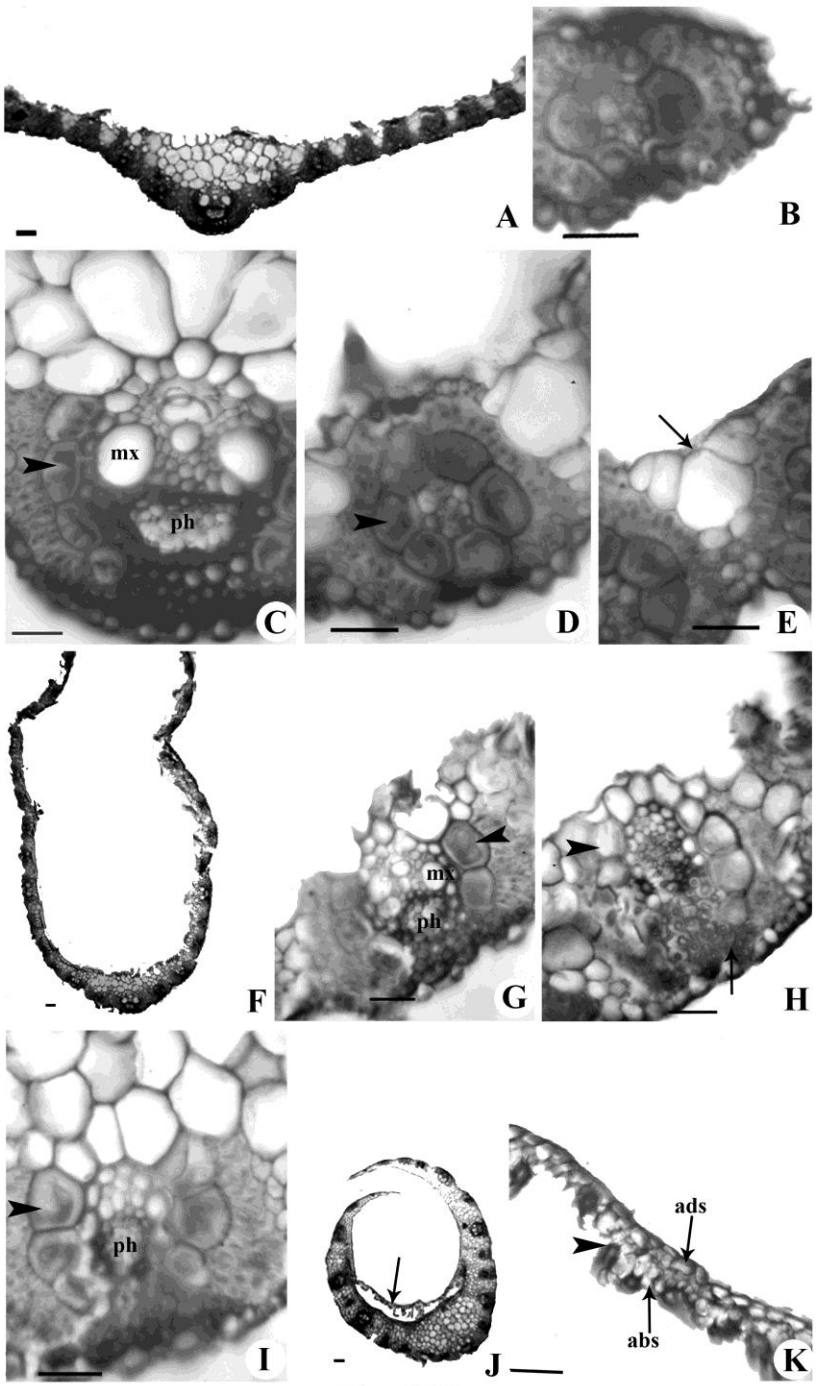

Fig. 200

Tetrapogon

78. *Tetrapogon tenellus* (Fig. 201)

79. *Tetrapogon villosus* (Fig. 202)

LEAF LAMINA: (Fig. 201 A-G, 202 A-G)

Outline of the lamina: Expanded in both species with straight arms in *T. tenellus* or wavy arms in *T. villosus* (Fig. 201 A, B, 202 A). Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are present on the leaf surface. Medium, narrow furrows between all vascular bundles and rounded ribs present over all vascular bundles.

Keel is well developed, V-shaped with single median vascular bundle. Small, sclerenhcyma cells are present surrounding adaxial to the median vascular bundle. Sclerenchyma on abaxial surface associated with vascular bundles in form of girders.

Epidermis: Adaxial epidermal surface has fan shaped bulliform cells in both species in which central cell is inflated (Fig. 201 F, arrow, 202 D, arrow). Abaxial epidermal cells are small, barrel to square shaped covered with thick cuticle. Epidermal cells have papillae in both species (Fig. 201 G, arrow, 202 E, arrow).

Mesophyll: Radiate, single layered, isodiametric chlorenchyma cells surrounding bundles. Compactly arranged homogenous chlorenchyma cells occuping the major area between the adaxial and abaxial epidermides. Chlorenchyma cells continuous between bundles. Colourless cells present (Fig. 201 E) which are smaller than bulliform cells and present near the bulliform cells.

Vascular bundles: 2-3 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundle. 4-5 3rd order bundles in *T. tenellus* or 6-7 3rd order bundles in *T. villosus* between consecutive larger bundles and 2-3 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed abaxially.

3rd order vascular bundles: (Fig. 201 E, 202 C, E)

Pentagonal with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: Elliptical shaped

1st order vascular bundles: (Fig. 201 D, 202 B)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely covered by sclerenchymatous fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity absent and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Shape of metaxylem vessels: Circular

Median vascular bundle: (Fig. 201 C)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely covered by sclerenchymatous fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity absent and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. 201 E, arrowhead, 202 C arrowhead)

Shape: Triangular

Shape of bundle sheath cell: Fan shaped

2nd order vascular bundle's bundle sheath:

Shape: Horse shoe

Shape of bundle sheath cell: Fan shaped

Number of bundle sheath cell: 6-7

Nature of bundle sheath (either complete or incomplete): Incomplete, abaxially interrupted by sclrenchyma cells

Chloroplast position in bundle sheath cell: Chloroplast fills entire cell lumen in *T. tenellus* or positioned towards inner tangential wall in *T. villosus.*

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. 201 D, arrowhead, 202 B, arrowhead)

Shape: Circular

Extent of bundle sheath around the vascular bundle: Incomplete, adaxially interrupted by parenchyma cell and abaxially interrupted by sclerenchyma cells

Extension of bundle sheath: Broad well developed girder present towards abaxial side

Number of cells comprising the bundle sheath: 7-8 parenchyma cells

Bundle sheath cell shape: Fan shaped and Chloroplast fill entire cell lumen in *T. tenellus* or positioned towards inner tangential wall in *T. villosus.*

Mestome/ Inner sheath: Complete and cells are smaller than the outer sheath cell

Sclerenchyma:

Adaxial sclerenchyma: Minute subepidermal strands present

Abaxial sclerenchyma: Well developed girder, wider than deep

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very small rounded cap. Epidermal cells at margin are thin with thick outer tangential wall.

LEAF SHEATH ANATOMY (Fig. 201 H-L, 202 F-I)

Outline of lamina: 'V' shaped with inrolled margins in both species (Fig. 201 H, 202 F). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular (Fig. 201 L)

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavity.

Vascular bundle:

Arrangement of vascular bundle: 2-3 in *T. tenellus*, 1-2 in *T. villosus* consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: (Fig. 201 J, 202 I)

Hexagonal in *T. tenellus* and pentagonal in *T. villosus* with vascular tissue consisting of only few indistinguishable vascular elements

2nd order vascular bundle: Elliptical shaped

1st order vascular bundle: (Fig. 201 I, Fig. 202 G)

Elliptical with phloem completely surrounded by thick walled fibers. Enlarged protoxylem vessel present in both and lysigenous cavity present only in *T. tenellus*. Circular narrow metaxylem vessels present.

Vascular bundle sheath: (Fig. 201 I, J, K arrowhead)

Shape: Horse shoe shaped

Extent of bundle sheath around the vascular bundle: Incomplete, abaxially interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 8-9 in *T. tenellus*, 7-8 in *T. villosus* parenchyma cells

Bundle sheath cell shape: Fan shaped and cells smaller than the ground tissue.

Mestome/ Inner sheath: Complete and cells are smaller than the outer sheath cell

Sclerenchyma: In form of straight horizontal abaxial strands.

LIGULE ANATOMY (Fig. 201M, N, 202 J, K)

Shape: Ligule attached to the midrib and few parts of lamina region because it is hairy ligule in both species (Fig. 201 M, 202 J).

Anatomy: Single in *T. tenellus* or two in *T. villosus* layered mesophyll cells between adaxial and abaxial surfaces (Fig. 201 N, 202 K).

Differentiating features:

Chloroplast fill entire full lumen, straight arms of leaf blade, single layered mesophyll in ligule……..……..……*T. tenellus*

Chloroplast concentrated near inner tangential wall, wavy arms of leaf blade, two layered mesophyll in ligule……...……...……*T. villosus*

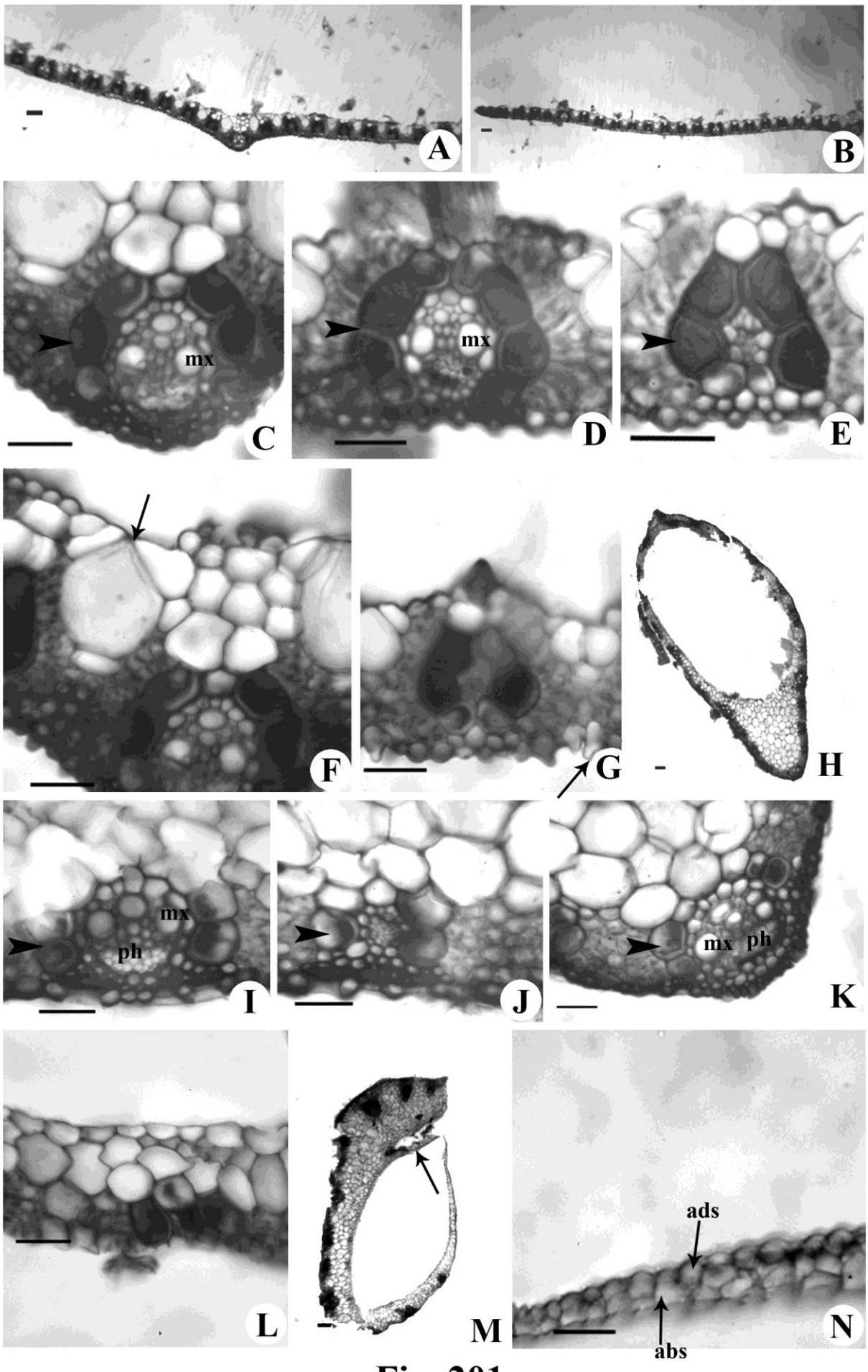

Fig. 201

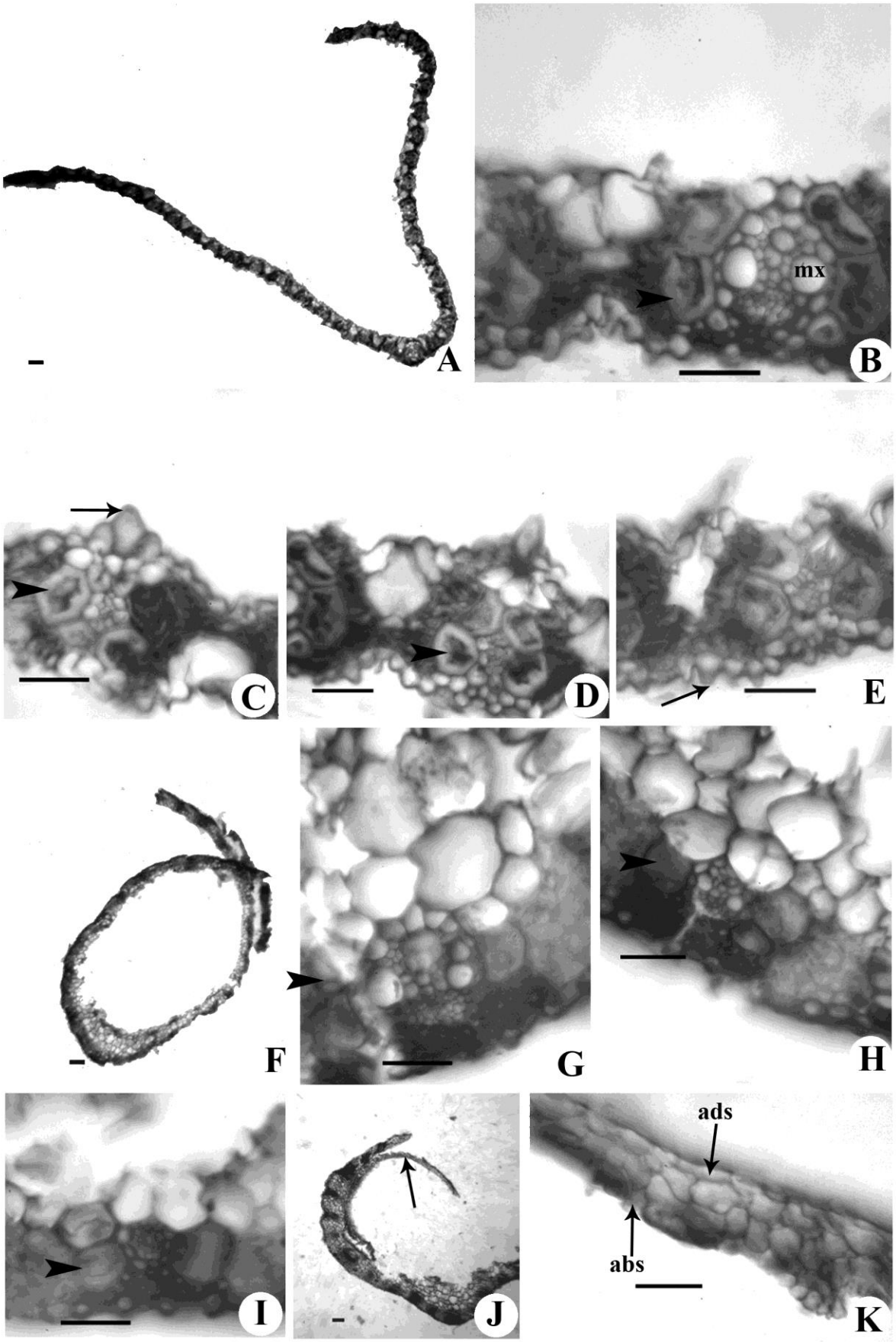

Fig. 202

80. *Acrachne racemosa*

LEAF LAMINA: (Fig. 203 A-G)

Outline of the lamina: 'V' shaped, broad angle with straight arms (Fig. A).Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are absent on the leaf surface.

Keel is well developed, V-shaped keel with single median vascular bundle, 3-4 3rd order vascular bundles. Small, sclerenhcyma cells are present surrounding adaxial to the median vascular bundle. Sclerenchyma on abaxial surface associated with vascular bundles in form of girders.

Epidermis: Adaxial epidermal surface has fan shaped bulliform cells in which central cell is shield shaped (Fig. E, arrow). Abaxial epidermal cells are small, barrel to square shaped covered with thick cuticle. Epidermal cells have papillae (Fig. C, arrow) and papillae are long and as wide as epidermal cell width.

Mesophyll: Radiate, single layered, isodiametric chlorenchyma cells surrounding bundles. Compact homogenous chlorenchymatous cells occuping the major area between the adaxial and abaxial epidermides. Chlorenchyma cells continuous between bundles. Colourless cells present which are smaller than bulliform cells and present near the bulliform cells..

Vascular bundles: 3-4 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundle. 6-7 3rd order bundles between consecutive larger bundles and 2-3 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally.

3rd order vascular bundles: Hexagonal (Fig. D, E) vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: Elliptical shaped

1st order vascular bundles: (Fig. C)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely covered by sclerenchymatous fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity absent and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Shape of metaxylem vessels: Circular

Median vascular bundle:

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely covered by sclerenchymatous fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity absent and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. D, E arrowhead)

Shape: Circular

Shape of bundle sheath cell: Cells with tangential wall inflated, two cells large which are placed in sides of vascular bundle

2nd order vascular bundle's bundle sheath:

Shape: Circular

Shape of bundle sheath cell: Cells with tangential wall inflated, two cells large which are placed in sides of vascular bundle

Number of bundle sheath cell: 8-9

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast positioned towards outer tangential wall

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. C, arrowhead)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 12-13 parenchyma cells

Bundle sheath cell shape: Cells with tangential wall inflated, two cells large which are placed in sides of vascular bundle. Chloroplast positioned towards outer tangential wall.

Mestome/ Inner sheath: Complete and cells are smaller than the outer sheath cell

Sclerenchyma:

Adaxial sclerenchyma: Minute subepidermal strands present (Fig. C, arrow)

Abaxial sclerenchyma: Well developed girder, wider than deep

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very small rounded cap. Epidermal cells at margin are thin with thick outer tangential wall.

LEAF SHEATH ANATOMY (Fig. 203 F-I)

Outline of lamina: 'V' shaped with inrolled margins (Fig. F). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavity.

Vascular bundle:

Arrangement of vascular bundle: 1-2 consecutive 3rd order vascular bundles between 1st and 2nd order vascular bundle

3rd order vascular bundle: Hexagonal with vascular tissue consisting of only few indistinguishable vascular elements (Fig. G)

2nd order vascular bundle: Elliptical shaped

1st order vascular bundle: Elliptical with phloem completely surrounded by thick walled fibers. Lysigenous cavity absent and enlarged protoxylem vessel present. Circular narrow metaxylem vessels present (Fig. I).

Vascular bundle sheath: (Fig. G, I arrowhead)

Shape: Circular

Extent of bundle sheath around the vascular bundle: Incomplete, abaxially interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 7-8 parenchyma cells

Bundle sheath cell shape: Cells with tangential wall inflated, two cells large which are placed in sides of vascular bundle and cells smaller than the ground tissue.

Mestome/ Inner sheath: Complete and cells are smaller than the outer sheath cell

Sclerenchyma: In form of straight horizontal abaxial band.

LIGULE ANATOMY (Fig. 203 J, K)

Shape: Ligule attached to the midrib and broad round shaped at connection point (Fig. J, arrow)

Anatomy: Two layered mesophyll cells between adaxial and abaxial surfaces (Fig. K)

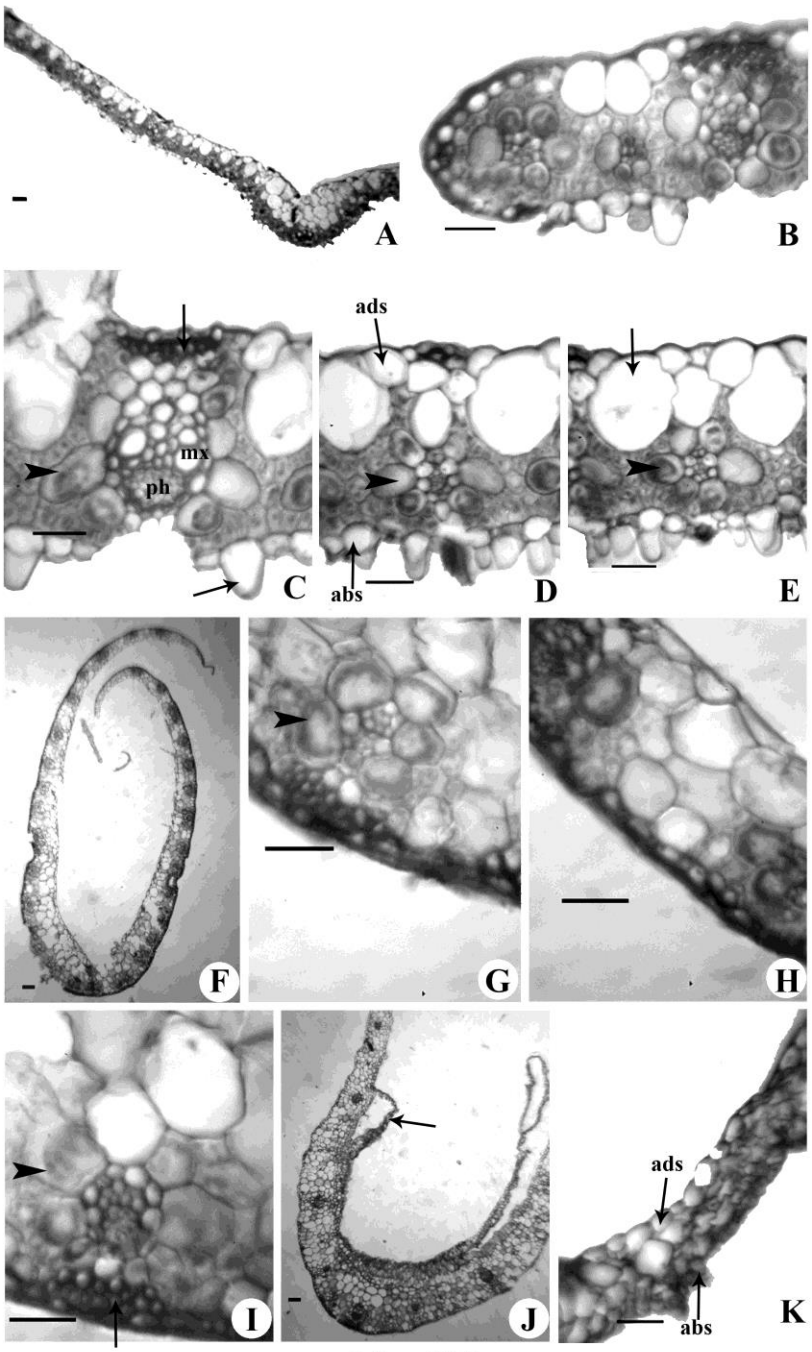

Fig. 203

Dactyloctenium

81. *Dactyloctenium aegyptium* (Fig. 204)

82. *Dactyloctenium scindicus* (Fig. 205)

LEAF LAMINA: (Fig. 204 A-E, 205 A-G)

Outline of the lamina: Expanded with straight arms in both species (Fig. 204 A, 205 A). Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are present on the leaf surface. Medium, narrow furrows between all vascular bundles and round ribs present over all vascular bundles.

Keel is well developed, V-shaped with single median vascular bundle. Small, sclerenhcyma cells are present surrounding adaxial to the median vascular bundle. Sclerenchyma on abaxial surface associated with vascular bundles in form of girders.

Epidermis: Adaxial epidermal surface has fan shaped bulliform in both species, inflated central cell is in *D. aegyptium* and shield shaped central cell in *D. scindicus* (Fig. 204 D, arrow, 205 arrow).

Abaxial epidermal cells are small, barrel to square shaped covered with thick cuticle. Epidermal cells have large, balloon shaped papillae (Fig. 204 E, arrow, 205 E). Abaxial epidermis has restricted group of long, inflated bulliform cells present in *D. scindicus* (Fig. 205 C).

Mesophyll: Radiate, single layered, isodiametric chlorenchyma cells completely surrounding bundles. Compactly arranged homogenous chlorenchyma cells occuping the major area between the adaxial and abaxial epidermides. Chlorenchyma cells continuous between bundles. Colourless cells absent.

Vascular bundles: 3-4 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundle. 6-7 3rd order bundles between consecutive larger bundles and 2-3 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed abaxially.

3rd order vascular bundles: (Fig. 204 E, 205 G)

Hexagonal with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: Elliptical shaped (Fig. 205 F)

1st order vascular bundles: (Fig. 204 D, 205 E)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely covered by sclerenchymaotus fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity absent and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Shape of metaxylem vessels: Circular

Median vascular bundle: (Fig. 204 C, 205 D)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely covered by sclerenchymaotus fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity absent and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. 204 E, arrowhead, 205 G, arrowhead)

Shape: Circular

Shape of bundle sheath cell: Outer tangential wall inflated; radial walls straight

2nd order vascular bundle's bundle sheath: (Fig. 205 F)

Shape: Circular

Shape of bundle sheath cell: Outer tangential wall inflated; radial walls straight

Number of bundle sheath cell: 8-9 in *D. aegyptium*, 6-7 in *D. scindicus*

Nature of bundle sheath (either complete or incomplete): Incomplete, abaxially interrupted by sclrenchyma cells

Chloroplast position in bundle sheath cell: Chloroplast centrally placed

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. 204 D, arrowhead, 205 E arrowhead)

Shape: Circular

Extent of bundle sheath around the vascular bundle: Incomplete, adaxially interrupted by parenchyma cell and abaxially interrupted by sclerenchyma cells

Extension of bundle sheath: Broad well developed girder present towards abaxial side

Number of cells comprising the bundle sheath: 7-8 in *D. aegyptium*, 9-10 in *D. scindicus* parenchyma cells

Bundle sheath cell shape: Outer tangential wall inflated; radial walls straight. Chloroplast centrally placed.

Mestome/ Inner sheath: Complete and cells are smaller than the outer sheath cell.

Sclerenchyma:

Adaxial sclerenchyma: Minute subepidermal strands present

Abaxial sclerenchyma: Well developed girder, wider than deep

Sclerenchyma between bundles: absent

Sclerenchyma in leaf margin: Forming crescent shaped in *D. aegyptium* or pointed shaped cap in *D. scindicus*. Epidermal cells at margin are thin with thick outer tangential wall and showed papillae.

LEAF SHEATH ANATOMY (Fig. 204 F-I, 205 H-J)

Outline of lamina: Round shaped with inrolled margins in both species (Fig. 204 F, 205 H). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavity.

Vascular bundle:

Arrangement of vascular bundle: 1-2 consecutive 3rd order vascular bundles between 1st and 2nd order vascular bundle

3rd order vascular bundle: (Fig. 204 I, 205 I)

Hexaagonal with vascular tissue consisting of only few indistinguishable vascular elements

2nd order vascular bundle: Elliptical shaped

1st order vascular bundle: (Fig. 204 H, 205 J)

Elliptical with phloem completely surrounded by thick walled fibers. Lysigenous cavity absent and enlarged protoxylem vessel present. Circular narrow metaxylem vessels present.

Vascular bundle sheath: (Fig. 204 H arrowhead , 205 J arrowhead)

Shape: Horse shoe shaped

Extent of bundle sheath around the vascular bundle: Incomplete, abaxially interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 9-10 parenchyma cells

Bundle sheath cell shape: Fan shaped and cells smaller than the ground tissue.

Mestome/ Inner sheath: Complete and cells are smaller than the outer sheath cell

Sclerenchyma: In form of straight horizontal abaxial strand.

LIGULE ANATOMY (Fig. 204 J, K, 205 K, L)

Shape: Ligule attached to the midrib and parts of lamina region and forms round shaped in *D. aegyptium* or 'V' shaped in *D. scindicus* at connection of point (Fig. 204 J, 205 J).

Anatomy: Single in *D. aegyptium* or two in *D. scindicus* layered mesophyll cells between adaxial and abaxial surfaces (Fig. 204 K, 205 L).

Differentiating features:

Crescent shaped leaf margin, round shaped ligule, single layered mesophyll in ligule……..……..*D. aegyptium*

Pointed leaf margin, 'V' shaped ligule, two layered mesophyll in ligule……..…….
……..……*D. sindicus*

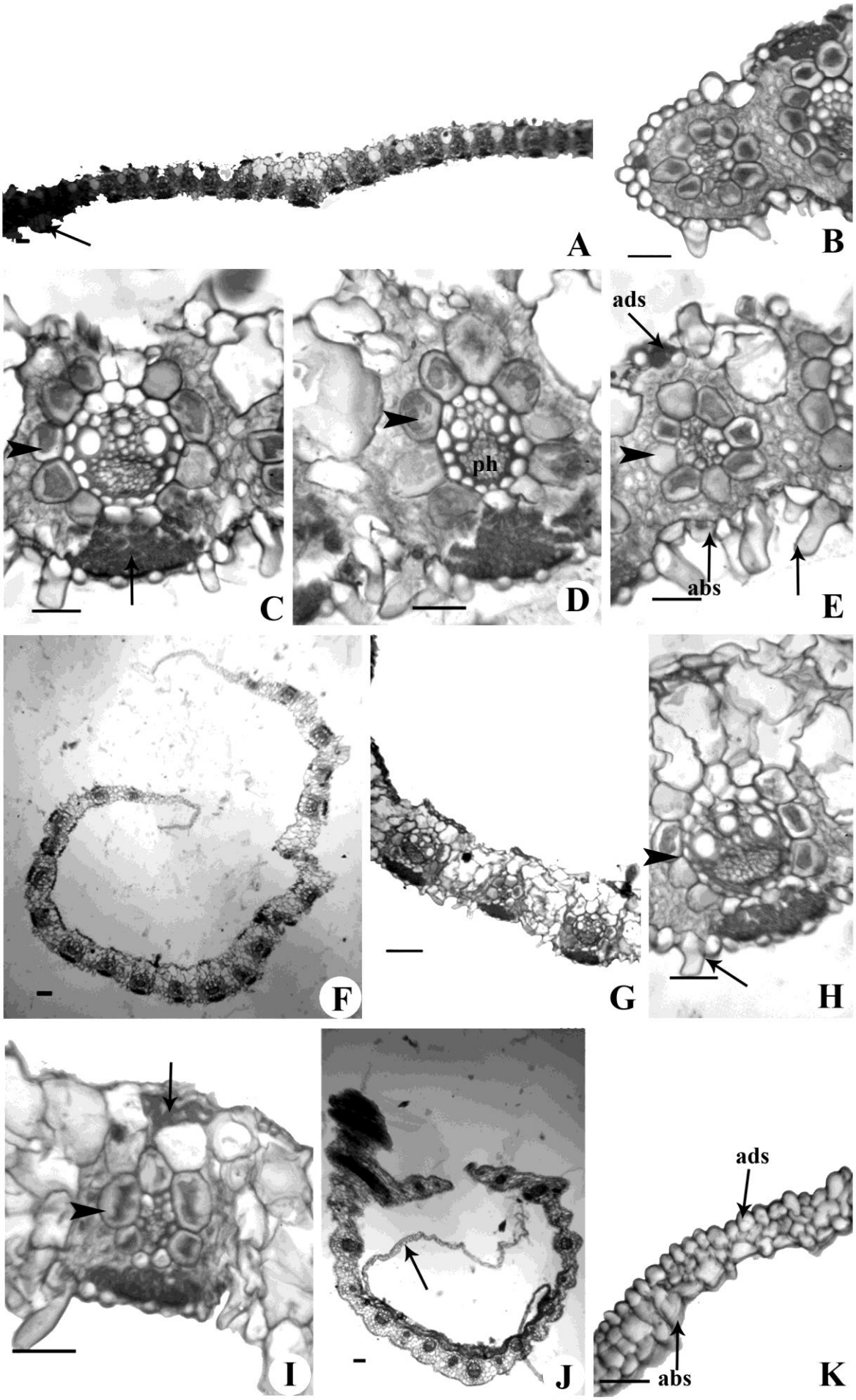

Fig. 204

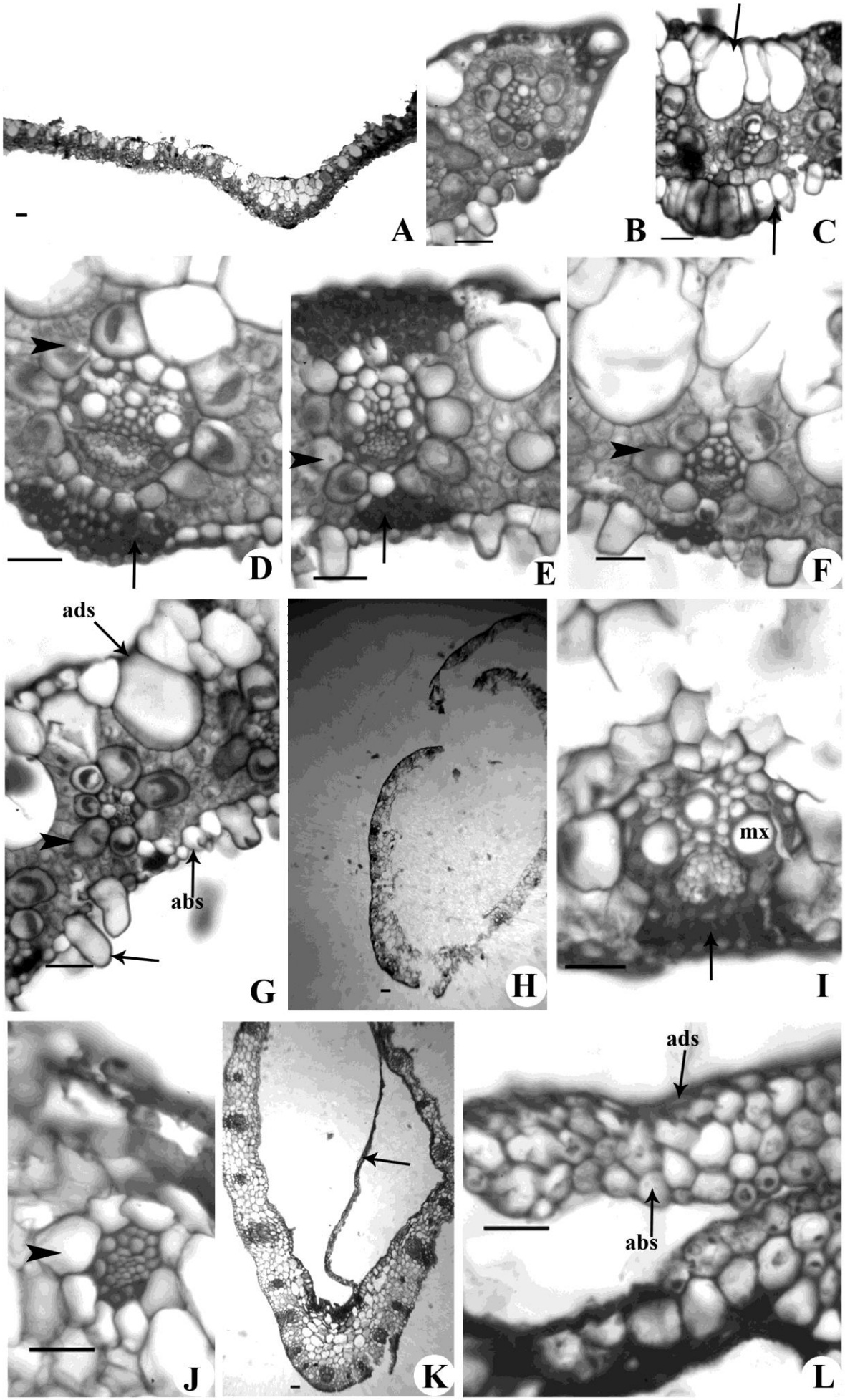

Fig. 205

83. *Desmostachya bipinnata*

LEAF LAMINA: (Fig. 206 A-G)

Outline of the lamina: Expanded with straight arms (Fig. A). Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are present on the leaf surface. Shallow, narrow furrows between all vascular bundles and round ribs present over all vascular bundles.

Keel is well developed, V-shaped keel with single median vascular bundle, 3-4 3rd order vascular bundles. Small, sclerenhcyma cells are present surrounding adaxial to the median vascular bundle. Sclerenchyma on abaxial surface associated with vascular bundles in form of girders.

Epidermis: Adaxial epidermal surface has fan shaped bulliform cells in which central cell is inflated, large shaped (Fig. E, arrow). Abaxial epidermal cells are small, barrel to square shaped covered with thick cuticle.

Mesophyll: Radiate, single layered, isodiametric chlorenchyma cells completely surrounding bundles. Compact homogenous chlorenchymatous cells occuping the major area between the adaxial and abaxial epidermides. Chlorenchyma cells discontinuous by colourless cells between bundles. Colourless cells present (Fig. E) and smaller than bulliform cells with one extension.

Vascular bundles: 2-3 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundle. 5-6 3rd order bundles between consecutive larger bundles and 2-3 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally.

3rd order vascular bundles: Triangular (Fig. D) with vascular tissue consisting of only few indistinguishable vascular elements (Fig. D, arrow).

2nd order vascular bundles: Elliptical shaped (Fig. C)

1st order vascular bundles: (Fig. B)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Phloem divided by intrusion of small fibres resulting in sclerosed phloem (Fig. B, arrow).

Nature of lysigenous cavity and protoxylem: Lysigenous cavity absent and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Shape of metaxylem vessels: Circular

Median vascular bundle: (Fig. D)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Vompletely covered by sclerenchymatous fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity absent and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath:(Fig. D)

Shape: Circular

Shape of bundle sheath cell: Outer tangential wall inflated; radial walls straight

2nd order vascular bundle's bundle sheath: (Fig. C)

Shape: Circular

Shape of bundle sheath cell: Fan shaped

Number of bundle sheath cell: 11-12

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast positioned towards inner tangential wall

Mestome/ Inner sheath: Complete and cells are smaller than the outer sheath cell

1st order vascular bundle's bundle sheath: (Fig. B, arrowhead)

Shape: Circular

Extent of bundle sheath around the vascular bundle: Complete,

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 12-14 parenchyma cells

Bundle sheath cell shape: Fans shaped. Chloroplast positioned towards inner tangential wall

Mestome/ Inner sheath: Complete and cells are smaller than the outer sheath cell

Sclerenchyma:

Adaxial sclerenchyma: Minute subepidermal strands present

Abaxial sclerenchyma: Well developed girder, wider than deep

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very small pointed cap. Epidermal cells at margin are thin with thick outer tangential wall and showed papillae.

LEAF SHEATH ANATOMY (Fig. 206 F-H)

Outline of lamina: Round shaped with inrolled margins. Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavity.

Vascular bundle:

Arrangement of vascular bundle: 1-2 consecutive 3rd order vascular bundles between 1st and 2nd order vascular bundle

3rd order vascular bundle: Hexagonal shaped with vascular tissue consists of only a few indistinguishable vascular elements (Fig. G)

2nd order vascular bundle: Circular shaped

1st order vascular bundle: Circular with phloem completely surrounded by thick walled fibers. Lysigenous cavity absent and enlarged protoxylem vessel present. Circular narrow metaxylem vessels present (Fig. H).

Vascular bundle sheath: (Fig. G, H arrowhead)

Shape: Circular shaped

Extent of bundle sheath around the vascular bundle: Incomplete, abaxially interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 9-10 parenchyma cells

Bundle sheath cell shape: Fan shaped and cells smaller than the ground tissue.

Mestome/ Inner sheath: Complete and cells are smaller than the outer sheath cell.

Sclerenchyma: In form of straight horizontal abaxial strand (Fig. H, arrow).

LIGULE ANATOMY (Fig. 206 I, J)

Shape: Ligule attached to the midrib and parts of lamina region and broad 'V' shaped at connection of point (Fig. I, arrow).

Anatomy: Single layered mesophyll cells between adaxial and abaxial surfaces (Fig. J).

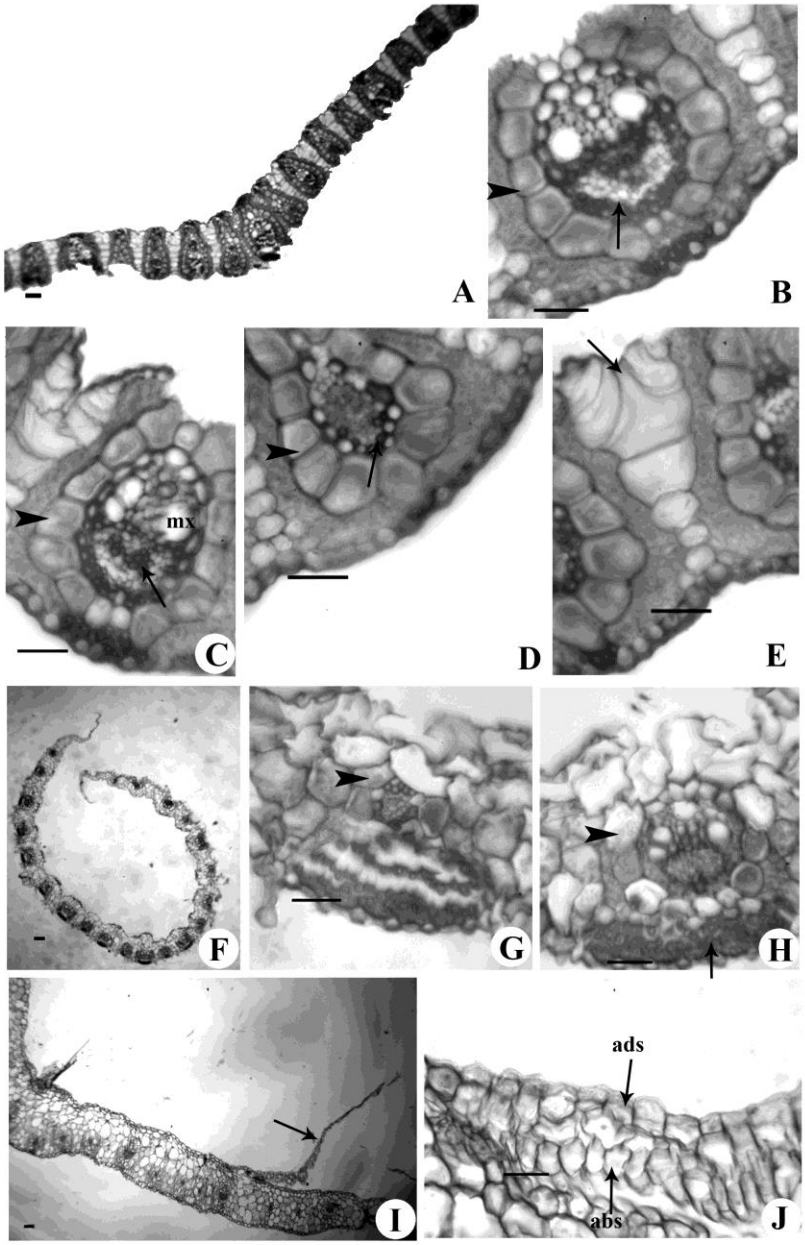

Fig. 206

84. *Dinebra retroflexa*

LEAF LAMINA: (Fig. 207 A-F)

Outline of the lamina: Expanded with straight arms (Fig. A). Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are present on the leaf surface. Medium, narrow furrows between all vascular bundles and rounded ribs present over all vascular bundles. Keel is inconspicuous.

Epidermis: Adaxial epidermal surface has fan shaped bulliform cells in which central cell is inflated, large shaped (Fig. F, arrow). Prickels present (Fig. C, arrow). Abaxial epidermal cells are small, barrel to square shaped covered with thick cuticle.

Mesophyll: Irregulary, vertically arranged chlorenchyma cells continuous between vascular bundles. Colourless cells absent.

Vascular bundles: 4-5 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundle. 5-6 3rd order bundles between consecutive larger bundles and 2-3 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally.

3rd order vascular bundles: Hexagonal (Fig. F) with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: Hexagonal shaped (Fig. E)

1st order vascular bundles: (Fig. D)

Shape: Circular

Relationship of phloem cells and the vascular fibres: Completely covered by sclerenchymatous fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Shape of metaxylem vessels: Circular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. F)

Shape: Circular

Shape of bundle sheath cell: Elliptical and elongated

2nd order vascular bundle's bundle sheath: (Fig. E, arrowhead)

Shape: Circular

Shape of bundle sheath cell: Elliptical and elongated

Number of bundle sheath cell: 6-7

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast positioned towards outer tangential wall

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. D, arrowhead)

Shape: Circular

Extent of bundle sheath around the vascular bundle: Incomplete, adaxially interrupted by sclrenchyma cells

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 10-11

Bundle sheath cell shape: Elliptical shaped. Chloroplast positioned towards inner tangential wall

Mestome/ Inner sheath: Complete and cells are smaller than the outer sheath cell

Sclerenchyma:

Adaxial sclerenchyma: Minute subepidermal strands present (Fig. D,arrow)

Abaxial sclerenchyma: Well developed girder, wider than deep

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very small pointed cap. Epidermal cells at margin are thin with thick outer tangential wall and showed papillae.

LEAF SHEATH ANATOMY (Fig. 207 G-J)

Outline of lamina: Round shaped with inrolled margins (Fig. G). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavity.

Vascular bundle:

Arrangement of vascular bundle: One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Hexagonal with vascular tissue consisting of only few indistinguishable vascular elements (Fig. I)

2nd order vascular bundle: Circular shaped

1st order vascular bundle: Circular with phloem completely surrounded by thick walled fibers. Lysigenous cavity and enlarged protoxylem vessel present. Circular narrow metaxylem vessels present (Fig. H).

Vascular bundle sheath: (Fig. H, arrowhead)

Shape: Circular shaped

Extent of bundle sheath around the vascular bundle: Incomplete, abaxially interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 12-13 parenchyma cells

Bundle sheath cell shape: Fan shaped, cells smaller than the ground tissue.

Mestome/ Inner sheath: Complete and cells are smaller than the outer sheath cell.

Sclerenchyma: In form of straight horizontal band girder on abaxial surface.

LIGULE ANATOMY (Fig. 207 K, L)

Shape: Ligule attached to the midrib and parts of lamina region and broad round shaped at connection of point (Fig. K, arrow)

Anatomy: Two layered mesophyll cells between adaxial and abaxial surfaces (Fig. L).

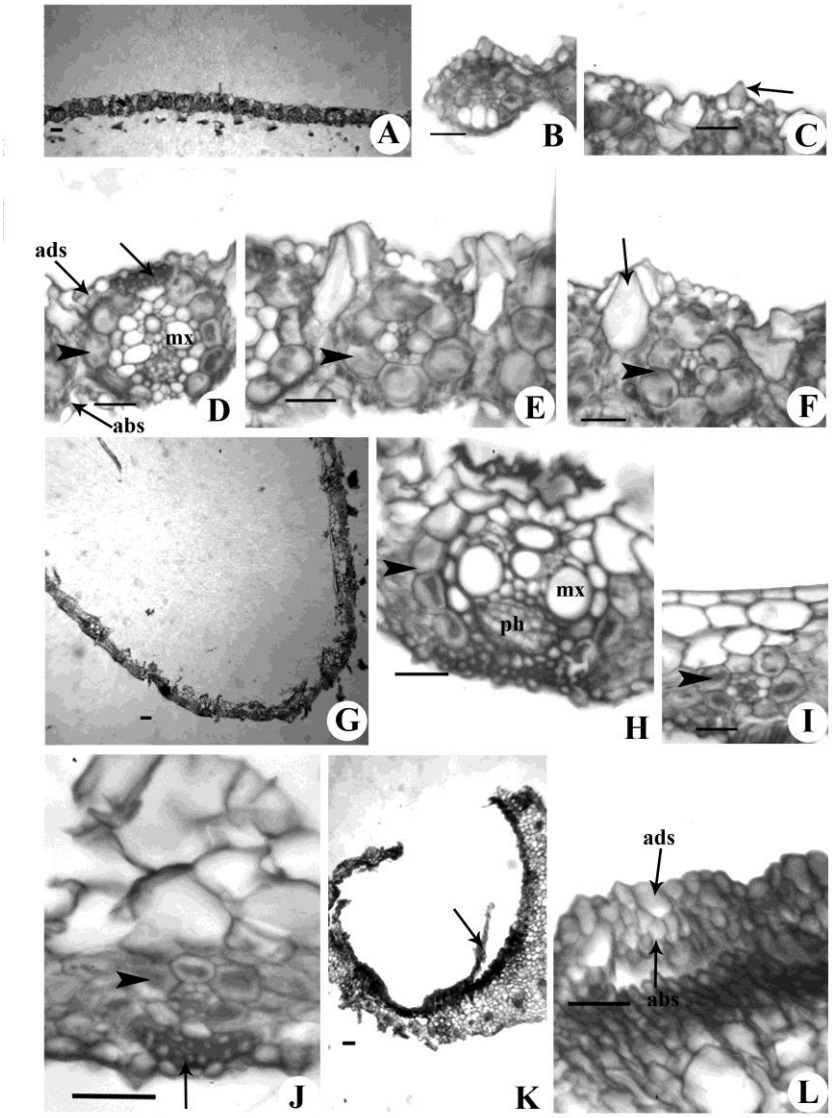

Fig. 207

85. *Eleusine indica*

LEAF LAMINA: (Fig. 208 A-E)

Outline of the lamina: V shaped, broad angle with straight arms (Fig. A). Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are absent on the leaf surface.

Keel is well developed, V-shaped with single median vascular bundle. Small, sclerenhcyma cells are present surrounding adaxial to the median vascular bundle. Sclerenchyma on abaxial surface associated with vascular bundles in form of girders.

Epidermis: Adaxial epidermal surface has fan shaped bulliform cells (Fig. C, arrow). Abaxial epidermal cells are small, barrel to square shaped covered with thick cuticle. Epidermal cells have papillae (Fig. D).

Mesophyll: Radiate, single layered, isodiametric chlorenchyma cells completely surrounding bundles. Compact homogenous chlorenchymatous cells occuping the major area between the adaxial and abaxial epidermides. Chlorenchyma cells continuous between bundles. Colourless cells present which are smaller than bulliform cells and present near the bulliform cells.

Vascular bundles: 3-4 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundle. 5-6 3rd order bundles between consecutive larger bundles and 2-3 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed abaxially.

3rd order vascular bundles: Hexagonal (Fig. E) with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: Elliptical shaped

1st order vascular bundles: (Fig. D)

Shape: Circular

Relationship of phloem cells and the vascular fibres: Completely covered by sclerenchymatous fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity absent and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Shape of metaxylem vessels: Circular

Median vascular bundle: (Fig. C)

Shape: Cicular

Relationship of phloem cells and the vascular fibres: Completely covered by sclerenchymatous fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity absent and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. E, arrowhead)

Shape: Circular

Shape of bundle sheath cell: Fan shaped

2nd order vascular bundle's bundle sheath:

Shape: Circular

Shape of bundle sheath cell: Fan shaped

Number of bundle sheath cell: 8-9

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast positioned towards inner tangential wall

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. D, arrowhead)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 12-13 parenchyma cells

Bundle sheath cell shape: Fan shaped. Chloroplast positioned towards inner tangential wall

Mestome/ Inner sheath: Complete and cells are smaller than the outer sheath cell.

Midrib vascular bundle: (Fig. C)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Complete

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 12-13 parenchyma cells

Bundle sheath cell shape: Fan shaped. Chloroplast positioned towards inner tangential wall

Mestome/ Inner sheath: Complete and cells are smaller than the outer sheath cell.

Sclerenchyma:

Adaxial sclerenchyma: Minute subepidermal strands present

Abaxial sclerenchyma: Well developed girder, wider than deep

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very small rounded cap. Epidermal cells at margin are thin with thick outer tangential wall.

LEAF SHEATH ANATOMY (Fig. 208 F-I)

Outline of lamina: 'U' shaped with inrolled margins (Fig. F). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular shaped with thick cuticle. Stomata present (Fig. I, arrow).

Ground tissue: Parenchymatous with absence of air cavity.

Vascular bundle:

Arrangement of vascular bundle: 1-2 consecutive 3rd order vascular bundles between 1st and 2nd order vascular bundle

3rd order vascular bundle: Pentagonal with vascular tissue consisting of only few indistinguishable vascular elements (Fig. H)

2nd order vascular bundle: Elliptical shaped

1st order vascular bundle: Elliptical with phloem completely surrounded by thick walled fibers. Lysigenous cavity absent and enlarged protoxylem vessel present. Circular narrow metaxylem vessels present (Fig. G).

Vascular bundle sheath: (Fig. G, arrowhead)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Incomplete, abaxially interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 11-12 parenchyma cells

Bundle sheath cell shape: Fan shaped and cells smaller than the ground tissue.

Mestome/ Inner sheath: Complete and cells are smaller than the outer sheath cell.

Sclerenchyma: In form of straight horizontal band of girder on abaxial surface (Fig. G, H arrow).

LIGULE ANATOMY (Fig. 208 J, K)

Shape: Ligule attached to the midrib and broad round shaped at connection point (Fig. J, arrow)

Anatomy: Two layered mesophyll cells between adaxial and abaxial surfaces (Fig. K).

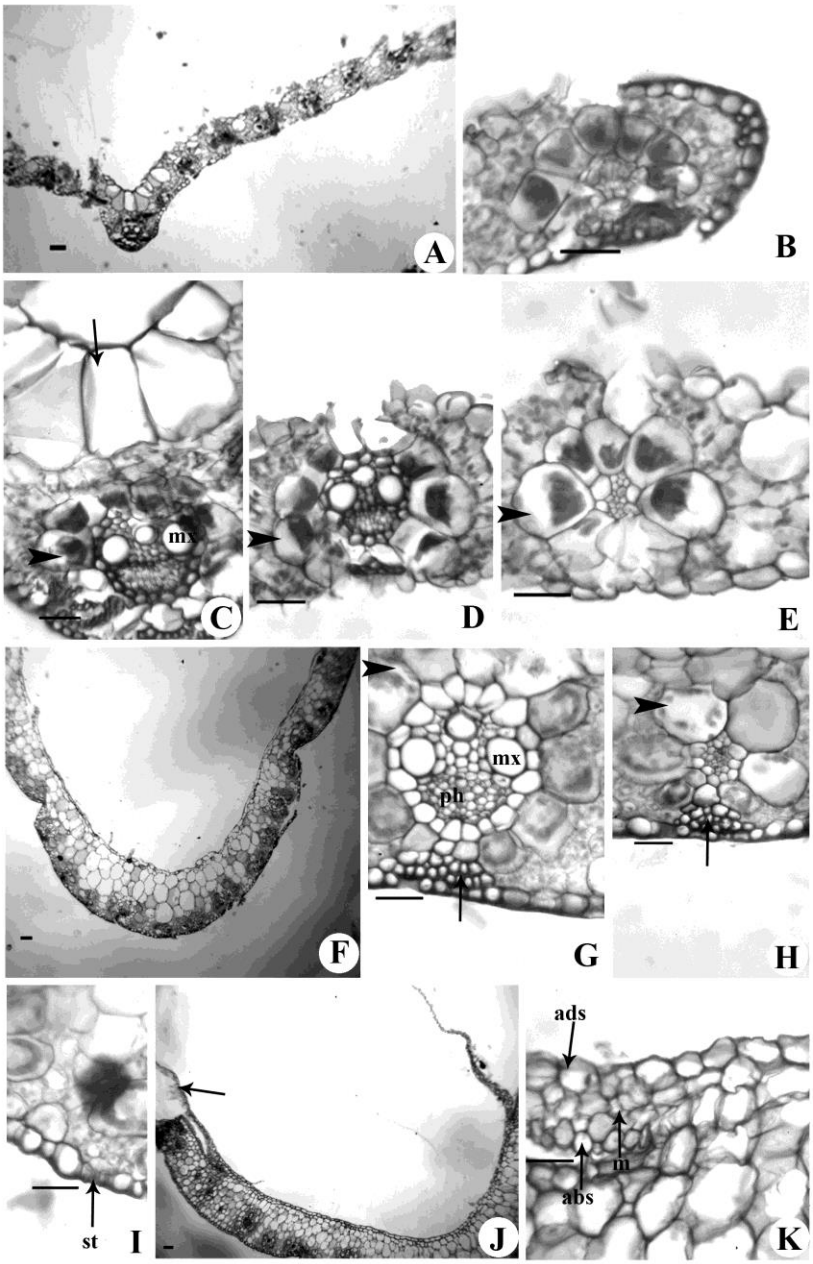

Fig. 208

Eragrostiella

86. *Eragrostiella bachyphylla* (Fig. 209)

87. *Eragrostiella bifaria* (Fig. 210)

LEAF LAMINA: (Fig. 209 A-E, 210 A-F)

Outline of the lamina: 'V' shaped, wide angled with straight arms (Fig. 209 A, 210 A). Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are present on the leaf surface. Shallow, narrow furrows present between all vascular bundles with flat ribs present over all vascular bundles. Keel is inconspicuous.

Epidermis: Adaxial epidermal surface has fan shaped bulliform cells, longated with parallel side in both species (Fig. 209 C, arrow, 210 C, arrow). Adaxial surface has small, barrel shaped cells with thick cuticle. Sharp macrohairs present in base of bulliform cells in *E. bachyphylla* (Fig. 209 D, arrow). Abaxial epidermal cells are round to barrel shaped covered with thick cuticle.

Mesophyll: Incompletely radiatechlorenchyma cells present between abaxial and adaxial epidermises. Colourless cells present, associated with bulliform cells and smaller than bulliform cells with single extension, extended till opposite epidermis in both species (Fig. 209 C, arrow, 210 C, arrow).

Vascular bundles: 1-2 1st order in *E. bachyphylla* or 3-4 1st order in *E. bifaria* vascular bundles regularly arranged from median bundle to marginal bundle in half lamina. 1-2 3rd order in *E. bachyphylla* or 2-3 3rd order in *E. bifaria* bundles between consecutive larger bundles and 1-2 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally.

3rd order vascular bundles: (Fig. 209 B, 210 D)

Circular in *E. bachyphylla* or elliptical in *E. bifaria* with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: (Fig. 210 E)

Circular in *E. bachyphylla* and elliptical in *E. bifaria*

1st order vascular bundles: (Fig. 209 F, 210 F)

Shape: Circular in *E. bachyphylla* or elliptical in *E. bifaria*

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Shape of metaxylem vessels: Circular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. 209 B, 210 E)

Shape: Circular in *E. bachyphylla* and elliptical in *E. bifaria*

Shape of bundle sheath cell: Fan shaped

2nd order vascular bundle's bundle sheath: (Fig. 210 E)

Shape: Circular in *E. bachyphylla* and elliptical *E. bifaria*

Shape of bundle sheath cell: Fan shaped

Number of bundle sheath cell: 7-8

Nature of bundle sheath (either complete or incomplete): Incomplete, adaxially and abaxially interrupted by sclerenchyma cells in *E. bachyphylla*, only on abaxially interrupted by sclerenchyma cells in *E. bifaria*

Chloroplast position in bundle sheath cell: Chloroplast positioned towards inner tangential wall

Mestome/ Inner sheath: Complete and inner sheath cells are smaller than the outer bundle sheath cell

1st order vascular bundle's bundle sheath: (Fig. 209 D, 210 F)

Shape: Circular in *E. bachyphylla* and elliptical in *E. bifaria*

Extent of bundle sheath around the vascular bundle: Incomplete, adaxially and abaxially interrupted by sclrenchyma cells

Extension of bundle sheath: Anchored shaped well developed girder present presented towards adaxially and abaxially in *E. bachyphylla*, only on abaxially interrupted by sclerenchyma cells in *E. bifaria*

Number of cells comprising the bundle sheath: 8-9 in *E. bachyphylla* and 9-10 *E. bifaria*

Bundle sheath cell shape: Fan shaped. Chloroplast positioned towards inner tangential wall.

Mestome/ Inner sheath: Complete in *E. bifaria* and incomplete, adaxially and abaxially interrupted by sclrenchyma cells in *E. bachyphylla*. Inner sheath cells are smaller than the outer bundle sheath cell.

Sclerenchyma:

Adaxial sclerenchyma: Well developed arched shaped girder present over vascular bundles in *E. bachyphylla* while equidmentional girder present over vascular bundles in *E. bifaria*

Abaxial sclerenchyma: Well developed arched shaped girder present below vascular bundle

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming well developed pointed fibrous cap curved towards adaxil surface (*E. bachyphylla*) and not curved in *E. bifaria*. Epidermal cells are small, thin walled. (Fig. 210 B)

LEAF SHEATH ANATOMY (Fig. 209 F-I, 210 G-J)

Outline of lamina: 'V' shaped, wide angled in *E. bachyphylla* and round shaped in *E. bifaria* with inrolled margins (Fig. 209 F, Fig. 210 G). Ribs and furrows absent on leaf sheath surface.

Epidermis: Adaxial epidermal cells: flat, rectangular.

Abaxial epidermal cells: small, barrel shaped with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavity.

Vascular bundle:

Arrangement of vascular bundle: 1-2 in *E. bachyphylla* or 2-3 in *E. bifaria* consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: (Fig. 209 H, 210 I)

Circular with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundle: Circular shaped

1st order vascular bundle: (Fig. 209 G, 210 H)

Circular with phloem completely surrounded by thick walled fibers. Lysigenous cavity and enlarged protoxylem vessel present. Circular narrow metaxylem vessel elements.

Vascular bundle sheath: (Fig. 209 G, arrowhead, Fig. 210 H, arrowhead)

Shape: Circular

Extent of bundle sheath around the vascular bundle: Sheath incomplete, abaxially interrupted by sclerenchyma cells

Number of cells comprising the bundle sheath: 8-9 parenchyma cells

Bundle sheath cell shape: Fan shaped

Mestome/ Inner sheath: Complete made up of by sclerenchyma cells, inner bundle sheath smaller than outer bundle sheath

Sclerenchyma: In form of well developed anchor shaped girder on abaxial surface in both speceis (Fig. 209 I, arrow, 210 J, arrow).

LIGULE ANATOMY (Fig. 209 J, K, 210 K, L)

Shape: Ligule attached to the half width of the leaf sheath region and it is round shaped at the connection point in both species (Fig. 209 J, 210 K)

Anatomy: Single in *E. bachyphylla* or two in *E. bifaria* layered mesophyll cells between adaxial and abaxial surfaces (Fig. 209 K, 210 L).

Differentiating features:

Circular shaped vascular bundles, 'V' shaped leaf sheath…… *E. bachyaphylla*

Elliptical shaped vascular bundles, round shaped leaf sheath…..…… *E. bifaria*

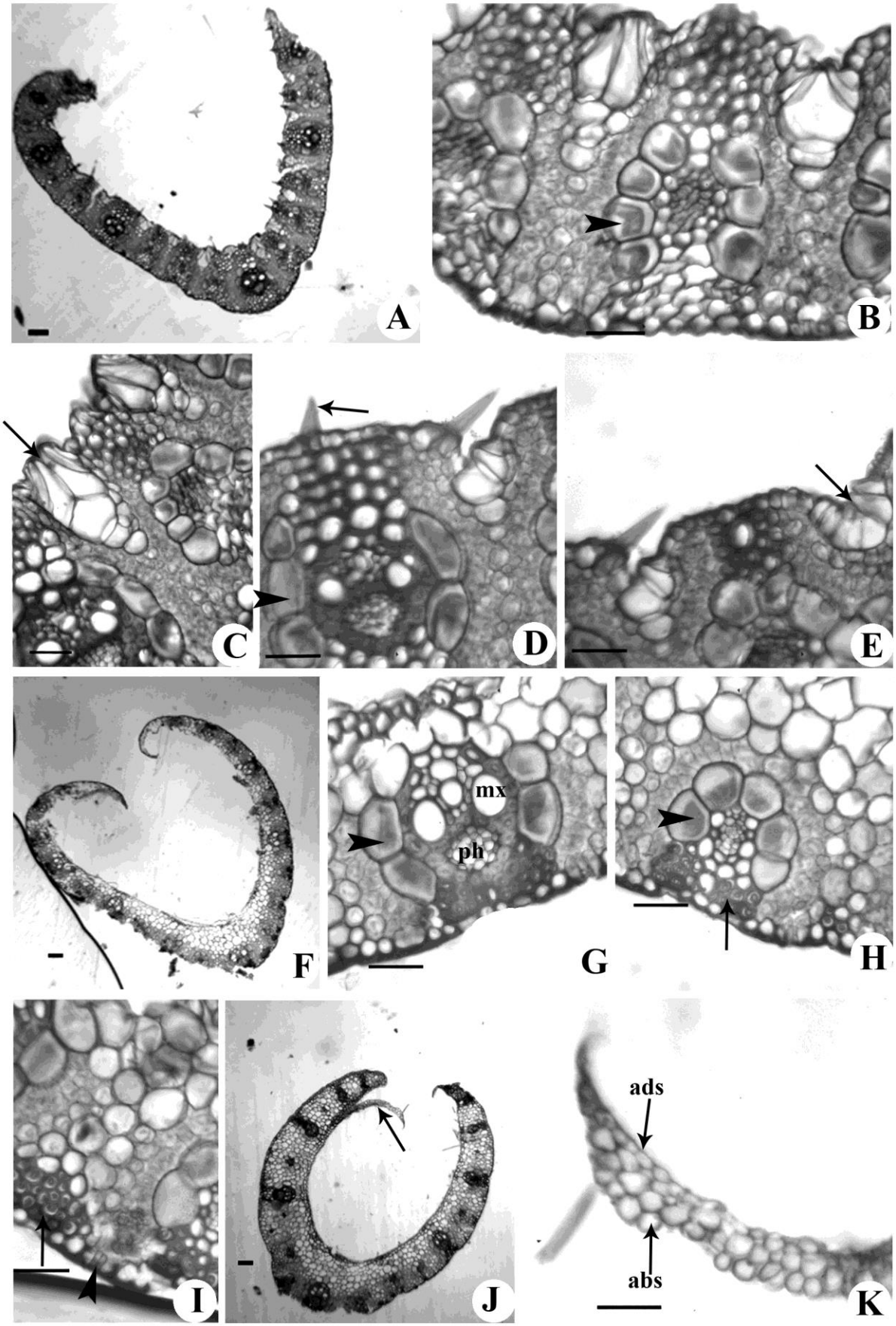

Fig. 209

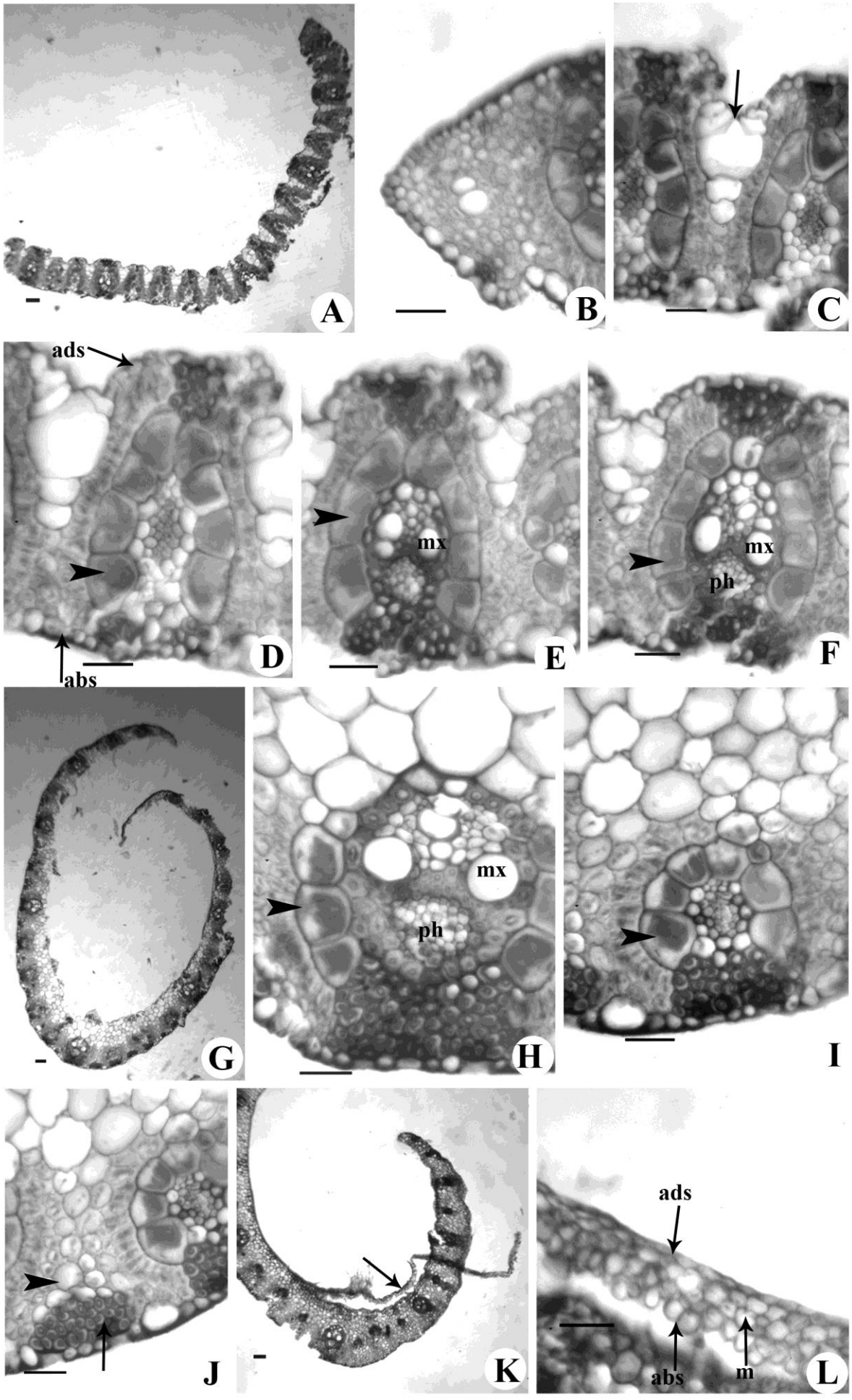

Fig. 210

Eragrostis

88. *Eragrostis cilianensis* (Fig. 211)

89. *Eragrostis ciliaris* (Fig. 212)

90. *Eragrostis japonica* (Fig. 213)

91. *Eragrostis nutans* (Fig. 214)

92. *Eragrostis pilosa* (Fig. 215)

93. *Eragrostis tenella* (Fig. 216)

94. *Eragrostis tremula* (Fig. 217)

95. *Eragrostis unioloides* (Fig. 218)

96. *Eragrostis viscosa* (Fig. 219)

LEAF LAMINA: (Fig. 211 A-F, 212 A-D, 213 A-D, 214 A-D, 215 A-F, 216 A-F, 217 A-F, 218 A-G, 219 A-E)

Outline of the lamina: Expanded with gently straight arms in *E. cilianensis* and *E. ciliaris* (Fig. 211 A, 212 A), 'V' shaped wide angled with straight arms in *E. japonica, E.nutans, E. pilosa, E. tenella* and *E. unioloides* (213 A, 214 A, 215 A, 216 A, 218 A) while inrolled in *E. tremula* and *E. viscosa.*

Two halves are asymmetrical on either side of the median vascular bundle. Ribs and furrows are present on the leaf surface. Shallow, wide furrows in *E. cilianensis, E. ciliaris, E. japonica* and *E.nutans;* narrow, medium furrows in *E. pilosa, E. tenella, E. tremula, E. unioloides* and *E. viscosa* present between all vascular bundles. Flat ribs present in *E. pilosa* and *E. tenella* while other species have round ribs present over all vascular bundles.

Keel is inconspicuous in *E. tremula* while other species showed well developed. V-shaped with single median vascular bundle in *E. cilianensis, E. ciliaris, E. japonica, E.nutans, E. pilosa, E. tenella* and *E. viscosa* while in *E. unioloides* round shaped. Small, round parenchyma cells are present surround the median vascular bundle adaxially. Sclerenchyma is present on abaxial surface associated with vascular bundles in form of narrow girders in all species except in *E. unioloides, E. viscosa*.

Epidermis: Adaxial epidermal surface has fan shaped bulliform cells in all species (Fig. 211 C arrow, 212 B, 213 C, 214 C arrow, 215 E, 216 F, 217 F). Abaxial epidermis has round to barrel shaped covered with thick cuticle. Short straight hook is present in *E. tenella* (Fig. 216 E). Short, slender hair present in *E. tremula* (Fig. 217 E). Long, slender macrohairs present in *E. unioloides*. Short macrohairs present in *E. viscosa* (Fig. 219 B arrow). Prickles present in *E. japonica* (Fig. 213 D arrow).

Abaxial epidermal cells have barrel shaped with thick cuticle. In *E. unioloides* cuticle is equal to or greater than the depth of the average epidermal cells.

Mesophyll: Radiate, single layered, tubular shaped chlorenchyma cells present between abaxial and adaxial epidermis in *E. cilianensis, E. tremula, E. unioloides* and *E. viscosa* or indistinctly or incompletely radiate chlorenchyma continuous between bundles and in form of horizontally elongated strap in *E. nutans, E. pilosa* and *E. tenella* while irregular, vertically arranged chlorenchyma in *E. ciliaris* and *E. japonica.*

Colourless cells absent in *E. ciliaris, E. japonica, E. nutans, E. tremula* and *E. viscosa* while it was present in *E. cilianensis, E. unioloides* and *E. tenella.* They are associated with bulliform cells and smaller than bulliform cells with single extension.

Vascular bundles: 3-4 in *E. cilianensis, E. ciliaris* and *E. tenella*, 2-3 in *E. pilosa, E. japonica* and *E. nutans*, 3 in *E. tremula* and *E. viscosa*, 4 in *E. unioloides* 1st order vascular bundles regularly arranged from median bundle to marginal bundlein half lamina.

2-3 in *E. tremula* and *E. viscosa*, 3-4 in *E. japonica* and *E. nutans*, 3 in *E. unioloides*, 4-5 in *E. ciliaris* and *E. tenella*, 5-6 in *E. pilosa*, 7-8 in *E. cilianensis* 3rd order bundles between consecutive larger bundles.

4-5 in *E. cilianensis*, 2-3 in *E. pilosa, E. viscosa, E. ciliaris, E. japonica* and *E. nutans*, 3-4 in *E. tenella*, 1-2 in *E. tremula*, 3 in *E. unioloides* 2nd order bundles between consecutive 1st order bundles. All the vascular bundles present abaxially at same level.

3rd order vascular bundles: (Fig. 211 E, 213 C, 214 B, C, 215 D, 216 F, 217 C, 219 D)

Elliptical in *E. cilianensis* and *E. unioloides*, pentagonal in *E. viscosa*, hexagonal in *E. nutans* and *E. pilosa*, circular in *E. ciliaris, E. japonica* and *E. tenella*, triangular in *E. tremula* with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: (Fig. 214 E, 215 F) Circular in *E. cilianensis, E. ciliaris, E. japonica, E. nutans, E. pilosa* and *E. tenella*, triangular in *E. tremula*, elliptical in *E. unioloides* and *E. viscosa*.

1st order vascular bundles: (Fig. 211 D, 212 B, 213 B, 214 F, 215 C, 216 E, 217 D, 219 E)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels in all species except in *E. pilosa, E. viscosa* showed narrow vessels

Shape of metaxylem vessels: Circular

Median vascular bundle: (Fig. 211 C, 212 C, 214 D, 215 C)

Shape: Elliptical in all species except round in *E. unioloides*

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Lysigenous cavity and enlarged protoxylem vessel present

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Wide vessels in all species except in *E. pilosa, E. viscosa* showed narrow vessels

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. 211 E, 213 C, 214 B, C, 215 D, 216 F, 217 C, 219 D)

Shape: Horse shoe in *E. cilianensis* and *E. pilosa*, round in *E. ciliaris, E. japonica* and *E. nutans*, triangular in *E. tenella, E. tremula* and *E. viscosa*, elongated in *E. unioloides.*

Shape of bundle sheath cell: Fan shaped in *E. cilianensis*, elliptical in *E. ciliaris, E. japonica, E. nutans, E. tremula* and *E. unioloides*, radial walls straight, tangential walls inflated in *E. pilosa* and *E. tenella*, elliptical and elongated cells with two basal cells towards abaxial surface are large in *E. viscosa.*

2nd order vascular bundle's bundle sheath:

Shape: Horse shoe shaped in *E. cilianensis, E. nutans, E. pilosa* and *E. tenella*, triangular in *E. ciliaris, E. tremula* and *E. viscosa*, round in *E. japonica, E. unioloides*

Shape of bundle sheath cell: Fan shaped in *E. cilianensis*, elliptical and elongated in *E. ciliaris, E. japonica, E. unioloides* and *E. tremula*, elliptical and elongated cells with two basal cells towards abaxial surface are large in *E. viscosa*, radial walls straight, tangential walls inflated in *E. tenella, E. pilosa* and *E. nutans.*

Number of bundle sheath cell: 7-8 in *E. pilosa, E. japonica* and *E. nutans*, 9-10 in *E. tenella* and *E. cilianensis*, 8-9 in *E. ciliaris, E. tremula* and *E. viscosa*, 16 in *E. unioloides*, 11-12 in *E. japonica*

Nature of bundle sheath (either complete or incomplete): Complete in *E. cilianensis E. ciliaris, E. japonica, E. viscosa* and *E. unioloides*

while incomplete, abaxially interrupted by sclerenchyma in *E. pilosa, E. tenella, E. tremula* and *E. nutans.*

Chloroplast position in bundle sheath cell: Chloroplast positioned towards inner tangential wall in *E. cilianensis*, translucent chloroplast in *E. ciliaris,* chloroplast fills entire lumen in *E. unioloides*, chloroplast placed centrally in *E. japonica, E. nutans, E. pilosa, E. tenella, E. tremula* and *E. viscosa.*

Mestome/ Inner sheath: Absent in *E. cilianensis, E. ciliaris, E. japonica, E. tenella* and *E. viscosa* while present in other species. Complete, inner bundle sheath smaller than outer bundle sheath in *E. pilosa, E. nutans* and *E. unioloides.*

1st order vascular bundle's bundle sheath: (Fig. 211 D, 212 B, 213 B, 214 F, 215 C, 216 E, 217 D, 219 E)

Shape: Horse shoe shaped in *E. cilianensis, E. pilosa* and *E. tenella,* round in *E. ciliaris* and *E. japonica,* elliptical in *E. nutans, E. tremula, E. unioloides, E. cilianensis* and *E. ciliaris*, triangular in *E. viscosa*

Extent of bundle sheath around the vascular bundle: Complete in *E. cilianensis, E. japonica* and *E. viscosa* while incomplete, abaxially interrupted by sclerenchyma cells in *E. ciliaris, E. nutans, E. pilosa, E. tenella* and *E. tremula* or abaxially interrupted by sclerenchyma, adaxially interrupted by parenchyma cells in *E. unioloides.*

Extension of bundle sheath: Absent in *E. cilianensis, E. japonica* and *E. viscosa.* Narrow, small girder present on abaxial side in *E. ciliaris, E. nutans, E. pilosa* and *E. tenella* while broad abaxial extension of the bundle sheath in *E. tremula* in *E. unioloides.*

Number of cells comprising the bundle sheath: 11-12 in *E. cilianensis* and *E. ciliaris,* 10-11 in *E. pilosa* and *E. tenella,* 13-14 in *E. tremula* and *E. unioloides,* 12-13 in *E. viscosa* and *E. japonica,* 16-17 *in E. nutans.*

Bundle sheath cell shape: Fan shaped in *E. cilianensis,* elliptical and elongated cells in *E. japonica, E. nutans, E. tremula* and *E. unioloides.* Elliptical cells and cells towards adaxial side are inflated and bigger in size than the others in *E. ciliaris,* cells are with straight radial walls, inflated tangential walls in *E. pilosa* and *E. tenella,* cells elliptical and elongated with two basal cells towards abaxial surface are large in *E. viscosa.*

Chloroplast positioned towards inner tangential wall in *E. cilianensis,* chloroplast translucent in *E. ciliaris,* chloroplast placed

centrally in *E. japonica, E. nutans, E. pilosa, E. tenella, E. tremula* and *E. viscosa,* chloroplast fills entire lumen of cell in *E. unioloides.*

Mestome/ Inner sheath: Present in all species except in *E. tremula* it is absent. Complete, inner bundle sheath smaller than outer bundle sheath in *E. cilianensis, E. nutans, E. pilosa, E. tenella, E. unioloides* and *E. viscosa* while incomplete, abaxially interrupted by sclerenchyma and inner bundle sheath smaller than outer bundle sheath in *E. ciliaris* and *E. japonica.*

Sclerenchyma:

Adaxial sclerenchyma: Absent in *E. japonica.* Narrow strands present over vascular bundles in *E. cilianensis,* subepidermal strands present in *E. ciliaris,* minute strand consisting of only a few subepidermal fibers in *E. nutans, E. pilosa, E. tenella, E. tremula* and *E. viscosa* and well developed girder, wider than deep and it follows shape of abaxial rib in *E. unioloides.*

Abaxial sclerenchyma: Well developed straight horizontal strands present in *E. cilianensis, E. pilosa* and *E. tremula*, well developed girder, wider than deep girder present below 1st order vascular bundle in *E. ciliaris, E. japonica, E. nutans, E. pilosa, E. tenella* and *E. unioloides*, as wide as tall in *E. tremula* and well developed narrow strand in *E. viscosa.*

Sclerenchyma between bundles: Absent in all species.

Sclerenchyma in leaf margin: Forming very small pointed fibrous cap in all species except round shaped in in *E. tremula, E. unioloides*. Epidermal cells are thin walled, elongated, arranged side by side.

LEAF SHEATH ANATOMY (Fig. 211 H-J, 212 E-H, 213 G-I,215 G-J, 216 G-J, 217 G-J, 218 H-K, 219 F-G)

Outline of lamina: V shaped, standard angle with overlapping inrolled margins in *E. cilianensis, E. nutans, E. pilosa, E. tenella* and *E. unioloides* (Fig. 211 H, 214 G, 215 G, 216 G, 218 H) or round shaped with inrolled margin in *E. ciliaris, E. japonica, E. tremula* and *E. viscosa* (Fig. 212 E, 213 E, 217 G, 219 F) .

Ribs and furrows present in all species except in *E. unioloides* and *E. viscosa* showed it is absent. Shallow, wide furrows present with rounded ribs present over all vascular bundles except medium, wide furrows present between all vascular bundles in *E. japonica.*

Epidermis: Adaxial epidermal cells: flat, rectangular.

Abaxial epidermal cells: small, barrel shaped with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavity in *E. cilianensis, E. ciliaris, E. tenella* and *E. tremula.* Round shaped air cavities in *E. unioloides* and *E. viscosa* or oval shaped air cavities in *E. pilosa, E. japonica* and *E. nutans.*

Vascular bundle:

Arrangement of vascular bundle: 1-2 consecutive 3rd order vascular bundles between 1st and 2nd order vascular bundle

3rd order vascular bundle: Elliptical in *E. cilianensis* and *E. unioloides*, round in *E. ciliaris*, *E. japonica*, *E. nutans*, *E. pilosa* and *E. viscosa*, hexagonal in *E. tenella*, pentagonal in *E. tremula* with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundle: Circular shaped in *E. cilianensis* and *E. ciliaris*, elliptical in *E. japonica*, *E. nutans*, *E. pilosa*, *E. tenella*, *E. tremula*, *E. unioloides* and *E. viscosa*.

1st order vascular bundle: Circular in all species except in *E. pilosa* and *E. viscosa* it is elliptical. Phloem completely surrounded by thick walled fibers. Lysigenous cavity and enlarged protoxylem vessel present. Circular narrow metaxylem vessel elements in *E. cilianensis*, *E. pilosa*, *E. tenella* and *E. unioloides* while other species showed wide metaxylem vessel elements.

Vascular bundle sheath:

Shape: Circular in all species except elliptical in *E. unioloides* and horse shoe shaped in *E. viscosa*.

Extent of bundle sheath around the vascular bundle: Sheath incomplete, abaxially interrupted by sclerenchyma cells in all species except in *E. unioloides* it is complete.

Number of cells comprising the bundle sheath: 10-11 in *E. cilianensis* and *E. ciliaris*, 8-9 in *E. pilosa*, 17-18 in *E. tremula*, 9-10 in *E. tenella*, 11-13 in *E. japonica*, *E. nutans* and *E. viscosa*, 22-23 in *E. unioloides* parenchyma cells

Bundle sheath cell shape: Fan shaped in *E. cilianensis*, Elliptical cells in *E. ciliaris*, *E. japonica*, *E. nutans*, *E. tremula*, *E. unioloides* and *E. viscosa*, cells with straight radial walls, inflated tangential walls in *E. pilosa* and *E. tenella*.

Mestome/ Inner sheath: Present in all species except in *E. tremula* it is absent. Complete, inner bundle sheath smaller than outer bundle sheath in *E. cilianensis*, *E. nutans*, *E. pilosa*, *E. tenella* and *E. viscosa* while incomplete, abaxially interrupted by sclerenchyma and inner bundle sheath smaller than outer bundle sheath in *E. ciliaris*, *E. japonica* and *E. unioloides*.

Sclerenchyma: In form of straight, horizontal band in *E. cilianensis*, *E. pilosa*, well developed, wider than deep girder in *E. ciliaris*, *E. japonica* and *E. nutans*, straight horizontal well developed girder t in *E. tenella*, triangular shaped girder in *E. tremula*, anchored shaped girder present bleow vasucalr bundle present in *E. unioloides*, well developed narrow girder in *E. viscosa*.

LIGULE ANATOMY (Fig. 211 K, L, 212 I, J, 213 J, K, 215 K,L, 216 K, L, 217 K, L, 218 L, M, 219 H, I)

Shape: Ligule attached to the lamina more than half length of it and blunt narrow 'V' shaped at the connection point in *E. cilinensis* and *E. japonica,* ligule attached to the lamina till the ¾ than is free and blunt, broad 'V' shaped at the connection in *E. ciliaris* (Fig. 212 I) while ligule attached to the lamina only ¼ portions and at connection point it was very almost like straight 'V' shaped with small sharp angled in *E. nutans* (Fig. 214 K)

Ligule attached to the midrib region and patially with lamina region and the connection it is broad round shaped in *E. pilosa, E. tenella* and *E. unioloides,* ligule attached only to the midrib region and broad round shaped at connections point in *E. tremula* (Fig. 217 J) or ligule attached to the half width of the leaf sheath region and it is round shaped at the connection point in *E. viscosa* (Fig. 219 H).

Anatomy: Two in *E. cilinensis*, three in *E. nutans*, single in *E. pilosa* and *E. tenella* or more than three in *E. ciliaris, E. japonica, E. tremula, E. unioloides* and *E. viscosa* layered mesophyll cells between adaxial and abaxial surfaces. Sclerenchyma cells present towards abaxila surface in *E. viscosa* (Fig. 219 I, arrowhead).

Differentiating features:

Inrolled leaf blade

Colourless cells present, centrally placed chloroplast in mesophyll cells…….. ……*E. tremula*

Colourless cells absent, chloroplast concentrated towards outer tangential wall of mesophyll cells…….. *E. viscosa*

Exapanded leaf blade

Round shaped outline of leaf sheath……..…….. *E. ciliaris*

'V' shaped outline of leaf sheath

'V' shaped ligule……..……. *E. cilianensis*

Round shaped ligule

Air cavities absent in leaf sheath…..……..….. *E. tenella*

Round shaped air cavities present in leaf sheath… *E. unioloides*

'V' shaped leaf blade

Vascular bundles are arranged towards abaxial side of leaf……..*E. pilosa*

Vascular bundles are placed center of leaf

Lysigenous cavity absent, chloroplast placed centrally of mesophyll cells…..……. *E. japonica*

Lysigenous cavity present, chloroplast concentrated near inner wall of tangential wall of mesophyll cells…… *E. nutans*

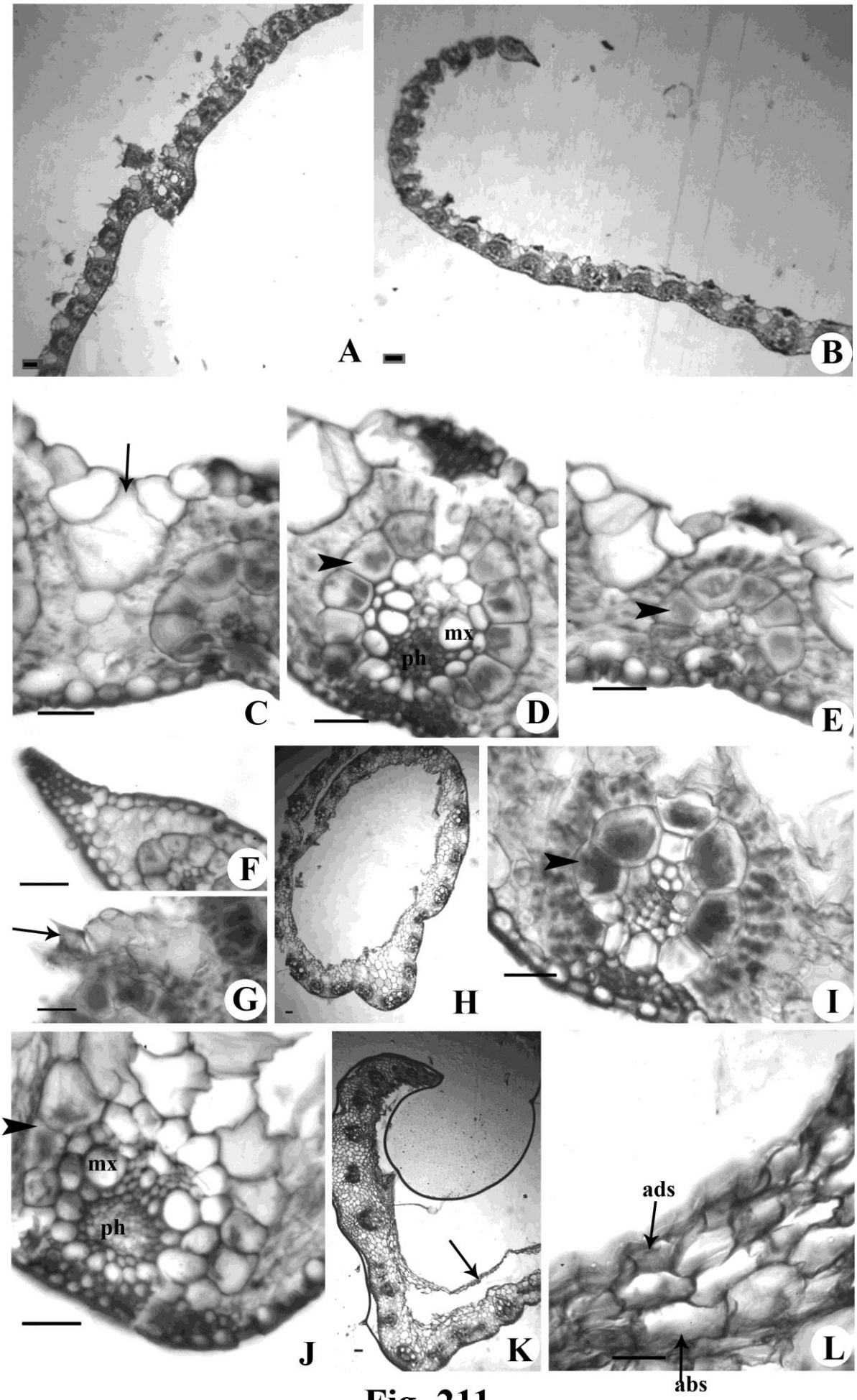

Fig. 211

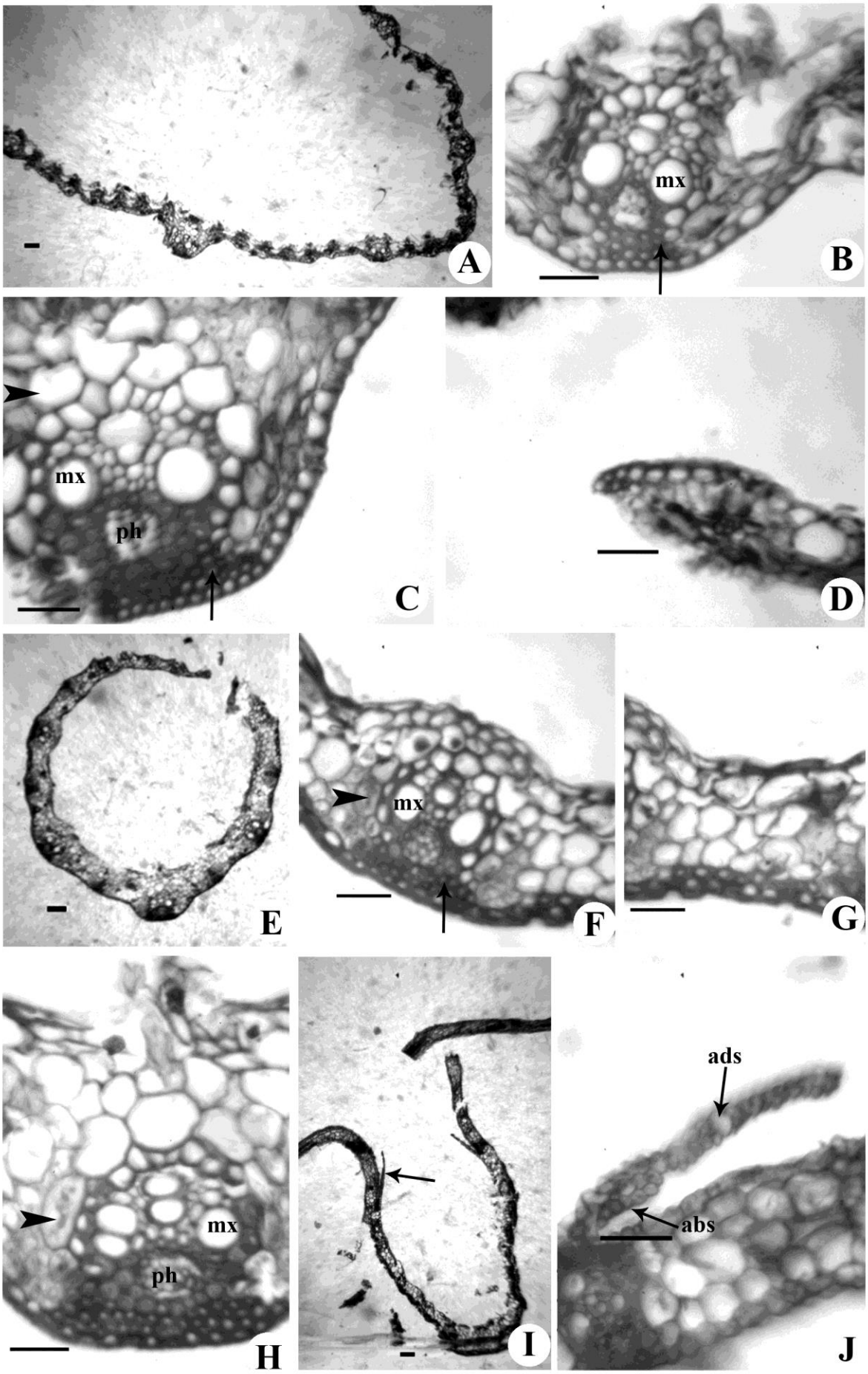

Fig. 212

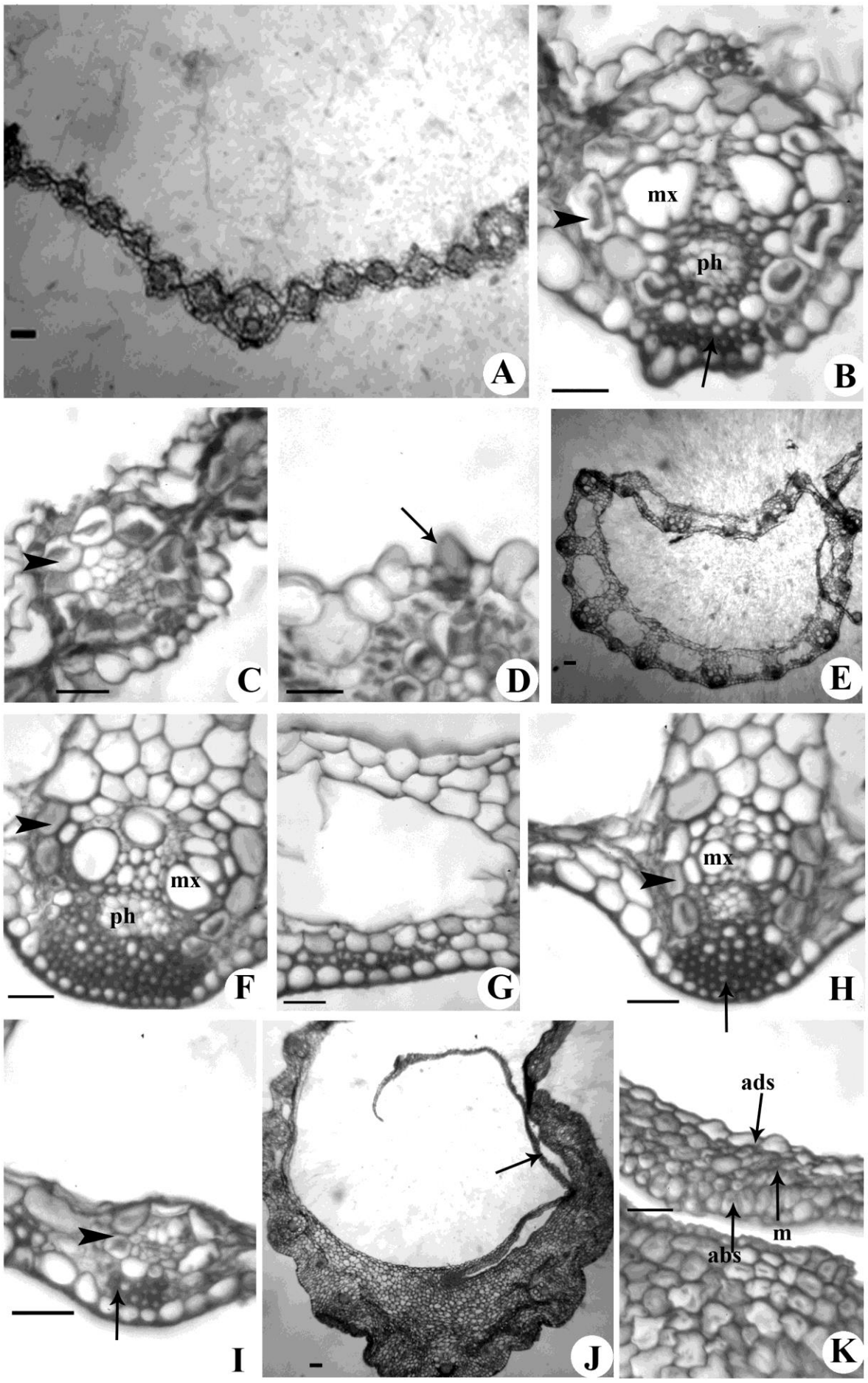

Fig. 213

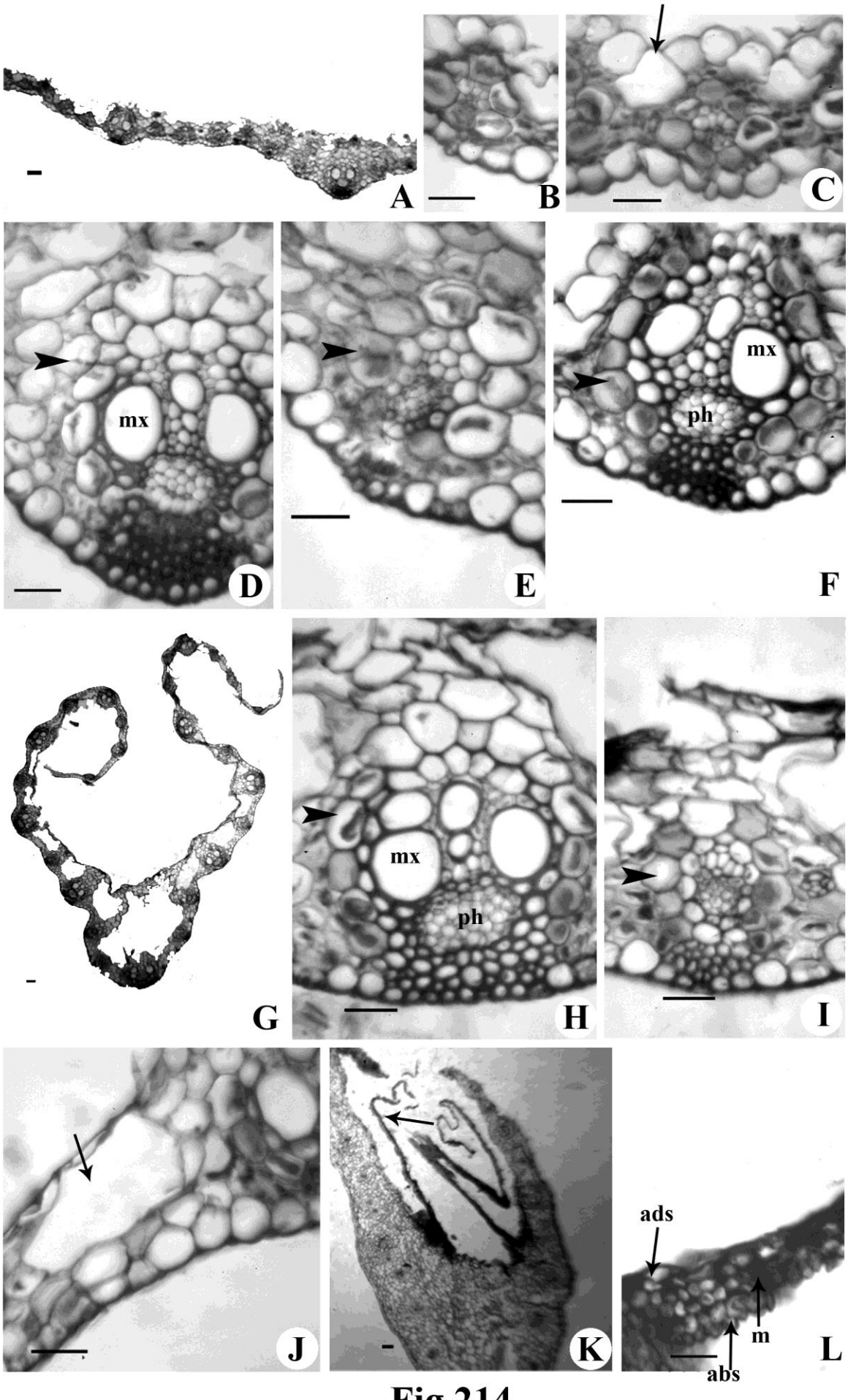

Fig.214

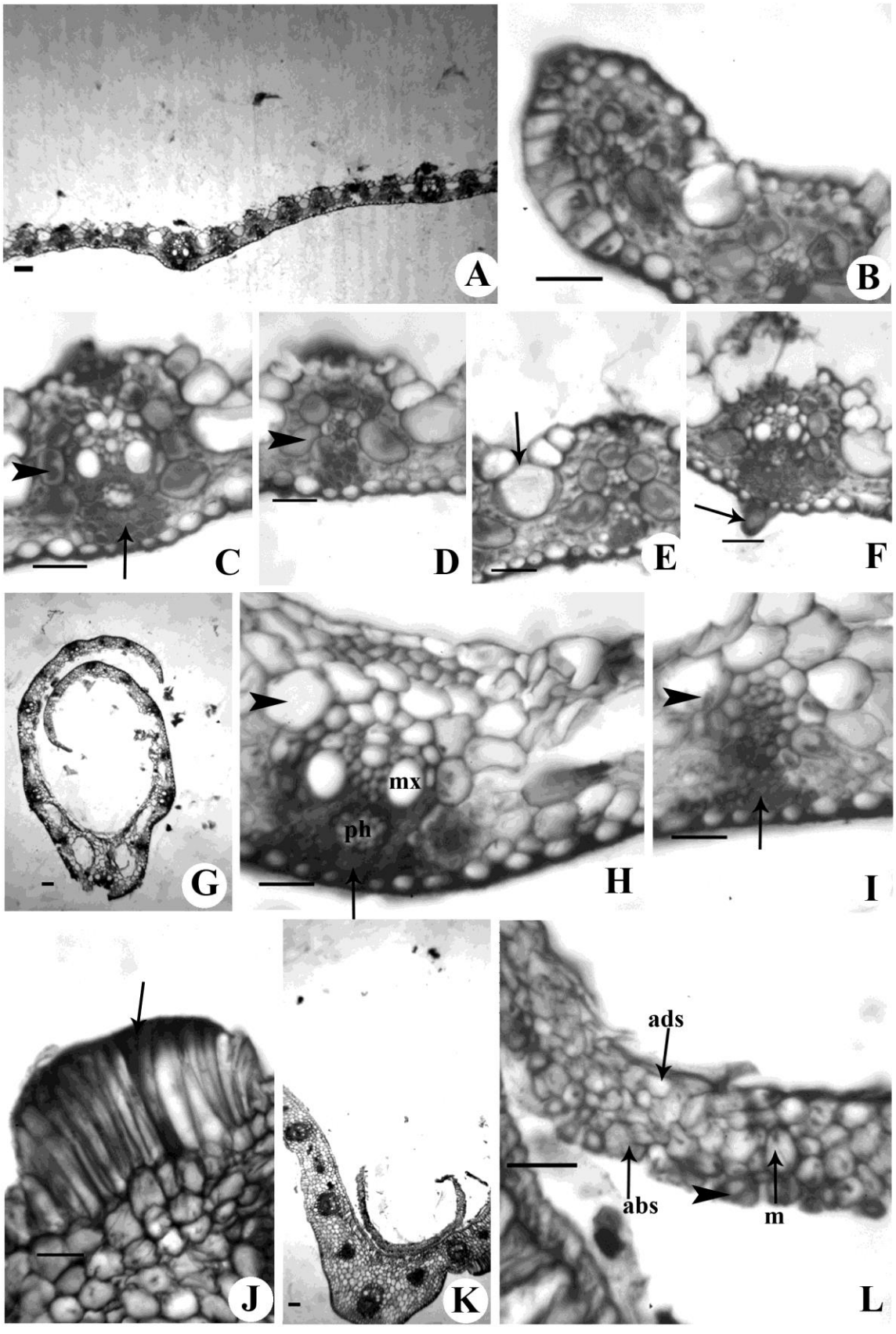

Fig. 215

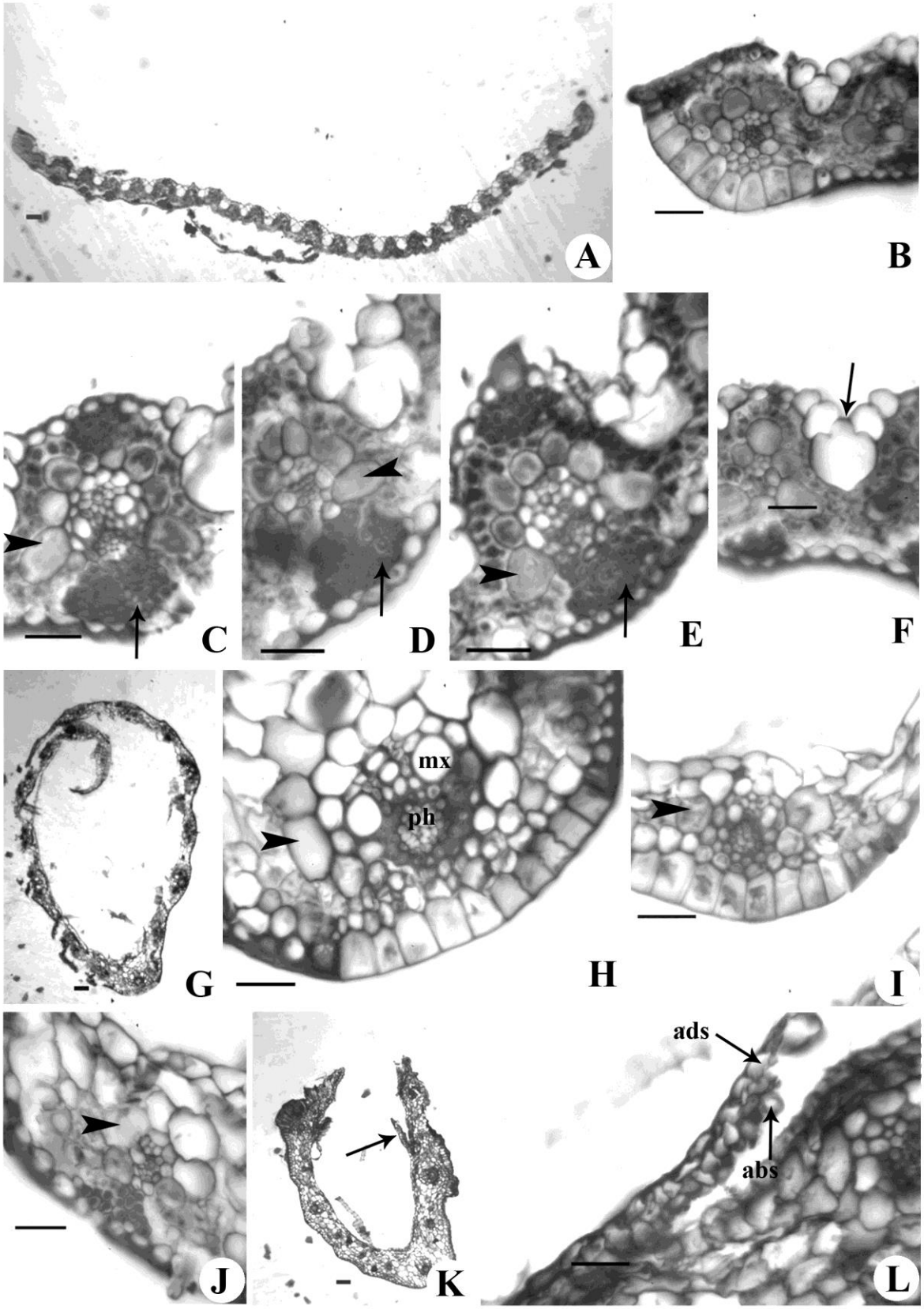

Fig. 216

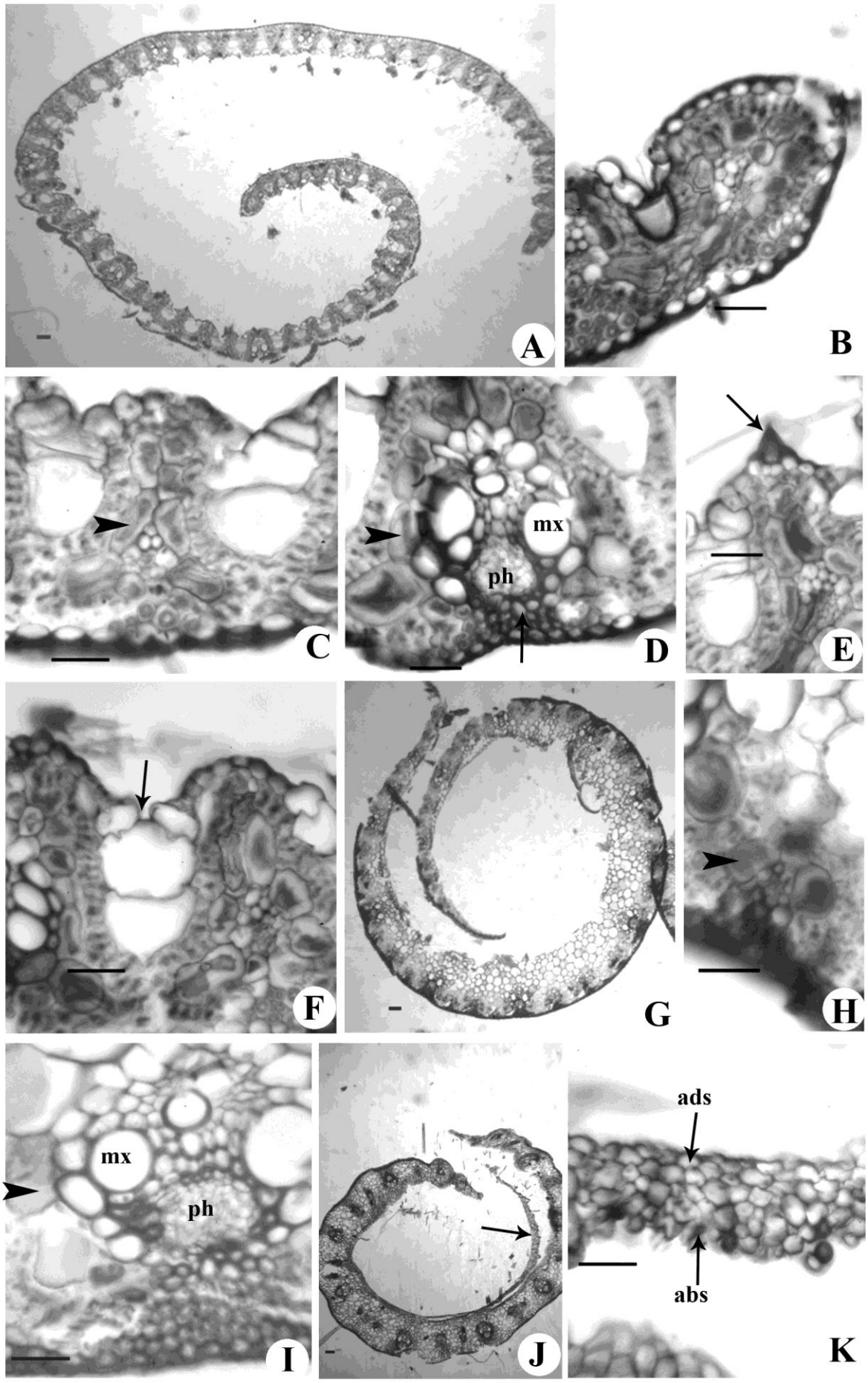

Fig. 217

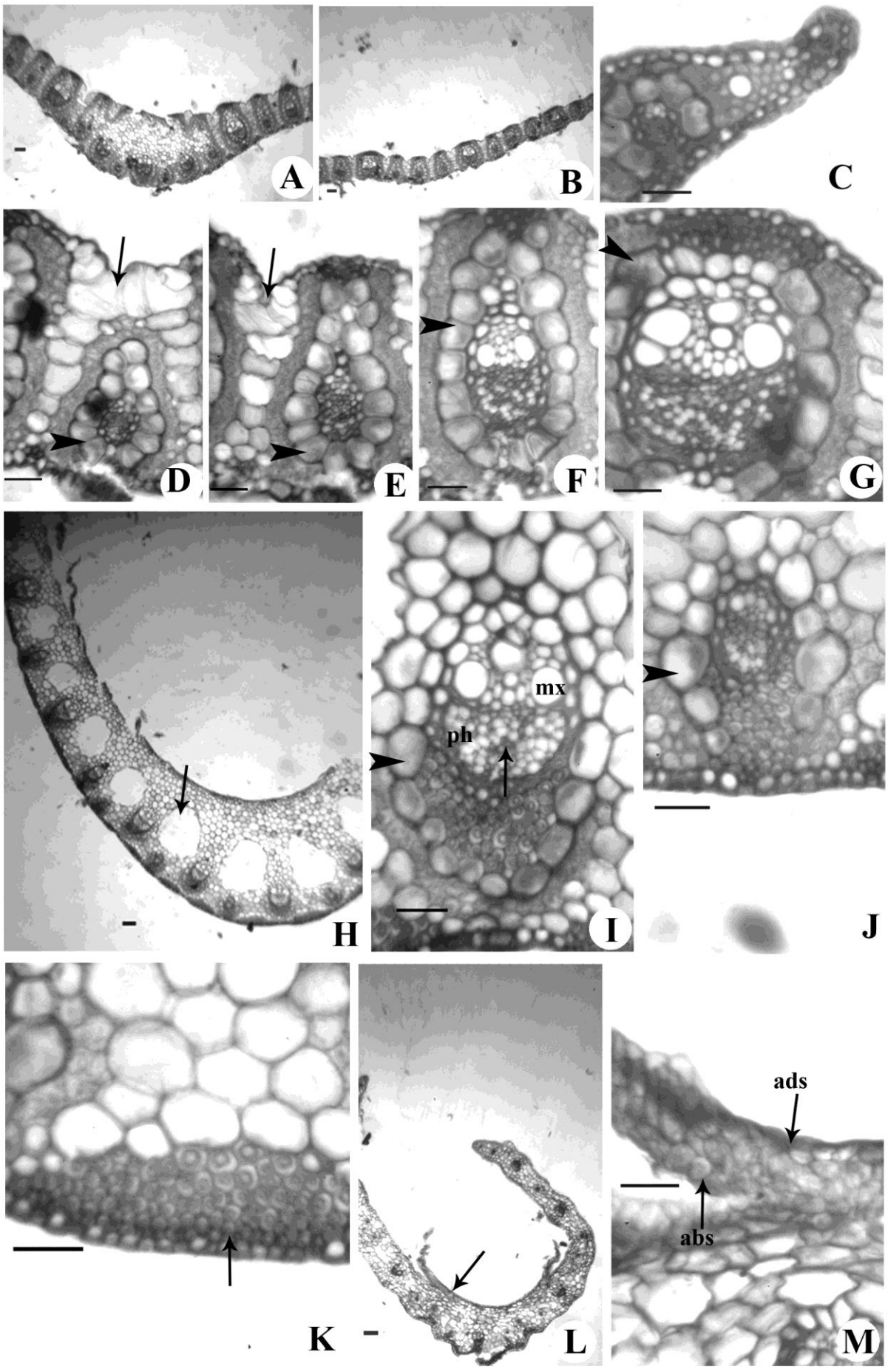

Fig. 218

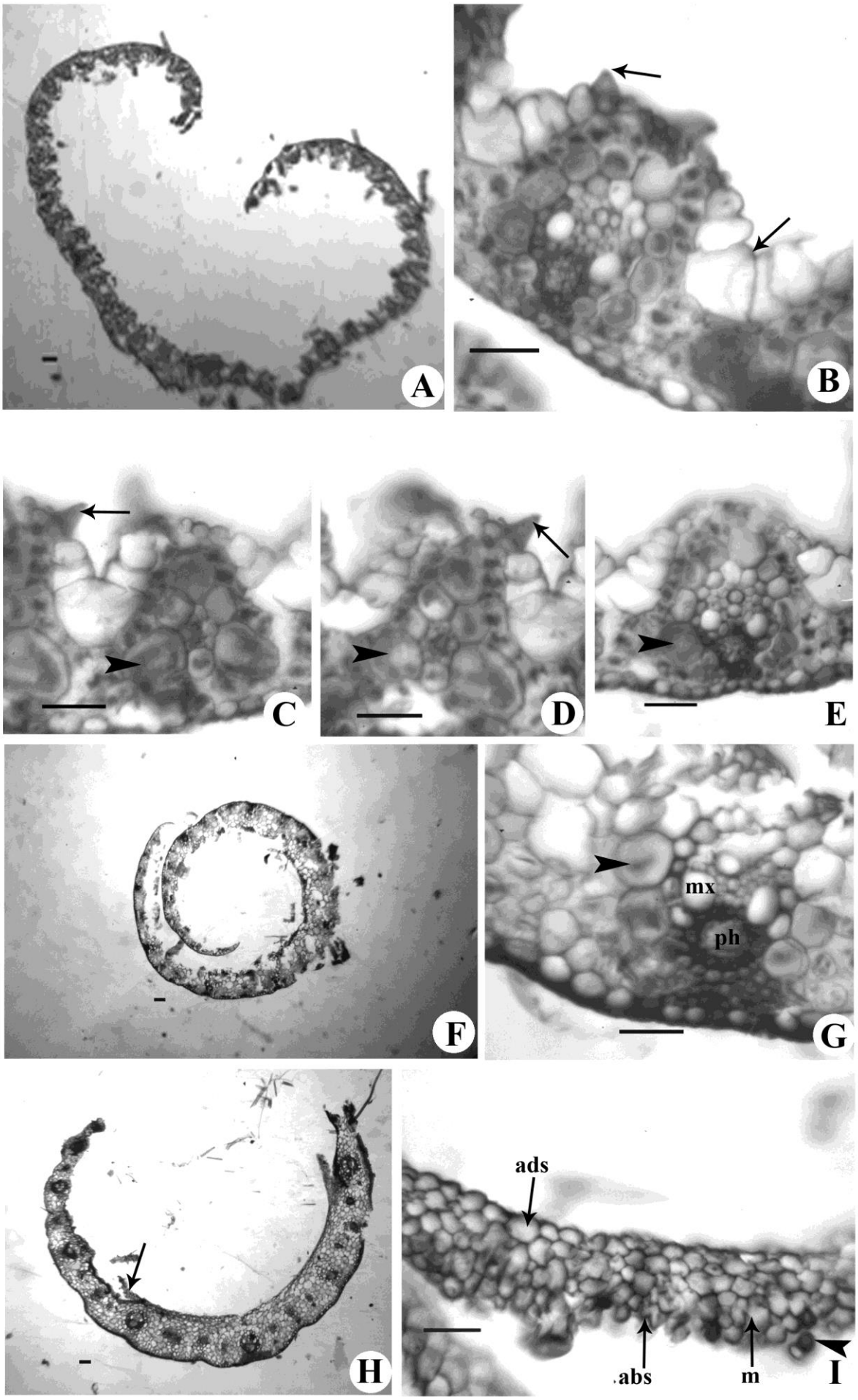

Fig. 219

Sporobolus

97. *Sporobolus coromandelianus* (Fig. 220)

98. *Sporobolus diander* (Fig. 221)

99. *Sporobolus indicus* (Fig. 222)

LEAF LAMINA: (Fig. 220 A-E, 221 A-E, 222 A-F)

Outline of the lamina: Expanded with flat, straight leaf blade in *S. coromandelianus* (Fig. 220 A). 'V' shaped with wide angle and outwardly curving, convex shaped arms in *S. diander* (Fig. 221 A) or 'V' shaped with broad angle and distinctly undulating with rounded wave in *S. indicus* (Fig. 222 A).

Two halves are symmetrical on either side of the median vascular bundle. Ribs and furrows are present on the leaf surface. Narrow, wide furrows present between all vascular bundles and ribs are flat in *S. coromandelianus*, on adaxial surface medium, deep furrow present between all vascular bundle in *S. diander*. Round ribs with obtuse apex situated over the vascular bundles placed adaxially in *S. indicus*.

Keel is inconspicuous in *S. coromandelianus* and *S. diander* but well developed in *S. indicus*, semicircular with single median vascular bundle.

Small, round parenchyma cells surround the median vascular bundle abaxially. Sclerenchyma in form of narrow adaxial strands and on abaxial surface associated with vascular bundles in form of subepidermal strands.

Epidermis: Adaxial epidermis has bulliform cells which are resembles fan shaped due to central large cell in all species (Fig. 220 C, 221 F, 222 C, arrow). Epidermal cells are small, round and highly cuticularised. Adaxial epidermal cells in *S. diander* frequently papillate with length of papillae much lesser than half the width of the cell and one papillae per cell (Fig. 221 E, arrow). Bulliform cells of *S. indicus* papillate with swollen tip (Fig. 222 C, arrow). Abaxial epidermal cells small, barrel shaped in *S. coromandelianus*, round to square in *S. diander* or round in *S. indicus* covered with cuticle.

Mesophyll: Indistinctly or incompletely radiate chlorenchyma cells forming horizontal strap continuous between bundles in *S. coromandelianus* and *S. diander* or radiate, single layered, isodiametric chlorenchyma cells completely surrounding bundles in *S. indicus*. Compactly arranged homogenous chlorenchyma cells occupy the major area between the adaxial and abaxial epidermides. Well define group of colourless cells in *S. indicus* and *S. coromandelianus* (Fig. 220 B, arrow, 222 D, arrow) which are closely associated with bulliform cells and girders extend to the opposite epidermis in *S. indicus*, smaller than bulliform cells with one extension in *S. coromandelianus*. Colourless cells absent in *S. diander*.

Vascular bundles: 4 1st order in *S. coromandelianus*, 3 1st order in *S. diander* or 2 1st order in *S. indicus* vascular bundles regularly arranged from median bundle to marginal bundle in half lamina.

3-4 3rd and 2-3 2nd order in *S. coromandelianus*, 2 3rd and 2 2nd order in *S. diander*, 2-3 3rd and 2nd order in *S. indicus* bundles between consecutive larger bundles between consecutive 1st order bundles present. All the vascular bundles present at same level and placed centrally.

3rd order vascular bundles: (Fig. 220 D, 221 C, 222 F)

Circular in all species except in *S. indicus* hexagonal with vascular tissue consisting of only few indistinguishable vascular elements.

2nd order vascular bundles: Circular shaped

1st order vascular bundles: (Fig. 220 E, 221 B, 222 E)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Completely surrounded by thick walled fibers

Nature of lysigenous cavity and protoxylem: Enlarged protoxylem vessel present in all species and lysigenous cavity present only in *S. indicus.*

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Shape of metaxylem vessels: Circular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. 220 D, 221 C arrowhead, 222 E)

Shape: Round

Shape of bundle sheath cell: All cells are similar in size with straight radial walls and inflated tangential walls in *S. coromandelianus* and *S. diander* or fan shaped in *S. indicus*.

2nd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Radial walls straight, tangential walls inflated in *S. coromandelianus* and *S. diander* or fan shaped in *S. indicus*.

Number of bundle sheath cell: 8-9

Nature of bundle sheath (either complete or incomplete): Complete

Chloroplast position in bundle sheath cell: Chloroplast fills entire lumen of cell in *S. coromandelianus* and *S. diander* or positioned towards outer tangential wall in *S. indicus*.

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. 220 E, 221 B, arrowhead, 222 E, arrowhead)

Shape: Elliptical

Extent of bundle sheath around the vascular bundle: Complete

Extension of bundle sheath: Narrow abaxial extension of the bundle sheath in *S. coromandelianus* and *S. diander* or absent in *S. indicus.*

Number of cells comprising the bundle sheath: 10 in *S. coromandelianus*, 15-16 in *S. diander*, 12-13 in *S. indicus* parenchyma cells

Bundle sheath cell shape: All cells are similar in size with straight radial walls and inflated tangential walls and chloroplast fill entire lumen of cell in *S. coromandelianus* and *S. diander* while fan shaped with chloroplast positioned towards outer tangential wall in *S. indicus.*

Mestome/ Inner sheath: Absent

Sclerenchyma:

Adaxial sclerenchyma: Minute strand consisting of only a few subepidermal fibers in *S. coromandelianus* and *S. indicus*, well developed girder, wider than deeper in *S. diander*

Abaxial sclerenchyma: Well developed girder, wider than deep in *S. coromandelianus*, minute small strand in *S. diander* or minute strand consisting of only a few subepidermal fibers in *S. indicus*.

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming well developed pointed fibrous cap in *S. coromandelianus* and *S. diander*, only pointed cap in *S. indicus*. Epidermal cells at margin are with thick outer tangential wall (Fig. 220 B).

LEAF SHEATH ANATOMY (Fig. 220 F-H, 221 H-J, 222 G-K)

Outline of lamina: Round with inrolled margins in *S. coromandelianus* and *S. diander* or 'V' shaped broad angle with inrolled margins in *S. indicus* (Fig. 220 F, 221 H, 222 G). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, rectangular

Abaxial epidermal cells: small, flat, rectangular in *S. coromandelianus* and *S. indicus* or round shaped in *S. diander* with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavity.

Vascular bundle:

Arrangement of vascular bundle: 2 3rd order vascular bundles in *S. coromandelianus* and *S. indicus* and 1 3rd order in *S. diander* between 1st and 2nd order vascular bundle.

3rd order vascular bundle: (Fig. 220 G, 221 J, 222 H, I)

Elliptical in *S. coromandelianus*, circular in *S. diander* and hexagonal in *S. indicus* with vascular tissue consisting of only few indistinguishable vascular elements in *S. coromandelianus* and *S. indicus* while xylem and phloem groups distinguishable in *S. diander*.

2nd order vascular bundle: Elliptical shaped

1st order vascular bundle: (Fig. 220 H, 221 I, 222 J)

Elliptical in *S. coromandelianus* and *S. diander* and circular in *S. indicus* with phloem completely surrounded by thick walled fibers. Lysigenous cavity and enlarged protoxylem vessel present. Circular narrow metaxylem vessel in *S. coromandelianus* and *S. diander* ; wide metaxylem vessel in *S. indicus*.

Vascular bundle sheath: (Fig. 220 H, 222 K)

Shape: Elliptical in *S. coromandelianus* and *S. diander* and circular in *S. indicus*

Extent of bundle sheath around the vascular bundle: Sheath incomplete, and abaxially interrupted by sclerenchyma cells in *S. coromandelianus* and *S. indicus* while complete in *S. diander*.

Number of cells comprising the bundle sheath: 8 parenchymatous cells in *S. coromandelianus*, 14-15 celled in *S. diander* and *S. indicus*

Bundle sheath cell shape: All cells similar in size and shape with straight radial walls, inflated tangential walls in *S. coromandelianus*. Cells towards abaxial surface are smaller than other cells in *S. diander* (Fig. 221 I, arrowhead). Fan shaped and adaxially interrupted by parenchyma cells and abaxially interrupted by sclerenchyma cells in *S. indicus.*

Mestome/ Inner sheath: Absent in *S. coromandelianus* and *S. indicus* while in *S. diander* it forms incomplete sheath with cells abaxially sclerenchymatous (Fig. 221 I).

Sclerenchyma: In form of straight horizontal well developed in *S. coromandelianus* and *S. diander* or small in *S. indicus* abaxial girder.

LIGULE ANATOMY (Fig. 220 I, J, 221 K, L, 222 L, M)

Shape: Ligule attached to the midrib region and partially with lamina with the connection being round and broad in *S. coromandelianus* and *S. diander* (Fig. 220 I, 221 K) or attached to half the width of the leaf sheath region with a round connection point in *S. indicus* (Fig. 222 L).

Anatomy: Single in *S. coromandelianus*, two in *S. diander*, three in *S. indicus* layered mesophyll cells between adaxial and abaxial surfaces (Fig. 220 J, 221 L, 222 M).

Differentiating features:

Expanded shaped leaf lamina……..……..……..*S. coromardelianus*

'V' shaped leaf lamina

Chloroplast fill entire full lumen, bundle sheath cells with inflated tangential walls…….……..……..*S. diander*

Chloroplast concentrated near outer tangential wall, fan shaped vascular bundle sheath

cells……..*S. indicus*

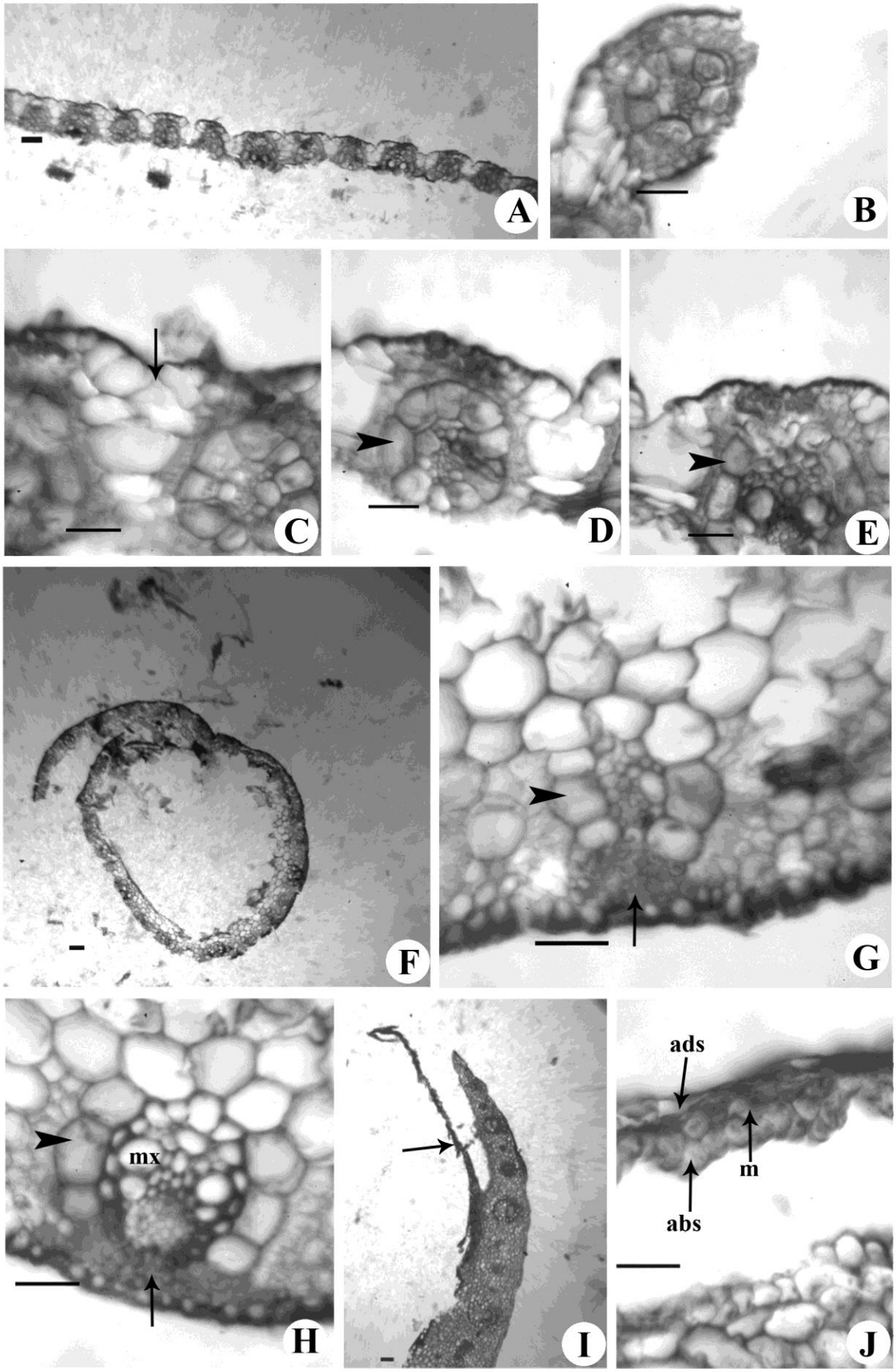

Fig. 220

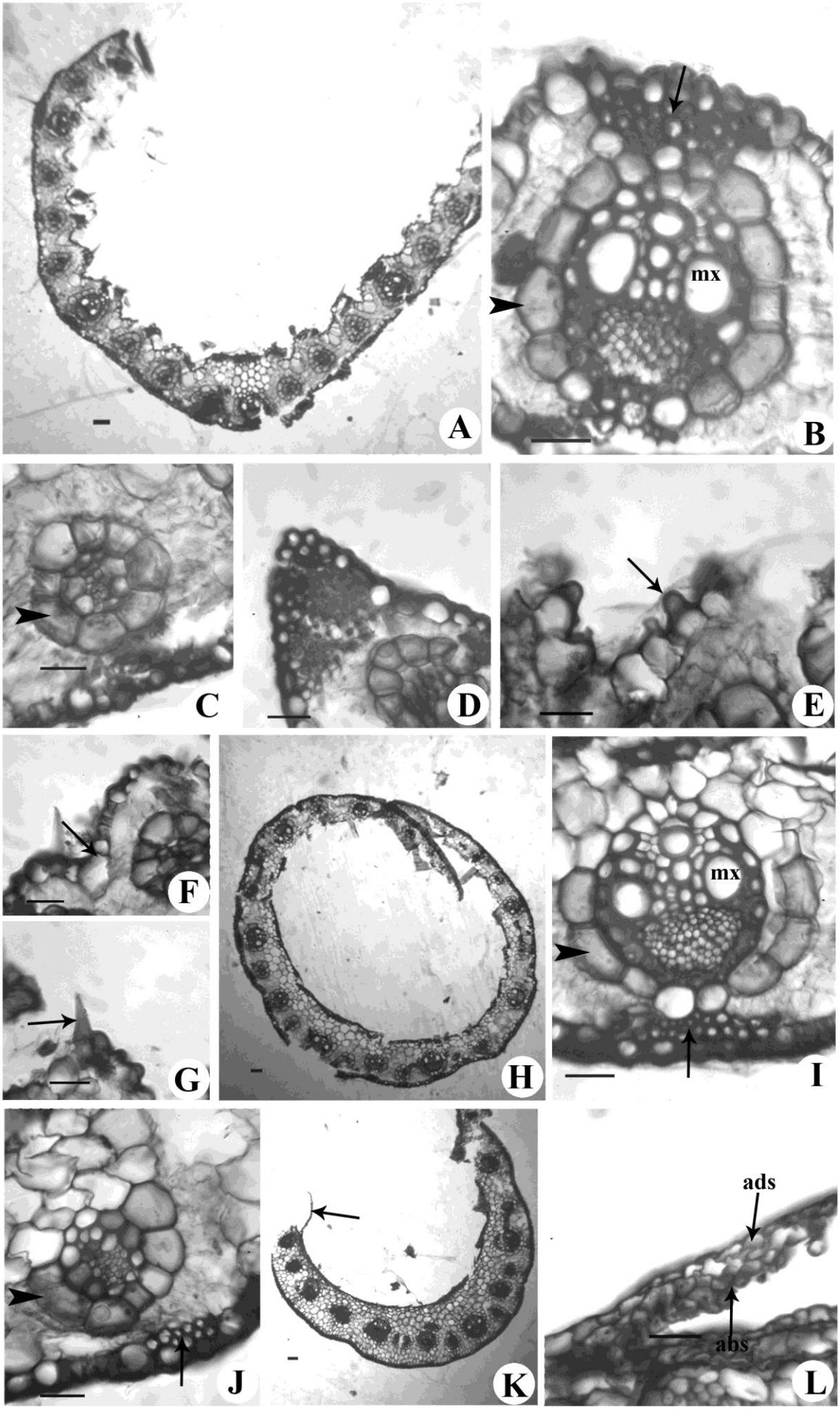

Fig. 221

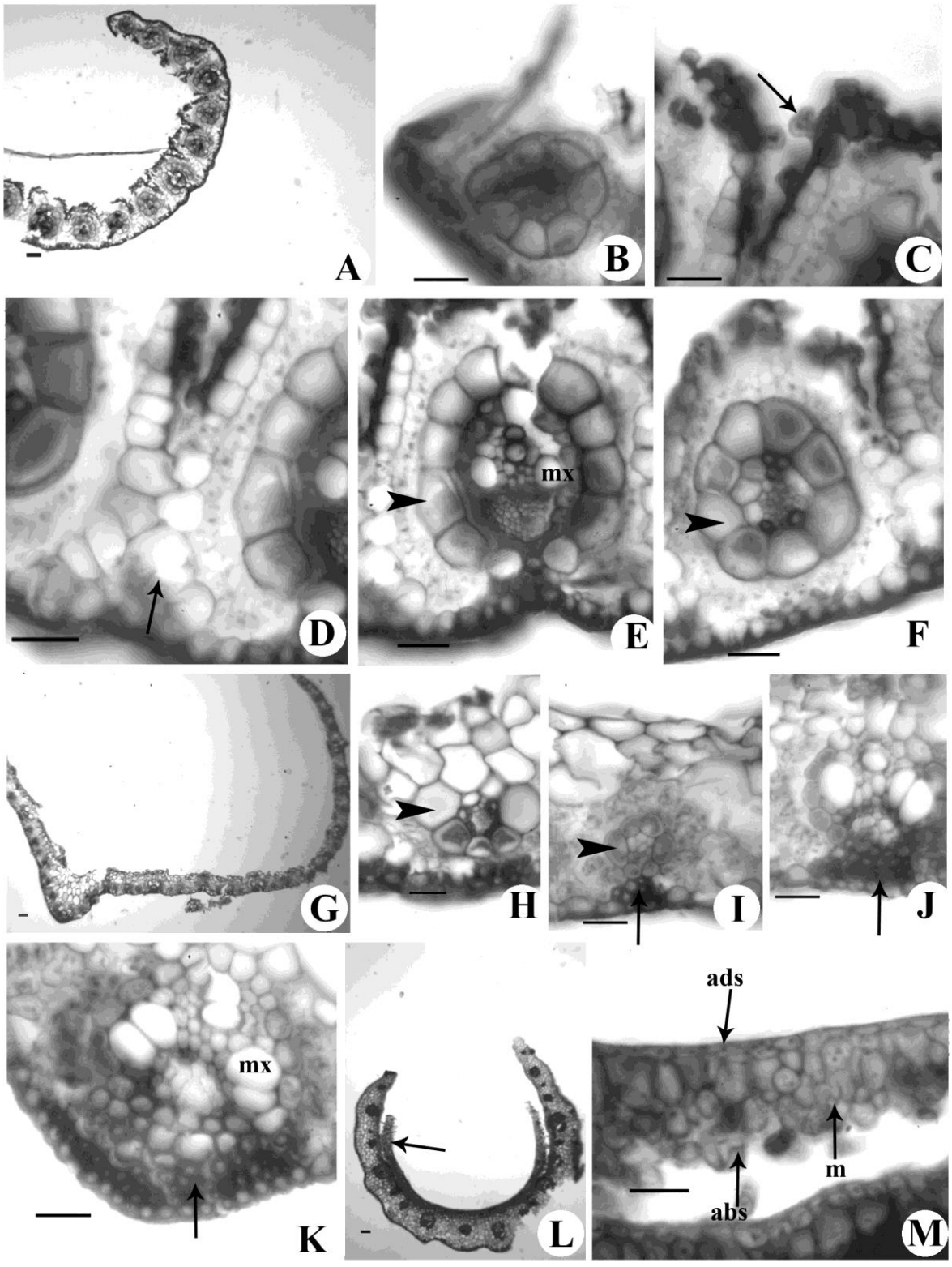

Fig. 222

100. *Tragrus biflorus*

LEAF LAMINA: (Fig. 223 A-D)

Outline of the lamina: Expanded with flat, straight leaf blades (Fig. A, B). Ribs and furrows are absent.

Midrib bundle not distinguishable. Keel is inconspicuous.

Epidermis: Adaxial epidermal surface with narrow group of bulliform cells occyping less than ½ of the leaf thickness (Fig. C, arrow). Bulliform cells with small papillae (Fig. D, arrow). Abaxial epidermal cells round which have thick cuticle.

Mesophyll: Indistinctly or incompletely radiate chlorenchyma continuous between bundles. Colourless cells absent.

Vascular bundles: 5 1st order vascular bundles in half lamina regularly arranged from median bundle to marginal bundles. 2-3 3rd order bundles between consecutive larger bundles and 2-3 2nd order bundles between consecutive 1st order bundles present. All the vascular bundles centrally placed and at same level.

3rd order vascular bundles: Hexagonal and vascular tissue consisting of only few indistinguishable vascular elements (Fig. C).

2nd order vascular bundles: Circular shaped

1st order vascular bundles: (Fig. D)

Shape: Elliptical

Relationship of phloem cells and the vascular fibres: Phloem adjoins the inner or parenchyma sheath

Nature of lysigenous cavity and protoxylem: Lysigenous cavity present protoxylem vessel absent

Size of metaxylem vessels in relation to parenchyma sheath cells in cross section: Narrow vessels

Shape of metaxylem vessels: Circular

Vascular bundle sheath:

3rd order vascular bundle's bundle sheath: (Fig. C, arrowhead).

Shape: Round

Shape of bundle sheath cell: Radial and inner tangential walls straight; outer tangential wall inflated; fan-shaped, all cells similar in shape and size and chloroplasts concentrated near the inner tangential wall.

2nd order vascular bundle's bundle sheath:

Shape: Round

Shape of bundle sheath cell: Radial and inner tangential walls straight; outer tangential wall inflated; fan-shaped, all cells similar in shape and size and chloroplasts positioned towards the inner tangential wall.

Number of bundle sheath cell: 9-10

Nature of bundle sheath (either complete or incomplete): Incomplete, abaxially interrupted by sclerenchyma

Chloroplast position in bundle sheath cell: Chloroplasts concentrated near the inner tangential wall

Mestome/ Inner sheath: Absent

1st order vascular bundle's bundle sheath: (Fig. D, arrowhead)

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath incomplete, abaxially partially interrupted caused by a narrow girder of 1 - 3 fibres wide.

Extension of bundle sheath: Absent

Number of cells comprising the bundle sheath: 10-11 parenchyma cells

Bundle sheath cell shape: Radial and inner tangential walls straight; outer tangential wall inflated; fan-shaped, all cells similar in shape and size and chloroplasts positioned towards the inner tangential wall.

Mestome/ Inner sheath: Sheath complete; completely surrounding the xylem and phloem and adaxially situated cells larger than lateral cells of the sheath

Sclerenchyma:

Adaxial sclerenchyma: Minute strand consisting of only a few subepidermal fibers

Abaxial sclerenchyma: Minute strand consisting of only a few subepidermal fibers

Sclerenchyma between bundles: Absent

Sclerenchyma in leaf margin: Forming very small fiberous pointed cap. Epidermal cells at margin with outer thick tangential wall.

LEAF SHEATH ANATOMY (Fig. 223 E-G)

Outline of lamina: Round with inrolled margins (Fig. E). Ribs and furrows absent.

Epidermis: Adaxial epidermal cells: flat, recatangular

Abaxial epidermal cells: small, barrel shaped with thick cuticle.

Ground tissue: Parenchymatous with absence of air cavity.

Vascular bundle:

Arrangement of vascular bundle: One consecutive 3rd order vascular bundle between 1st and 2nd order vascular bundle

3rd order vascular bundle: Hexagonal with vascular tissue consisting of only few indistinguishable vascular elements (Fig. F)

2nd order vascular bundle: Oval shaped

1st order vascular bundle: Elliptical with phloem adjoins the inner or parenchyma sheath. Lysigenous cavity present and protoxylem vessel absent. Circular narrow metaxylem vessel elements.

Vascular bundle sheath: (Fig. F, G arrowhead)

Shape: Round, circular

Extent of bundle sheath around the vascular bundle: Sheath incomplete, partially interrupted by a narrow girder of 1 - 3 fibres wide

Number of cells comprising the bundle sheath: 10-11 parenchyma cells

Bundle sheath cell shape: Radial and inner tangential walls straight; outer tangential wall inflated; fan-shaped, all cells similar in shape and size,

Mestome/ Inner sheath: Sheath complete; completely surrounding the xylem and phloem

Sclerenchyma: In form of minute strand consisting of only a few subepidermal fibers present on abaxial surface.

LIGULE ANATOMY (Fig. 223 H, I)

Shape: Ligule attached only to the midrib region and broad round shaped at connections point (Fig. H, arrow).

Anatomy: Single layered mesophyll cells between adaxial and abaxial surfaces (Fig. I)

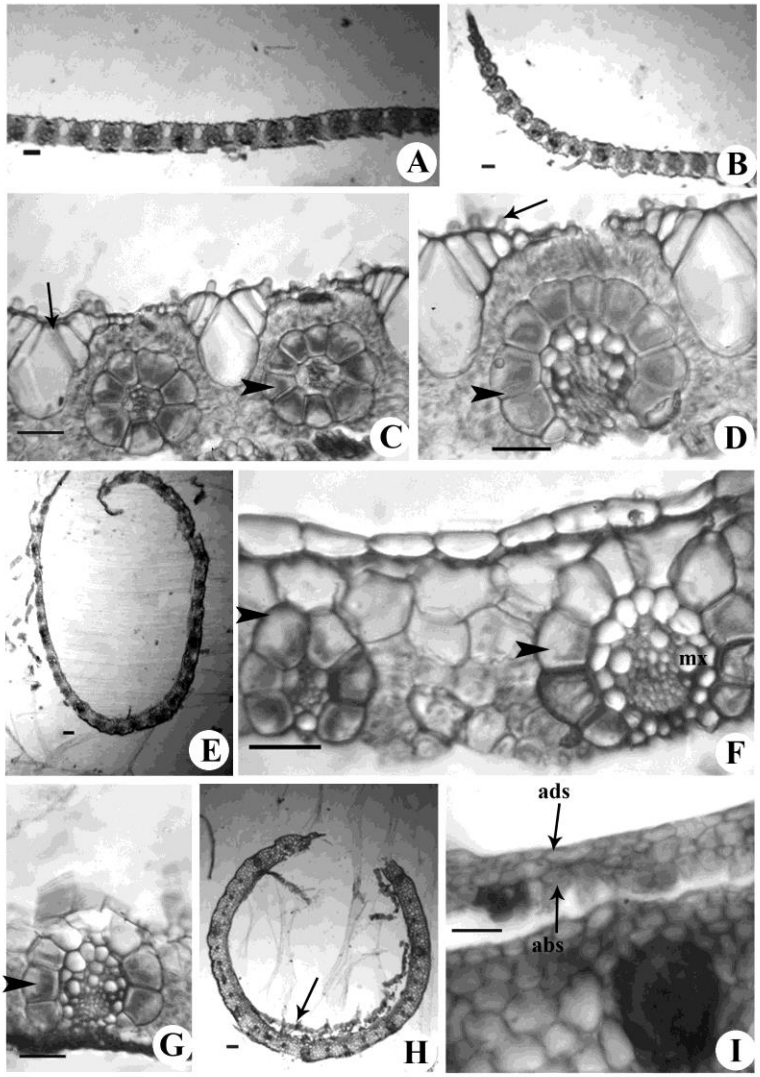

Fig. 223

Discussion

Initially grasses were classified by their morphological characteristic features of spike and inflorescence. Part (1932, 1936) used the microscopic characters of leaf epidermal cell for identification of grasses. Later on different authors studied aspects like chromosomes, root hairs, stem apices, first seedling leaf, embryo structure, physiology, nucleoli, geographical distribution leaf epidermis, leaf anatomy and characterised the taxa within a particular family (Avdulov, 1931; Yakovlev, 1950; Stebbins, 1956; Brown and Emery, 1957; Brown *et al.*, 1957; Reeder 1957, Row and Reeder, 1957).

Grass leaf anatomical study has been emphasized as a very fundamental character. Transverse sections of grass leaves are also helpful in the identification and taxonomic delimitation of grasses (Kumar and Nautiyal, 2017). Leaf anatomy of different grass species has been examined by various authors (Renvoize, 2002; Keshavarzi *et al*., 2007, Abbasi *et al.*, 2010; Abbasi and Asadi, 2014). Duval-Jouve (1875) used character like presence or absence of bulliform cells in both abaxial and adaxial epidermises and position of bulliform cells in respect to vascular bundle. He concludes that if bulliform cells are present over tertiary nerves this was character observed in both Paniceae and Andropogoneae. In Paniceae also it may be present in both epidermises. This feature was not found in Andropogoneae and hence a specific character of Paniceae. Avdulov (1931) also described two basic type of leaf anatomy: Type I and Type II. The species with characters like thick walled mestome sheath, connected by sclerenchyma to both epidermises, a poorly developed parenchyma sheath and irregular arrangement of chlorenchyma, were of Type I and the species with characters like the large size of the parenchyma sheath cells which separate the xylem from the sclerenchyma next to upper epidermis, the radial arrangement of chlorenchyma cells were belongs to the Type II. Prat (1932) designated Type I as Festucoid type and Type II as Panicoid type of leaf anatomy. Tribes Paniceae, Maydeae, Andropogoneae, Chlorideae, Zoysieae in the present study belongs to the Type II leaf anatomy.

In the present study, the characteristic features used for description are adapted from Ellis (1976) which includes a very detailed description of the different tissues of the leaf, its sheath and ligule. Characteristic features of the cells which form each tissue (epidermal, mesophyll and vascular) has been critically examined and presented.

Brown (1958) studied, leaf blades of 101 species in 72 genera and categorized them into six categories based on their plastid structure, presence and absence of mestome, arrangement of mesophyll chlorenchyma cells, character of outer bundle sheath: **Festucoid type**: It consist of well developed, thick walled endodermis surrounded by a very indistinct parenchyma sheath, the cells of which are small and very thin walled and contain chloroplasts similar to those of loose, irregularly arranged, spongy mesophyll cells. **Bambusoide type**: Characterized by an endodermis, some specialization of the parenchyma sheath cells and modified chlorenchyma tissue. **Arundinoid type:** Characterized by the complete lack of chloroplasts in the enlarged parenchyma sheath cells. The chlorenchyma cells are

densely packed and the endodermis is poorly developed. **Panicoid type:** Characterized by radial arrangement of the adjacent chlorenchyma cells, some species showed absence of mestome or endodermis while some showed presence of it. **Aristicoid type:** It is unique type with no mestome sheath but having a double parenchyma sheath, the cells of both containing specialized plastids. **Chloridoid type:** Characterized by an endodermis around the large bundles by a single parenchyma sheath, chlorenchyma of long, narrow, radially arranged cells forming one layer and containing few chloroplasts.

Renvoize studied leaf anatomy of different tribes like Andropogoneae (1982), Arundinelleae (1982), Garnotideae (1982), Eragrostideae (1983), Arundionoideae (1986), Centhothecoideae (1986), Bambuseae (1987), Paniceae (1987) and only described the leaf micromorphological character and leaf anatomical characters which includes long cells, short cells, stomata, outline of lamina in transverse section, vascular bundles, epidermis and mesophyll cells arrangement for the different tribes. Cladera and Soderstrom (1973) studied morphological and anatomical features of *Maclurolyra* belonging to Bambusoideae.

Metcalfe (1960) in his book, studied on anatomy of the monocotyledons and included around 315 species of grasses. The 315 grass species studied has been treated in general. He studied and described the micromorphology and anatomy of leaf blade. Some of the observations varied from the present study. Individual species have been characterized anatomically but the different features have not been critically analysed as done in the present study. *Perotis indica* has anchor shaped girder which is made up of by sclerenchyma cells while in present study it showed minute subepidermal strands on abaxial surface. In present study also species like *Apluda mutica, Chloris virgata, Coix, Dactyloctenium aegyptium, Desmostachya bipinnata, Eleusine indica, Panicum maximum, Panicum miliaceum, Rottbelia exaltata, Vetiveria zinzanoides* showed large sclerenchyma bundle on abaxial side. Moreover only selective diagrammatic representation and no microphotographs have been given. In the present study each species has been characterized individually and represented with microphotographs.

Patel (1976) examined morhpho taxonomic characters in 51 grass species from Ahmedabad districts. He also examined the leaf anatomy of 24 species. However only 17 species from the present study has been included in his work. Moreover these species have not been described anatomically in detail and is supplemented with diagrams unlike the present study which describes leaf, leaf sheath and ligule anatomy of 100 grass species in detail as per Ellis (1976). Martinez-Sagarra *et al.* (2017) studied leaf anatomy in the Iberian species of *Festuca.* According to them, leaf anatomy has certain limitations for the delimitation of species, although it has taxonomic value for the separation of some groups. Few characters were found to be overlapping to a great extent, especially number of outer/inner bundle sheath cells, number of bulliform cells, thickness of sclerenchyma, abundance and length of trichomes. The reason proposed for existence of these characters may be due their responses to environmental conditions. The anatomical differences between the species of the two major clades are evident and there are many features that

distinguish them. Kok and Van der Schiff (1973) proposed a key for the identification of sixty grass species on the basis of leaf anatomical features.

Aliscioni *et al.* (2016) studied morphology and leaf anatomy of *Setaria* in which characters like well developed chlorenchyma with irregular or incompletely radiate arrangement, presence of colourless cells, presence of sclerenchyma in form of girders either on adaxial or abaxial surface, presence of features like papillae and mestome has been considered. In the present study, *Setaria* contradicted by showing absence of mestome and papillae, well developed sclerenchyma in form of girder, irregularly arranged chlorenchyma cells and well developed, semicircular shaped keel. *Setaria glauca* and *Setaria tomentosa* had straight arms of leaf blade while *Setaria verticiallata* had gently wavy arms of leaf blade.

Ghahreman *et al.* (2006) studied anatomy of 25 Iranin species of *Bromus.* They considered 81 total characters were selected for variable and constant species characters, among them 28 characters are variable while 40 characters constant in all species. Variable anatomical quantitative and qualitative characters like shape of lamina in transverse section, width of one half lamina, thickness, size of adaxial rib, number of adaxial ribs and furrows, depth of adaxial furrow, thickness of keel, length and width of midrib, distance of midrib from abaxial and adaxial surface, number of vascular bundles, arrangement of different orders of vascular bundles, shape of midrib, number of protoxylem, number of lysigenous cavity, size of metaxylem, number of outer sheath cells, radial wall of outer sheath cells, macrohairs density, shape and distribution, number of bulliform cells. When they evaluate the anatomical characters in the *Bromus* apart from separating and categorizing the perennial and the annuls, no other grouping is shown and the remaining anatomic attributes have only taxonomic value among the species. Kumar and Nautiyal (2017) studied leaf anatomy of two genera, *Eragrostis* and *Eleusine* belonging to tribe Eragrostideae from Uttarakhand. They said that different species exhibit variations in different anatomical characters which are valuable in their identification and differentiation, which there are some characters which are similar in all species of the tribe. *Eleusine indica* having V shaped keel, radially arranged chlorenchyma, fan shaped bulliform cells or irregular groups deeply penetrating into the mesophyll.

Olsen *et al.* (2013) studied the environmental and inherited variation in leaf anatomy of *Andropogon gerardii*. They concluded that leaf anatomy was influenced by that environment and genetic source population. Leaves from plants grown in mesic sites had thicker midribs, larger veins, fewer trichomes, and a larger proportion of bulliform cells compared to plants grown in drier situations. Bor (1960) noticed that the blades of grass leaves may be penned up, convoluted or pleated in the bud. Thus the arrangements of leaves in a bud may simply be related to the major types of involution exhibited in mature leaves. In the present study, all the members of Maydeae showed expanded leaf lamina. In Andropogoneae members showed either expanded or 'V' shaped leaf lamina except for *Triplopogon ramosissimus* which showed an inrolled leaf lamina. Tribe Paniceae members also generally showed either expanded or 'V' shaped leaf lamina except *Pennnisetum setosum* showed 'U' shaped leaf lamina. Among the tribe Chlorideae, only *Chloris* showed 'V' shaped.

Longitudinal ribs and furrows were present either on the adaxial or abaxial surface of a leaf. Depth, shape, spacing, and location of the ribs and furrows varied in the different species. The ribs were usually developed in association with the large vascular bundles and were more developed on the adaxial than the abaxial surface (Metcalfe, 1960). Most of the studied species showed presence of ribs and furrows except *Chionachnae, Coix, Andropogon, Bothriochloa, Chrysopogon, Cymbopogon, Ophiuros, Rottboellia, Saccharum, Sorghum, Thelepogon, Vetiveria, Digitaria, Eremopogon, Paspalidium, Setaria, Acrachne, Eleusine* and *Tragus. Heteropogon triticeus, Triplopogon ramosissimus, Alloteropsis cimicina, Cynodon, Chloris, Melanocenchris,* etc. showed smooth ribs on the adaxial surface of the leaf. The ribs were present on 1st order vascular bundle and furrows were present below the other vascular bundles. *Cenchrus biflorus* showed prominent smooth ribs abaxially. *Panicum miliaceum, Eragrostis* species and *Sporobolus* species also have smooth ribs on both the surfaces of leaf lamina. *Capillipedium hugelii, Sehima ischaemoides, Heteropogon contortus* var. *geninus* subvar. *typicus, Themeda cymbaria, Oplismenus,* etc. posses triangular shaped, sharp ribs present on abaxial surface of leaf lamina. *Iseilema laxum, Isachne globosa* have triangular shaped ribs on the adaxial surface of leaf lamina.

Keel is an important diagnostic feature to recognize and easily distinguish the species. Presence and absence of keel, its size and shape, number of vascular bundles within the keel are some of the important features which help in distinguishing the species. In the studied species variation was observed in the number of vascular bundles in the keel. The variation was observed in the different genus of the same tribe as well as in different tribes. *Chionachnae koenigii* and *Coix lachryma jobi* of tribe Maydeae showed many vascular bundles within keel. Species like *Bothriochloa pertusa, Chrysopogon fulvus, Ischaemum, Saccharum spontanum, Thelopogon elegans, Themeda,* etc., of tribe Andropogoneae also had many vascular bundles in the keel. But other species from Andropogoneae like *Apluda mutica, Capillipedium huegelli, Heteropogon, Sehima, Sorghum,* etc. had a single vascular bundle in keel. *Chloris virgata, Chloris montana, Paspalidium flavidum, Digitaria longiflora, Cenchrus ciliaris, Alloteropsis cimiciana,* etc. also had single vascular bundle in keel. Species like *Oplismenus, Panicum trypheron, Setaria tomentosa, Setaria verticillata, Chloris, Eleusine,* etc. had many vascular bundles in keel region. The keel was protruded abaxially either because of sclerenchyma or because of the vascular bundle which was located closer to abaxial surface. Shape of the keel also varied, it was either 'V' shaped or 'U'/semicircular shaped.

Generally epidermal cells in the leaves of all the grass species were barrel, square, rectangular or round shaped which was covered with either thin or thick cuticle. Jauhar (1967) studied the epidermal features of four species of *Panicum.* He pointed out a wide range of variation existed in respect to the length of the long cells and the extent of rippling and cuticularisation of their anticlinal walls, shape of short cells, cuticular appendages, frequencies and size of stomatas in the different species. In the present study the characteristic features of cuticularisation has been considered in detail. In some species, few epidermal cell showed papilla which was either sharp,

blunt or balloon shaped and broad. Width of papillae was equal to the width of epidermal cell in some species like *Bothriochloa pertusa, Heteropogon sp., Sehima sp., Digitaria ciliaris, Echinochloa crusgalli, Chloris montana, Chloris virgata* and *Acrachne ramosa* showed blunt end/round papillae which were as wide as the epidermal cells. *Capillepedium hugleii, Ischaemum molle, Ischaemum rugosum, Themeda cymbaria, Themeda triandra* showed sharp papillated epidermal cells. Very few species showed *Eremopogon faveolatus, Dactyloctenium aegyptium* and *Dactyloctenium scindicus* balloon shaped long papillae.

Presence of bulliform cells in most of the grass species is a well known feature. Features like the shape/form of the bulliform cells, its arrangement, presence on both epidermises or on a single epidermis, number of bulliform cells served as a characteristic diagnostic feature for identification of the species. Their morphology combined with enlarged mesophyll, colourless cells has been used as taxonomic characteristics (Metcalfe, 1960). Function of bulliform cells are different according to different authors (Haberlandt, 1914; Mauseth, 1988; Moulia, 2000). It is mainly considered for water storage (Eleftheriou and Noitsakis, 1978; Vecchia *et al.*, 1998); or it can be participate in the young leaf expansion that was rolled in the apex, due to water stress (Shields, 1951; Jane and Chiang, 1991). Easu (1965) said that during excessive water loss, the bulliform cells become flaccid and enabled the leaf either to fold or to roll, in conjugation with or without colourless cells. Alvarez *et al.* (2008) studied structure of bulliform cells in relation to its function in *Tristachya leiostachya* and *Loudetiopsis chrysothrix.* According to their study, bulliform cells appeared to play an active role during the leaf movement. Thus, involving the bulliform cells in the involution mechanism of young and mature leaves. Clayton and Renvoize (1986) suggested that bulliform cells favored the light enhance in the hygroscopic leaf movement because they accumulated large amount of silicon and their outermost walls might thicken and cutinize becoming stiff (Ellis, 1976). Longhi-wagner (2001) studied two native grasses *Loudetiopsis chrysothrix* and *Tristachya leiostachya* and showed that leaf rolling occurred under water stress and features like epicuticular waxes, silica bodies in the costal zone and stomata in furrows can be related to water saving (Alvarez *et al.,* 2005). Alvarez *et al.* (2008) studied the anatomical and ultrastructural characterization of the bulliform cells in these plants and described the main characteristic features as the periclinal walls being thinner than the adjacent epidermal wall, abundance of pectic substance in cuticular layer, sinuous anticlinal walls with ramified plasmodesmata, vacuum formed by a developed vacuole or innumerous small vacuoles, abundance of phenolic substances and oil drops, all of these characteristics suggesting its involvement in the mechanism of foliar involution. Considering the taxonomic and likely ecophysiological role of bulliform cells, their structural details have been studied in the 100 grass species selected in the present study. Fisher (1939) found the keel-size, amount of parenchymatous and sclerenchymatous tissue and bulliform cells to be a valuable diagnostic character in separating four species of *Chloris*. In the present study, *Chloris* species showed fan shaped bulliform cells which was similar to observation made by Fisher (1939) but

shape of central cell differed. In *Chloris barbata* it was diamond shaped, *Chloris virgata* shield shaped and *Chloris montana* inflated round shaped.

Breakwell (1914) on the basis of the leaf anatomy divided six grass species into three groups, based on their vascular bundle character, sclerenchyma mass developed under different bundles, epidermal cells and bulliform cells; group I had three species- *A. interiuedius, A. affinis, A. cericeus,* group II had *A. ischaemum* and group III had *A. refractus, A. intermedius*. In the present study, *Andropogon plumis* also shared few similar characters like fan shaped bulliform cells, a well developed sclerenchymatous girder on abaxial surface and thick cuticle. Most of the studied species showed fan shaped bulliform cells eg. *Eragrostis, Sporobolus diander, Andropogon, Imperata, Iseilema, Sehima, Oplismenus, Panicum, Perotis, Tragus, Cynodon, Melanocenchris, Eragrostis, Eragrostiella, Dinebra, Tetrapogon, Desmostachya* and *Eleusine*. *Soporoblus coromandelians, Ischemum pilosum, Iseilema laxum, Eragroestiella* showed bulliform cells in furrows. Arrangement of the bulliform cells were found to be varying in different species. In some species like *Coix, Bothriochloa, Capillipedium, Chrysopogon, Heteropogon, Ischaemum, Ophiuros, Rottboellia, Sorghum, Thelepogon, Triplopogon, Cenchrus, Digitaria, Eremopogon, Paspalidium, Paspalum* and *Setaria* showed large, inflated bulliform cells while species like *Chionachane, Apluda, Dicanthium, Saccharum, Sehima* and *Oplismenus* have restricted group of bulliform cells. Few species showed very small or narrow group of bulliform cells for eg. *Vetiveria, Alloteropsis, Echinochloa.*

Mesophyll cells and its characteristic features were also found to be a diagnostic identifying feature. The mesophyll can be subdivided into the assimilatory chlorenchyma and the colourless parenchyma which consists of translucent cells. In some species the adaxial chlorenchyma cells are more regular and vertically arranged than the residual. Metcalfe (1960) correctly stresses that this distinction is rare and at best unclear. According to him *Apluda mutica, Cenchrus biflorus, Cenchrus ciliaris, Chloris virgata, Cymbopogon martini, Cynodon dactylon, Echinochloa colona, Echinochloa crusgalli, Eleusine indica, Heteropogon contortus, Imperata cylindrica, Panicum miliaceum, Perotis indica, Setaria glauca, Sorghum halepense, Themeda triandra* had radiate arrangement of chlorenchyma cells, *Chloris barbata, Dacyloctenium aegyptium, Desmostachya bipinnata, Eragrostis unioloides, Panicum maximum, Paspalidium geminatum, Rottboellia exaltata, Sporobolus diander* had incomplete radiate arrangement of chlorenchyma cells while *Coix* had irregular arrangement of chlorenchyma cells. But in present study *Cenchrus biflorus, Cenchrus ciliaris, Echinochloa colona, Echinochloa crusgalli, Setaria glauca* and *Paspalidium geminatum* showed irregular arrangement of chlorenchyma cells, *Cynodon dactylon, Coix, Chloris barbata, Sporobolus diander* and *Perotis indica* showed incomplete radiate arrangement of chlorechyma cells while *Rottboellia exaltata, Panicum maximum, Eragrostis unioloides, Dacyloctenium aegyptium, Desmostachya bipinnata, Apluda mutica, Chloris virgata, Cymbopogon martini, Eleusine indica, Heteropogon contortus, Panicum miliaceum* and *Sorghum halepense* showed radiate arrangement of chlorenchyma cells.

Chonan (1978) studied the shape of mesophyll cell and divided it into and three categories: (1) Tubular palisade, (2) Longitudinally elongated arm pallisade cell (3) Transversely elongated arm pallisade cell. Garnier and Laurent (1994) proposed that leaf thickness was similar in annual and perennial grass species but density was different in all and it was higher in perennials. The area occupied by mesophyll in leaf was higher in annuals, at the expense of the three other tissue i.e. epidermis, sclerenchyma, vascular tissue. He also on the basis of the anatomy of mesophyll in leaves of Gramineae classified the grasses into four subfamily groups: Festucoideae, Bambusoideae, Panicoideae and Eragrostideae, based on structure of mesophyll. According to Ellis (1976) the species which showed radiate arrangement of chlorenchyma cells belonged to Panicoid group while those who showed irregular arrangement belonged to festucoid group. *Ophiuros exaltatus, Oplismenus, Vetiveria zinzanoides, Andropogon plumis, Themeda triandra, Bothriochloa pertusa, Arthraxon lanceolatus, Dicanthium annulatum, Dicanthium caricosum, Cymbopogon martini, Ischaemum, Rottboellia exaltata* showed radiate arrangement of chlorenchyma i.e. they are belong to panicoid group while *Setaria glauca, Setaria verticillata, Setaria tomentosa, Eragrostis japonica, Eragrostis nutans, Digitaria ciliaris, Digitaria longiflora, Tragus biflorus, Sporobolus, Aristida* species had irregular chlorenchyma arrangement and belonged to festucoid group. Few species showed incomplete radial arrangement of chlorenchyma cells eg. *Coix, Chionachnae, Echinochloa colona, Echinochloa crusgalli, Echinochloa stagnina, Dactyloctenium aegyptium, Dactyloctenium scindicus, Acrachne racemosa.*

There was evidence documented for the taxonomic distribution of C_3 and C_4 photosynthetic pathways in the subfamilies of the Poaceae (Kanai and Kashiwagi, 1975; Dangler *et al.*, 1994; Sage and Sage, 2009; Lundgren *et al.*, 2014). In tribe Bambusoideae and group Pooideae with tribe Arundinoidae (from Panicoideae group) being C_3 only few genera have C_4 pathway. Panicoideae and Chlorideae had the C_4 pathway with only few Panicoid genera recorded to being C_3. Makino and Ueno (2018) studied structural and physiological responses of the C_4 pathway in *Sorghum bicolor* to nitrogen limitation. Nitrogen is one of the major nutrients influencing photosynthesis and productivity of C_4 plants as well as C_3 plants. This study revealed the structural response of *Sorghum* leaves to N limitation in relation to the physiological responses of photosynthesis. C_4 photosynthesis is a highly regulated biochemical mechanism achieved by close coordination between mesophyll cells and bundle sheath cells. They proved that structural traits like leaf thickness, stomatal density, chloroplast number and arrangement, cell wall thickness, density of plsmodesmata, vascular bundle sheath are altered along with physiological traits of C_4 photosynthesis. Most changes would be associated with cellular allocation of N, light use, Co_2 diffusion and leakiness, and metabolite transport under N limitation. Hettersley (1984) studied on the characterization of C_4 leaf type anatomy in grasses and described the leaf anatomy with relation to physiology. He observed that evolution of C_4 suitable anatomy might require relatively few changes in plant linages with anatomical traits across C_3 and C_4 taxa has important implications for the functional diversity of C_4 linages and for the approaches used to identify genetic

determinants of C_4 anatomy. In studied species, most of the genera showed C_4 leaf anatomy except the species *Oplismenus, Chionachnae.*

In grasses vascular bundles are arranged centrally within the vertical plane of the blade. In leaf blades of *Ophiuros, Sorghum, Apluda, Haceklochloa, Paspalidium flavidum, Eragrostis, Brachiaria, Panicum, Iseilema, Setaria, Themeda, Eremopogon, Capillipedium huegelii, Digitaria, Echinochloa, Tragus,* etc. had a position of vascular bundles were centrally positioned. But in some grass species, vascular bundles were observed to be located closer to the abaxial or to the adaxial surface. Species like *Chionachnae, Coix, Heteropogon triticeus, Chloris montana, Schoenefeldia gracilis, Tetrapogon, Dactyloctenium, Eragrostis,* etc. had vascular bundles arranged closer to abaxial surface. Irregular arrangements of vascular bundles of different orders situated at different levels within the mesophyll were also observed. This positioning of the vascular bundles in the blade appears to be a useful diagnostic character above the genus level that has been largely overlooked in the past. In the present study, few grass species showed irregular arrangement of vascular bundles, in which 3rd order vascular bundles placed closer to abaxial surface and 1st order vascular bundles placed centrally of leaf blade. Species like *Vetiveria zinzanoides, Themeda cymbaria, Cenchrus biflorus, Paspalidium geminatum, Chloris barbata*, etc. showed irregular arrangement of vascular bundles.

It was observed that wider leaves do not necessarily have more vascular bundles than narrower leaves. Studied grass species showed large variation in arrangement and alternation of vascular bundles of different orders. For example, *Coix* had two 2nd and two 3rd order vascular bundles between two consecutive 1st order vascular bundles, *Andropogon plumis* had four 2nd and two 3rd order vascular bundles between two consecutive 1st order vascular bundles, *Bothriochloa pertusa* had two 2nd and four 3rd order vascular bundles between two consecutive 1st order vascular bundles, *Cymbopogon martini* had two 2nd and one 3rd order vascular bundles between two consecutive 1st order vascular bundles, *Dicanthium caricosum, Heteropogon contortus, Heteropogon ritchei* had three 2nd and three 3rd order vascular bundles between two consecutive 1st order vascular bundles, *Heteropogon triticeus* had one 2nd and six 3rd order vascular bundles between two consecutive 1st order vascular bundles, *Ischaemum* showed had four 2nd and three 3rd order vascular bundles between two consecutive 1st order vascular bundles, *Vetivaria* had one 2nd and three 3rd order vascular bundles between two consecutive 1st order vascular bundles, *Alloteropsis* had three 2nd and ten 3rd order vascular bundles between two consecutive 1st order vascular bundles, *Capillipedium* had ten vascular bundles between two consecutive 1st order vascular bundles, *Ophiuros* had nine 3rd order vascular bundles between two consecutive 1st order vascular bundles but 2nd order vascular bundles absent, *Apluda mutica, Chloris* showed alternate arrangement of 2nd and 3rd orders vascular bundles between two consecutive 1st order vascular bundles, *Eragrostis* had one to two 2nd and three to four 3rd order vascular bundles between two consecutive 1st order vascular bundles, *Echinochloa colona* had two 2nd and three 3rd order vascular bundles between two consecutive 1st order vascular bundles, *Echinochloa crusgalli* had four 2nd and seven 3rd order vascular bundles between two

consecutive 1st order vascular bundles. This relative proportion and the alternation of the various sizes of vascular bundle along leaves of any one species of grass is remarkably constant. The distribution patterns of bundles of different orders, and their variation are important diagnostic characters.

Generally three different orders of vascular bundles are present in grasses, which differ in their sizes and presence of vascular tissue type. The 1st order bundles according Metcalfe, 1960 are characterized by having a metaxylem vessel on either side of the protoxylem, and as the protoxylem was nonfunctional it was replaced by a lysigenous cavity. A few well-developed protoxylem vessels may be present in addition to the lysigenous cavity, or both cavity and vessels may be absent. In 2nd order bundles, the xylem and phloem are easily distinguishable, but the large metaxylem vessels are lacking and xylem and phloem is reduced to a few elements or even may be indistinguishable. Authors Vickery, 1935 and Goossens, 1938 have pointed out that second order bundles may show a tendency to develop into first order bundles. In the 3rd order vascular bundles metaxylem vessel elements are always lacking and in the smallest bundles of this order the xylem and phloem elements may be indistinguishable. 3rd order vascular bundles were angular, circular or elliptical in outline. This feature was taxonomically very important. Angular bundles were a characteristic feature of the panicoids and non angular bundles were the characteristic feature of festucoid grasses. Amongst the studied species most of panicoideae members had angular or elliptical shaped 3rd order vascular bundles and most of pooideae members had circular shaped 3rd order vascular bundles. *Chionachnae, Coix, Andropogon, Chrysopogon, Cymbopogon, Capillepedium, Heteropogon,* etc. of panicoideae had angular shaped 3rd order vascular bundles and species like *Cynodon dactylon, Eragrostis tremula* of panicoideae had a triangular shaped 3rd order vascular bundle while *Brachiaria, Eragrostis, Sporobolus, Dactyloctenium,* etc. of festucoid showed circular shaped 3rd order vascular bundle. *Desmostachya, Eragrostiella,* etc. of festucoid showed an elliptical shape of 3rd order vascular bundles.. 2nd order vascular bundles also showed shapes like 3rd order vascular bundle, but most of the species had circular shaped 2nd order vascular bundle i.e were belongs to festucoid.

Vascular bundles were surrounded by bundle sheath either completely or partially. Sometimes two layers of bundle sheaths were present, with outer one known as outer bundle sheath and inner one as inner bundle sheath or mestome. Bundle sheath distribution and type of cells were very important character for the taxonomic study. Ellis (1974) reported anomalous bundle sheath in *Alloteropsis semialata*. It showed double bundle sheath with the inner bundle sheath composed of large cells with specialized chloroplast and outer bundle sheath of smaller cells with or without chloroplast. Schwendener (1890) studied the distribution of sclerenchyma between the vascular bundle and epidermises to be of systematic importance and he classified grasses into two groups, based on the presence and absence of mestome sheath. Members of Maydeae, Andropogoneae and few members of Paniceae showed absence of mestome sheath while members of Pooideae and few members of Paniceae showed presence of mestome. The species with single bundle sheath was characteristic feature of panicoid while the species with double sheaths was the

characteristic of festucoid members. Most of the Panicoideae members showed absence of mestome i.e single bundle sheath except *Brachiaria, Eriochloa* and *Panicum.* From the tribe Pooideae, *Aristida, Perotis, Chloris, Tetrapogon, Dactyloctenium, Elesusine, Eragrostis, Ergrostiella, Sporobolus, Tragus* showed presence of mestome i.e. double bundle sheath within the 1st order vascular bundle. Brown (1958) differentiates the genus *Aristida* from all other grasses in having each vascular bundle surrounded by two parenchymatous sheaths and with an absence of sclerenchymatous, thick walled or mestome sheath being absent. But Metcalfe (1960) is of the opinion that the bundle may be surrounded by three sheaths the innermost being mestome sheath.

Shape of bundle sheath varied with the change in the shape of vascular bundles. The 3rd order vascular bundles are generally angular, circular or elliptical Shape of bundle sheath was also either circular or elliptical. *Chionachnae, Coix, Apluda, Andropogon, Chrysopogon, Cymbopogon, Dicanthium, Hackelochloa, Ischaemum, Sehima, Sorghum, Thelepogon, Brachiaria, Cenchrus, Digitaria, Eremopogon, Eriochloa, Oplismenus, Setaria, Chloris, Eragrostis* from group Panicoideae or Pooideae etc. showed round /circular shaped bundle sheath, *Bothriochloa pertusa, Imperata, Ophiuros, Sachharum, Vetiveria, Pennisetum, Eragrostis tenella* showed elliptical shaped bundle sheath while *Perotis, Tetrapogon, Tragus* showed horse shoe shaped bundle sheath. Bundle sheath is further also designated as complete or incomplete and if incomplete then it is because of interruption by sclerenchyma or parenchyma, either from abaxial or adaxial or both sides. Species like *Chionachnae, Coix, Apluda, Cymbopogon, Hackelochloa, Thelepogon, Cenchrus, Panicum, Setaria,* etc. showed complete bundle sheath while species like *Andropogon, Bothriochloa, Chrysopogon, Dicanthium, Iseilema, Echinochloa, Eremopogon, Eriochloa, Tragus,* etc. showed incomplete bundle sheath because sclerenchyma interrupted from abaxial side. But *Ophiuros, Eragrostiella* and *Vetiveria* showed incomplete bundle sheath from the abaxial and adaxial side. *Eragrostiella* in fact showed abaxial interruption because of sclerenchyma and adaxially because of parenchyma while other two species showed sclerenchyma on both sides.

In the grass leaf blade, the sclerenchymatous tissue includes all fibers as well as other thick-walled cells in certain instances. The sclerenchyma is commonly found in association with the vascular bundles, the midrib or keel and in the margin. Species like *Hackelochloa granularis, Panicum antidotale, Brachiaria ramosa, Chlrois montana, Capillipedium hugelii, Sporobolus coromandenlianus,* etc. showed absence of sclrenchyma in the margin. *Apluda, Paspalidium flavidum, Eragrostis nutans, Pennisetum setosum, Iseilema laxum, Oplismenus compositus, Panicum maximum, Vetiveria, Themeda triandra, Eremopogon foveolatus, Desmostachya, Tragus,* etc. had a small cap of sclrenchyma a margin while *Chionachnae koenigii, Coix, Ophiuros, Sorghum halepense, Brachiaria eruciformis, Bothriochloa pertusa, Eragrostiella bifaria,* etc. had a well developed sclerenchyma in the margin. The sclerenchyma associated with the vascular bundles is in the form of sub-epidermal longitudinal bands following the course of either 1st order vascular bundle or each

vascular bundle. They were in the form of either strands or girders; the former is usually associated with the third order vascular bundles and the latter with larger bundles. The distribution and arrangement of the sclerenchyma associated with the bundles were found to be characters of taxonomic interest.

Changes in leaf biochemistry, ultrastructure and plant biomass allocation, leaf morphological and anatomical modifications are frequent components of plant adjustment to contrasting habitat light conditions (Mendes *et al.*, 2001; Oguchi *et al.*, 2003; Lambers *et al.*, 2004; Mojzes *et al.*, 2005). The species which were grown under different habitats, showed variations in their anatomical structure. Species like *Melanocenchris, Eragrostiella bachyphylla, Eragrostiella bifaria* grown in stony or rocky area showed unique characters like incomplete outer bundle sheath which was interrupted from both the sides by sclerenchyma cells, presence of colourless cells which follows bulliform cells and ends till opposite end of epidermis, mestome was either parenchymatous or sclerenchymatous which was either complete or incomplete. But the species like *Coix, Brachiaria* grown in moist area showed characters like presence of colourless cells which generally occupied either ½ or ¼ or less than that portion of the leaf thickness, mestome was always made up of parenchyma cells, outer bundle sheath was complete or incomplete and if incomplete it was due to interruption of parenchyma or sclerenchyma cells from abaxial surface.

Leaf sheath anatomy was more or less same as leaf lamina. Most of the characters like adaxial and abaxial epidermis, ground tissue, distribution of vascular bundles, vascular bundle arrangement, vascular bundle structure, vascular bundle sheath structure, outline of leaf sheath, are similar to the structure of leaf lamina. Leaf sheath showed variation in outline i.e. 'V'/ 'U' or round shaped. Among studied species, *Chionachnae, Heteropogon triticeus, Eragrostis pilosa, Paspalidium flavidum, Eragrostis nutans, Pennisetum setosum, Brachiaria eruciformis, Panicum antidotale, Vetiveria zinzanoides, Chloris montana, Digitaria ciliaris, Sachoenefeldia gracilis, Bothriochloa pertusa*, etc. showed 'V' shaped outline of leaf sheath while species like *Coix, Hackelochloa, Eleusine indica, Tragus, Panicum miliaceum, Paspalum scorbiculatum, Aristida funiculata,* etc. showed 'U' shaped outline of leaf sheath. Species like *Ophiuros, Sorghum, Apluda, Iseilema, Setaria glauca, Eragrostis japonica, Eragrostis tremula, Eragrostis viscosa, Eragrostis unioloides, Cymbopogon, Dicanthium,* etc. showed round shaped outline of leaf sheath. Unlike leaf lamina, in the ground tissue of leaf sheath air cavities were present which could be categorised into four different shapes. Some of the species showed an absence of air cavities. *Chionachnae, Coix, Ophiuros, Sorghum, Panicum antidotale, Vetivaria,* etc. showed vertically oval shaped air cavities while *Hackelochloa, Hetropogon triticeus, Paspalidium flavidum, Pennisetum setosum, Brachiaria eruciformis, Setaria glauca, Eragrostis japonica, Triplopogon, Brachiaria distachya, Brachiaria ramosa,* etc. showed horizontally oval shaped air cavities. Species like *Eragrostis unioloides, Panicum miliaceum, Arthraxon lanceolatus, Ischanae globosa,* etc showed round shaped air cavities while *Chloris montana, Andropogon, Themeda triandra, Capillipedium, Digitaria ciliaris, Echinochloa colona, Bothriochloa, Schoenefeldia,*

Tetrapogon, Dactyloctenium, Eragrostiella, Eragrostis ciliaris, Acrachanae ramosa, Paspalum, Eragrostis tremula, Eragrostis viscosa, etc. showed absence of air cavities.

Grasses with ligules have higher fitness (Moreno *et al.,* 1997; Korzun *et al.,* 1997). Ligule may be membranous or hairy. It may be mainly fully or partially attached to leaf lamina or leaf sheath. The main role of the ligule is to protect the inner side of the leaf sheath from water, dust, and spore but in a few species, it also had a function of secretion (Chaffey, 2000). Chaffey (1984) studied epidermal structure in the ligules of four species of *Poa.* He described long cells, short cells and unicellular prickle hairs over the surface, with unicellular hairs and papillate cells on the free edges of the ligules. Ligule anatomy is important for identifying individuals living in non-optional environments (Neumann, 1938). Chaffey (1994) demonstrated the functional anatomy of ligules in 49 grass species from ten tribes. As chloroplast was found to be present in the ligules studied he has deduced it as a photosynthetic leaf organ. Structurally ligule anatomy is simpler than the leaf lamina. Sometimes prickle hairs are observed and are present on abaxial surface. Ligules consist of three layers: the mesophyll and two epidermal cell layers with absence of intercellular spaces. Mesophyll is generally present throughout the ligule except at the edges which consisted of epidermal cells only (Neumann, 1938). Neumann also suggested that ligule character is also vital for identifying individual, species living in non-optimal environments (Pathak *et al.,* 2013). Ligule cells are generally much smaller than other grass plant parts. Generally, the abaxial epidermis appears to consist of parenchyma like cells. Szabo *et al.* (2006) studied ligule anatomy and morphology of five species of *Poa.* both by light and scanning electron microscopy. They have described the ligule in detail emphasizing interspecific differences and habitat dependant variation of shape, length and prickle hair density. They observed that ligules of *Poa anustifloia* are decurrent on the leaf sheath margin and the connection of the ligule blade and the adaxial epidermis of the leaf sheath is a straight line forming a right angle to the longitudinal axis of the leaf sheath while the ligule of *P. pratensis* describes a curve in its connection to the adaxial epidermis of the leaf sheath. This provides a good discriminating character between the two closely related taxa, irrespective of modifications caused by habitat conditions. Among the studied species mesophyll layers are either one, two, three or more. Sometimes prickles and sclerenchyma cells were present on abaxial surface. Adaxial cells of the ligule were usually flat, square to rectangular shaped and abaxial cells were square shaped with outer tangential wall round. Species like *Andropogon, Brachiaria reptans, Digitaria granularis, Digitaria longiflora, Eremopogon, Eriochloa, Panicum antidotale, Perotis, Eleusine indica, Eragrostis ciliaris,* etc. showed single layered mesophyll, species like *Setaria, Chloris virgata, Imperata, Ischaemum molle, Iesilema, Ophiuros, Rottboellia, Themeda laxa, Triplopogon, Vetiveria,* etc. showed two layered mesophyll and species like *Apluda, Chrysopogon, Cymbopogon, Sorghum, Alloteropsis, Cenchrus, Dinebra,* etc. showed

three or more layered of mesophyll. Few studied species showed presence of sclerenchyma on abaxial surface i.e. *Apluda, Arthraxon, Capillipedium, Dicanthium caricosum, Dicanthium annulatum, Hackelochloa granularis, Ischaemum molle, Ischaemum rugosum, Saccharum, Sorghum halepense, Paspalidium geminatum, Setaria glauca, Setaria verticillata,* etc. Species like *Heteropogon contortus, Cenchrus setigerus* shows presence of prickles on abaxial surface.

Based on the characteristic features of a dichotomous key for the studied species has been prepared.

1. Outline of leaf lamina is 'U' shaped.....***Pennisetum setosum***
1. Outline of leaf lamina is 'V'/expanded/inrolled shaped.....**2**
2. Outline of lamina inrolled.....**3**
2. Outline of leaf lamina is 'V'/expanded shaped.....**5**
3. Vascular bundle positioned centrally within the leaf blade……..……..***Triplopogon ramosissimus***
3. Vascular bundle located close to abaxial surface of leaf blade…..…..…..…….**4**
4. Vascular bundle sheath cells with chloroplast in the center.....….***Eragrostis tremula***
4. Vascular bundle sheath cell with chloroplast adpressed near the outer tangential wall……...……...……..***Eragrostis viscosa***
5. Outline of lamina 'V' shaped……..……..……..……..**6**
5. Outline of lamina expanded……...……..……..……..**56**
6. Ribs and furrows present……..……..……..……**7**
6. Ribs and furrows absent……..…..……..…….**37**
7. Ligule absent……..……..……..……**8**
7. Ligule present……..……..……..……...**9**
8. 'U' shaped keel…….…..***Echinochloa colona***
8. 'V' shaped keel……..…….….***Echinochloa crusgalli***
9. 'V' shaped ligule……..……....**10**
9. Round shaped ligule……..……..**18**
10. Well developed sclerenchyma present at the margin of leaf lamina…..…..……**11**
10. Only 4-6 sclerenchyma cells present at the margin of leaf lamina…..…..……**13**
11. Vertically oval shaped air cavities present in leaf sheath...… ***Alloteropsis cimicina***
11. Air cavities absent in leaf sheath……...……**12**
12. Phloem adjoins with the inner or parenchyma sheath cells in 1st order vascular bundle…….……***Cenchrus biflorus***
12. Phloem completely surrounded by thick walled fibers…..…….***Cenchrus ciliaris***
13. Mestome present in 1st order vascular bundle…...……..……. ***Eragrostis nutans***
13. Mestome absent in 1st order vascular bundle……...……..**14**
14. Fan shaped bulliform cells present…..…….…….. ***Themeda cymbaria***
14. Large, inflated bulliform cells……..…..……**15**
15. Vascular bundles arranged towards abaxial side of leaf blade……...

…….. ***Heteropogon triticeus***

15. Vascular bundles arranged in the center of the leaf blade……..…..……**16**

16. Two layered mesophyll present in ligule…… ***Heteropogon ritchiei***

16. More than three layered of mesophyll present in ligule ……..…….……**17**

17. Absence of prickles on abaxial surface of ligule……
……..…..……..….. ***Heteropogon contortus* var. *genuinus* sub var. *typicus***

17. Presence of prickles on abaxial surface of ligule……..……..
……....…***Heteropogon contortus* var. *genuinus* sub var. *hispidissimus***

18. Mestome absent in 1st order vascular bundle……..……...……**19**

18. Mestome present in 1st order vascular bundle……...…….……**27**

19. Air cavities present in leaf sheath……...……..……..**20**

19. Air cavities absent in leaf sheath…...……...……..**21**

20. Round shaped leaf margin of leaf blade…...…….…….. ***Apluda mutica***

20. Pointed leaf margin of leaf blade…..…… ***Saccharum spontaneum***

21. 'V' shaped in outline of leaf sheath……...……**22**

21. Round shaped in outline of leaf sheath…….……..**24**

22. Radiate arrangement of mesophyll cells……..… ***Capillipedium huegelii***

22. Incomplete radiate arrangement of mesophyll cells……...…**23**

23. Large, inflated bulliform cells…...……..…….. ***Echinochloa stagnina***

23. Fans shaped bulliform cells...……..….. ***Sporobolus indicus***

24. Vascular tissue consisting of only a few indistinguishable vascular elements in 3rd order vascular bundles…...…….……..***Sporobolus diander***

24. Xylem and phloem distinguishable in 3rd order vascular bundles…...…...……**25**

25. Elliptical shaped of 1st order vascular bundle…...…… ***Ischaemum pilosum***

25. Obovate shaped of 1st order vascular bundle…...…….……..……**26**

26. Sclerenchyma absent on abaxial surface of ligule……..***Dicanthium annulatum***

26. Sclerenchyma present on abaxial surface of ligule……. ***Dicanthium caricosum***

27. Air cavities absent in leaf sheath……...…….……**28**

27. Air cavities present in leaf sheath……...……**32**

28. 3rd order vascular bundles are angular……...…….……**29**

28. 3rd order vascular bundles are round/elliptical……..……**30**

29. Outline of leaf sheath is 'U' shaped……...……...…… ***Schoenefeldia gracilis***

29. Outline of leaf sheath is round shaped…...…… ***Chloris barbata***

30. Bulliform cells absent……...……..…...…….. ***Aristida adscensionis***

30. Fan shaped bulliform cells present……**31**

31. Circular shaped vascular bundles, 'V' shaped leaf sheath……..…….
……..……..……***Eragrostiella bachyaphylla***

31. Elliptical shaped vascular bundles, round shaped leaf sheath..***Eragrostiella bifaria***

32. Xylem and phloem distinguishable in 3rd order vascular bundles……..…
……...***Aristida funiculata***

32. Vascular tissues consisting a few indistinguishable vascular elements in 3rd order vascular bundles..……**33**
33. Chloroplast arranged in center of vascular bundle sheath cells……..…..…….**34**
33. Chloroplast adpressed towards tangential wall of vascular bundle sheath cells……..……...…….**35**
34. Circular shaped vascular bundle sheath..…….…. ***Eragrostis japonica***
34. Horse shoe shaped vascular bundle sheath…...…… ***Eragrostis pilosa***
35. Colourless cells absent……..……. ***Panicum miliaceum***
35. Colourless cells absent……..……..……..**36**
36. Hexagonal shaped 3rd order vascular bundles in leaf sheath...***Panicum antidotalae***
36. Elliptical shaped 3rd order vascular bundles in leaf sheath..... ***Panicum maximum***
37. Mestome present in 1st order vascular bundle...……**38**
37. Mestome absent in 1st order vascular bundle…..……..….**41**
38. Radiate arrangement of mesophyll cells…..…….…….**39**
38. Irregular arrangement of mesophyll cells……...……..……..**40**
39. Outline of leaf sheath is ‘U’ shaped…...…….. ***Eleusine indica***
39. Outline of leaf sheath is ‘V’ shaped…..……..…. ***Acrachne racemosa***
40. Central cell of bulliform cells is inflated, round……..…...…….. ***Choris montana***
40. Central cell of bulliform cells is shield shape…...…… ***Chloris virgata***
41. Outline of leaf sheath is round shaped……...……..….**42**
41. Outline of leaf sheath is ‘V’ shaped……..……..…..….**48**
42. Inverted triangular shaped keel……..……..……..**43**
42. V shaped keel…...……..……**44**
43. Lysigenous cavity present in 1st order vascular bundle of leaf blade.....
……..……***Ophiuros exaltatus***
43. Lysigenous cavity absent in 1st order vascular bundle of leaf blade.....
…...……...……***Sorghum halepense***
44. Phloem adjoins the inner or parenchyma sheath cells in 1st order vascular bundle...
……..…… ***Rottboellia exaltata***
44. Phloem completely surrounded by thick walled fibers in 1st order vascular bundle……...**45**
45. Fan shaped 3rd order vascular bundle sheath cells ...…….……**46**
45. Elliptical shaped 3rd order vascular bundle sheath cells……**47**
46. Chloroplast apressed near inner tangential wall...……...…... ***Ischaemum indicus***
46. Chloroplast apressed near outer tangential wall.....…..……. ***Ischaemum rugosum***
47. Vascular bundles arranged centrally of leaf blade...……..…..… ***Ischaemum molle***
47. Vascular bundles arranged towards abaxial surface of leaf blade……....
……...……..…….***Paspalidium geminatum***
48. Air cavities present in leaf sheath……...……...……**49**
48. Air cavities absent in leaf sheath……...…….**50**

49. Complete vascular bundle sheath of 1st order vascular bundle……. ……...……..***Paspalidium flavidum***

49. Incomplete vascular bundle sheath of 1st order vascular bundl……. ……...……...….. ***Chrysopogon fulvus***

50. All the vascular bundles placed at different level in leaf blade…...……...……**51**

50. All the vascular bundles placed at same level…...……...……..**52**

51. Large, inflated bulliform cells…..……. ***Cenchrus setigerus***

51. Fan shaped bulliform cells……..……...……. ***Themeda laxa***

52. Chloroplast placed at center of vascular bundle sheath cell... ***Bothriochloa pertusa***

52. Chloroplast placed towards outer tangential wall of vascular bundle sheath cell..**53**

53. Xylem and phloem distinguishable elements in 3rd order vascular bundles…..…… ……...…….. ***Vetivaria zinzanoides***

53. Vascular tissue consisting of a few indistinguishable vascular elements in 3rd order vascular bundles……...……**54**

54. Square shaped 3rd order vascular bundle of leaf sheath… ***Eremopogon foveolatus***

54. Pentagonal shaped 3rd order vascular bundle of leaf sheath…...……**55**

55. Circular shaped 1st order vascular bundle…..…… ***Themeda qurqdrivalvis***

55. Elliptical shaped 1st order vascular bundle…...…….. ***Themeda triandra***

56. Mestome present in 1st order vascular bundle…..……..……**57**

56. Mestome absent in 1st order vascular bundle……..……...……**75**

57. ‘V’ shaped outline of leaf sheath……..…….……**58**

57. Round shaped outline of leaf sheath……...……**64**

58. Lysigenous cavity absent in 1st order vascular bundle…..……...……..**59**

58. Lysigenous cavity present in 1st order vascular bundle…...…….……..**62**

59. Pointed leaf lamina margin ……..…….……**60**

59. Round leaf lamina margin……...…….……..**61**

60. Radiate arrangement of mesophyll cells…..……...…… ***Brachiaria eruciformis***

60. Irregularly arrangement of mesophyll cells…..…… ***Oropetium villosulum***

61. Chloroplast fill entire full lumen, straight arms of leaf blade, single layered mesophyll in ligule…….……..…...……***Tetrapogon tenellus***

61. Chloroplast concentrated near inner tangential wall, wavy arms of leaf blade, two layered mesophyll in ligule…...…….....…… ***Tetrapogon villosus***

62. ‘V’ shaped ligule……...……...…. ***Echinochloa stagnina***

62. Round shaped ligule……..…….……...…….**63**

63. Air cavities absent in leaf sheath…...……..……. ***Eragrostis tenella***

63. Round shaped air cavities present in leaf sheath...……..…… ***Eragrostis unioloides***

64. Colourless cells absent ……..……...……**65**

64. Colourless cells present……..……...…..**73**

65. Ribs and furrows absent …...…….…… ***Tragrus biflorus***

65. Ribs and furrows present……...……**66**

66. Irregular arrangement of mesophyll cells……..……**67**
66. Radiate/incomplete radiate arrangement of mesophyll cells…...…….……..**68**
67. Chloroplast fill entire lumen of vascular bundle sheath cell..….. ***Eragrostis ciliaris***
67. Chloroplast apressed towards inner outer tangential wall of vascular bundle sheath cell……..…….……..…… ***Dinebra retroflexa***
68. Horse shoe shaped vascular bundle sheath …...……...……..**69**
68. Circular shaped vascular bundle sheath…..……..……**72**
69. Phloem adjoins inner or parenchyma sheath cell of 1st order vascular bundle…..
……..……***Perotis indica***
69. Phloem completely surrounded by thick walled fibers in 1st order vascular bundle……...**70**
70. Extension of vascular bundle sheath is present..…… ***Brachiaria distachya***
70. Extension of vascular bundle sheath is absent...……**71**
71. Chloroplast placed centrally of mesophyll cells..……..… ***Brachiaria ramosa***
71. Chloroplast concentrated near outer tangential walls of mesophyll cells…..……
……...……***Brachiaria reptans***
72. Crescent shaped leaf margin, round shaped ligule, single layered mesophyll in ligule……...……..... ***Dactyloctenium aegyptium***
72. Pointed leaf margin, 'V' shaped ligule, two layered mesophyll in ligule……
……...……..…..***Dactyloctenium sindicus***
73. Radiate arrangement of mesophyll cells…..... ***Desmostachya bipinnata***
73. Irregular arrangement of mesophyll cells……...……...…….**74**
74. Triangular shaped 3rd order vascular bundles...……..…… ***Cynodon dactylon***
74. Hexagonal shaped 3rd order vascular bundles…….. ***Melanocenchris jaequemontii***
75. All vascular bundles present at different level……..……...……..**76**
75. All vascular bundles present at same level…...……..…..……..**78**
76. Circular shaped 3rd order vascular bundles...……..……***Sehima ischaemoides***
76. Pentagonal shaped 3rd order vascular bundles…...……...……..**77**
77. Shallow furrows present on abaxial leaf surface, subepidermal strands of 2-4 fibers on abaxial leaf surface ……..……...…...***Sehima nervosum***
77. Deep furrows present on abaxial leaf surface…..…….……..…***Sehima sulcatum***
78. Vascular bundles present towards abaxial surface of leaf blade……...……**79**
78. Vascular bundles present at center of leaf blade…..……..……..…….**83**
79. Round shaped outline of leaf sheath……...……**80**
79. V/U shaped outline of leaf sheath……..……**81**
80. Air cavities absent in leaf sheath…...……. ***Cymbopogon martini***
80. Oval shaped air cavities present in leaf sheath…....…… ***Hackelochloa granularis***
81. V shaped keel……..……...…… ***Eriochloa procera***
81. Semicircular shaped keel……...…….……**82**

82. Large air cavity present in keel..…….…..… ***Coix lachryma-jobi***
82. Air cavity absent in keel…..……..…. ***Chionachne koenigii***
83. V/U shaped outline of leaf sheath……..……...…….**84**
83. Round shaped outline of leaf sheath……...……...…….**93**
84. U shaped outline of leaf sheath……...……..…… ***Imperata cylindrica***
84. V shaped outline of leaf sheath……..……**85**
85. Phloem adjoins inner or parenchyma sheath cell in 1st order vascular bundle…..**86**
85. Phloem completely surrounded by thick walled fibers…..……...…….**89**
86. Xylem and phloem distinguishable in 3rd order vascular bundle……...…
……..***Thelepogn elegans***
86. Vascular tissue consisting of only a few indistinguishable vascular elements in 3rd order vascular bundle……..……...……..**87**
87. Circular shaped 3rd order vascular bundle…..……..…..…… ***Isachne globosa***
87. Hexagonal shaped 3rd order vascular bundle……...…….……..**88**
88. Elliptical shaped 1st order vascular bundles...……..…….. ***Setaria verticillata***
88. Circular shaped 1st order vascular bundles…...……***Setaria tomentosa***
89. Fan shaped bulliform cells……..……...… ***Andropogon pumilus***
89. Large, inflated restricted groups of bulliform cells……...…….……**90**
90. Circular shaped 3rd order vascular bundle…...……..…….. ***Digitaria granularis***
90. Pentagonal shaped 3rd order vascular bundles in leaf sheath…….....……**91**
91. Egg shaped midrib vascular bundle…..…….…. ***Digitaria stricta***
91. Round shaped midrib vascular bundle……..…….……**92**
92. Square shaped 3rd order vascular bundles in leaf lamina...…… ***Digitaria ciliaris***
92. Angular (penta and hexagonal) shaped 3rd order vascular bundles in leaf lamina….
……...…….……...……...***Digitaria longiflora***
93. Colourless cells present…...…….……. ***Sporobolus coromandelianus***
93. Colourless cells absent……...…….…….…….**94**
94. Irregularly arranged mesophyll cells……...……...……**95**
94. Radiate/incomplete radiate arranged mesophyll cells……..……..**98**
95. Inconspicuous keel…..……...……. ***Paspalum scrobiculatum***
95. Well developed keel……..……...……..**96**
96. Wide vessels present……...……..……...….. ***Setaria glauca***
96. Narrow vessels present……...……..……..**97**
97. Air cavities absent in leaf sheath…...…….…… ***Oplismenus burmannii***
97. Oval shaped air cavities absent in leaf sheath…...…….. ***Oplismenus composites***
98. Incomplete radiate arrangement of mesophyll cells...…..… ***Arthraxon lanceolatus***
98. Radiate arrangement of mesophyll cells……..……..**99**
99. Chloroplast apressed towards outer tangential wall of vascular bundle sheath….
……...……..***Panicum trypheron***
99. Chloroplast placed at centre of vascular bundle sheath…….. ***Iseilema laxum***