

ANATOMICAL STUDIES OF SOME SPECIES OF *ERAGROSTIS* P. BEAUV.

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Several authors have classified the family *Gramineae* on morphological basis. The importance of anatomical characters from the systematic point of view has been found by a number of workers, foremost of them being Avdulov (1931), Brown (1958), Metcalfe (1960), Prat (1936), Tateoka (1959) and Chih Ying Wu (1962). The present investigation was undertaken because the writer was faced with certain difficulties in the separation of some allied species on the morphological characters alone which are rigid, and the differences even microscopical. Professor K. N. Kaul, therefore, directed the author to study their anatomical characters. The present study gives an account of ten species of *Eragrostis* out of a total of 35 spp. found in India (Bor, 1947 and 1960).

Material and Methods

Material of *Eragrostis ciliaris*, *E. diarrhena*, *E. gangetica*, *E. japonica*, *E. pilosa*, *E. tenella* was collected from the National Botanic Gardens and its sub-station Banthra, those of *E. nigra*, *E. unioloides*, and *E. viscosa* were obtained from Forest Research Institute, Dehra Dun.

The fresh material was fixed in formalin acetic-alcohol, and that from herbarium first soaked in water for about 12 hours and then boiled until it became soft. These materials have been then dipped in 0.5%—1% hydrofluoric acid for 24 hours, to remove silica which makes the leaf hard.

The epidermis was scrapped off, stained in aqueous safranin and mounted in glycerine. Free hand and microtome sections were cut of culms and leaves. The sections were stained in safranin and light green.

Observations

All the 10 spp. studied here are annuals excepting *E. gangetica* and *E. nigra* which are perennial.

Culms grow erect or ascend from a curved or a prostrate base, and are mostly cylindrical rarely compressed. The culm is solid in the young stage but

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at maturity it generally becomes hollow.

As seen in T. S., the culm generally consists of cuticularized epidermis. The hypodermal layer or layers are generally sclerenchymatous, parenchymatous cells occupying this region, only in certain cases, do not conform to the general type.

The rest of the ground tissue consists of parenchymatous cells; mostly all the culms are with a hollow pith. Vascular bundles are unevenly scattered in the ground tissue. Those lying nearer the periphery are smaller while those towards the inner side are bigger. Each bundle is collateral, closed and endarch. The xylem consists of two prominent metaxylem elements, to the inner side of which is the small protoxylem element with or without a lysigenous cavity formed by the breaking down of inner cells of the protoxylem. The phloem, which has a characteristic monocot structure with sieve tubes and companion cells bulges out of the place within the two metaxylem elements. Each vascular bundle has a small sheath of sclerenchyma. Those bundles that lie near the periphery are embedded in the sub-hypodermal or hypodermal sclerenchyma. This general type of culm structure is found only in *E. ciliaris* (Fig. 1, A), *E. diarrhena*, *E. poaeoides* and *E. unioides*. On the other hand *Eragrostis gangetica* (Fig. 1, B) presents a characteristic broad zone of thin-walled tissue with abundant intercellular spaces between the epidermis and the sclerenchyma. In *E. japonica* (Fig. 1, C) sclerenchymatous layer is separated from the epidermis by a few layers of parenchyma. In *E. nigra* (Fig. 1, D) patches of unthickened cells are embedded in the sclerenchymatous layer. The sclerenchyma in *E. pilosa* (Fig. 1, E & F) possesses a sinuate inner border forming ribs and grooves. In *E. viscosa* (Fig. 1, G & H) between the sclerenchyma and the epidermis there are 2-3 cell layers of thin walled tissue.

The grass leaf consists of a leaf sheath, ligule and leaf blade, the distal end of leaf sheath may be with or without hairs. The ligule may be thin or rigidly membranous, being sometimes hairless or may bear hairs at the back. The leaf blade may be narrow, linear or lanceolate. The texture also varies from species to species.

1. *Eragrostis ciliaris* (Linn.) R. Br: *Leaf sheath* running to about half to two third the length of the internodes. The sheath practically covers the culm on all sides, distal end has well developed long hairs; *ligule* is represented by a fringe of short hairs; *leaf blade* is narrow and elongated 5 cm.—7.5cm. long, 3-5 mm. broad, flat, glabrous, margin slightly serrulate, midrib not prominent. *Abaxial epidermis of leaf* (Fig. 1, I) possesses two type of cells in all cases. *Long cells* elongated along the length of the leaf, walls being slightly wavy. *Short cells* solitary in the intercostal region paired over the costal region. *Silica bodies*-saddle shaped. *Micro hairs* 76.5 μ in length. *Stomata* 240

per mm². subsidiary cells low dome-shaped. *Anatomy of leaf*: the lamina has an inconspicuous keel containing a single vascular bundle. *Sclerenchyma*: adaxial, rib rounded, grooves shallow. Adaxial girder is of 2-5 cells in width, 3 cells in height, abaxial girder is of 5 cells in width, 2 cells in height, lateral to the keel on both sides are 7 large basic type of bundles. *Mesophyll* inconspicuously radiate. *Bulliform cells* sporobolus type. *Bundle sheath* double in all cases.

2. *Eragrostis diarrhena* (Schult.) Steud: *Leaf sheath* loose, glabrous; *ligule* a fringe of small hairs; *leaf blade* linear, upper surface rough, lower smooth, 7-35 cm. long, 3-5 mm. broad, flat, glabrous. *Abaxial epidermis of leaf*: *Long cells* sinuations intermediate. *Short cells* solitary in intercostal region, in rows over costal region. *Silica bodies* saddle-shaped. *Microhairs* absent. *Stomata* 175 per mm², subsidiary cells low dome-shaped. *Anatomy of leaf*: (Fig. 2, A) the lamina is with a conspicuous keel with single large, basic type of bundle and two subsidiary small angular ones. *Adaxial surface* smooth, ribs plain, grooves shallow. *Sclerenchyma*: adaxial girder 3 cells in width, 2 cells in height, abaxial girder 8 cells in width 3 cells in height, lateral to the keel on both sides are 4 large basic type of bundles. *Mesophyll* inconspicuously radiate; two aerenchyma tissue are formed by anastomosing mesophyll cells. *Bulliform cells* sporobolus type. *Bundle sheath* double.

3. *Eragrostis gangetica* (Roxb.) Steud: *Leaf sheath* mouth bearded, rest glabrous; *ligule* a narrow ciliated ridge; *leaf blade* linear, tapering to a narrow apex, 5 cm.-32 cm. long, abaxial surface smooth, adaxial surface slightly rough, convolute, rigid, glabrous. *Abaxial epidermis of leaf* consists of two type of cells. *Long cell* walls wavy. *Short cells* paired or in rows in the costal region, intercostal zone mostly with solitary cells. *Silica bodies* saddle-shaped. *Microhairs* length 58.5 μ . *Stomata* 163 per mm². subsidiary cells low dome-shaped. *Anatomy of leaf*: the lamina is with an inconspicuous keel with a single large vascular bundle of basic type, slightly larger in size in comparison to the subsidiary ones. *Adaxial surface*: ribs slightly rounded, grooves shallow. *Sclerenchyma*: adaxial girder of 8-9 cells wide, 3 cells in height, abaxial girder of 13-14 cells wide and 3 cells wide, lateral to keel on both sides are 4 large bundles on each side. *Mesophyll* inconspicuously radiate. *Bundle sheath* double.

4. *Eragrostis japonica* (Thunb.) Trin: *Leaf sheath* loose, glabrous, mouth of the sheath not hairy; *ligule* a fimbriate membrane; *leaf blade* slender, linear, narrow, pointed apex, 7-16 cm. long, 1.5-2 mm. broad, glabrous, flat. *Abaxial epidermis of leaf*: *Long cell* walls with intermediate sinuations. *Short cells* solitary cells in the inter-costal region and two or more than two cells in the costal region. *Silica bodies* dumb-bell as well as saddle-shaped. *Microhairs* absent. *Stomata* 82 per mm², subsidiary cells low, dome-shaped. *Anatomy of leaf*: slightly

conspicuous, keel with single large basic type vascular bundle. *Adaxial surface* ribs plain and shallow grooves. *Sclerenchyma*: adaxial girder 5 cells wide, 3 cells in height, abaxial girder 8 cells wide, 2 cells in height, lateral to keel on both sides are 4 large type of bundles on each side. *Mesophyll* inconspicuously radiate, *Bulliform cells* sporobolus type. *Bundle sheath* double.

5. *Eragrostis nigra* Nees ex Steud: *Leaf sheath* rather loose obscurely compressed with mouth bearded with long stiff hairs, margins smooth; *ligule* a ciliated rim; *leaf blade* lanceolate, tapering to a sharp point, up to 21 cm. long, 2-3 mm. broad, margin smooth. *Abaxial epidermis of leaf* consists of two type of cells. *Long cells* situations intermediate. *Short cells* solitary in intercostal region and in rows over costal region. *Silica bodies* saddle-shaped. *Microhairs* absent. *Stomata* 175 per mm.², subsidiary cells low dome-shaped. *Anatomy of leaf* (Fig. 2, B & C): conspicuous keel containing single large basic type of bundle and two small subsidiary ones. *Adaxial surface*: ribs flat in appearance while groove is wavy. *Sclerenchyma*: adaxial girder inconspicuous, 3-5 cells in height, abaxial girder throughout conspicuous and it is 18-20 cells in thickness and 3-5 cells in height, lateral to keel on both sides are 2 large basic type of bundle on each side. *Mesophyll* inconspicuously radiate, two aerenchyma are formed by anastomosing mesophyll cells. *Bulliform cells* sporobolus type. *Bundle sheath* double.

6. *Eragrostis pilosa* (Linn.) P. Beauv: *Leaf sheaths* appressed, glabrous, smooth, bearded at the mouth; *ligule* with a rim of short hairs; *leaf blade* linear, acuminate tip, upper surface and margins rough, glabrous, 7 cm - 10 cm. long up to 2 mm broad, convolute. *Abaxial epidermis of leaf*: consists of two type of cells. *Long cells* situations intermediate. *Short cells* solitary over intercostal region, in rows over costal region. *Silica bodies* saddle-shaped, tall and narrow in costal region. *Microhairs* 46.2 μ in length. *Stomata* 144 per mm.², subsidiary cells low, dome-shaped. *Anatomy of the leaf* (Fig. 2, E): inconspicuous, keel with single basic type of bundle. *Adaxial surface* ribs rounded and slightly deep grooves. *Sclerenchyma*: adaxial ribs very small, 5 cells in width, 2-3 cells in height, abaxial girder 14 cells wide, 4-5 cells in height, lateral to keel on both sides are 2 basic types of bundles. *Mesophyll* conspicuously radiate. *Bundle sheath* double, outer sheath touches the adaxial sclerenchyma.

7. *Eragrostis poaeoides* P. Beauv: *Leaf sheaths* slightly tight, shorter than the culms, heavily bearded; *Ligule* a pubescent ridge. *Leaf blade* linear, acute, 3.0 to 13.5 cm. long, 2.5-6 mm. broad convolute, crateriform glands present on the margins. *Abaxial epidermis of the leaf* (Fig. 1, J): consists of two type of cells. *Long cell* walls slightly wavy, *Short cells* solitary in costal as well as in intercostal region. *Silica bodies* mostly saddle-shaped. *Microhairs* length of hair 54.0 μ . *Stomata* 62 per mm.²; subsidiary cells conical as well as low dome-

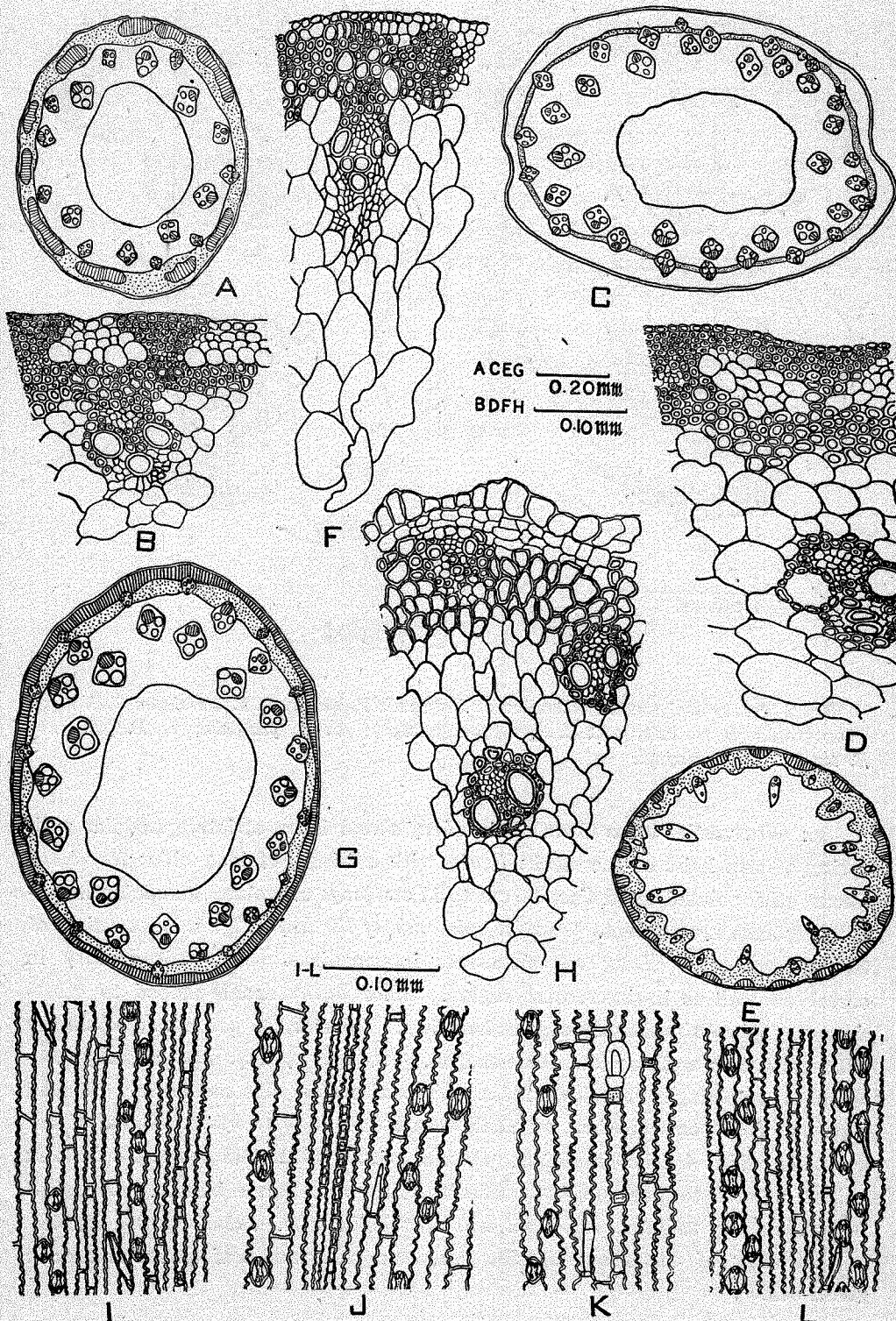
shaped. *Anatomy of leaf* (Fig. 2, D): conspicuous keel with one bundle. *Adaxial surface* ribs round, grooves shallow. *Sclerenchyma*: adaxial girder 9-10 cells wide, 5-6 cells in height, lower girder is complete in all other veins but in the keel region girder gets divided in two halves by enlarged abaxial epidermal cells, each of 6-7 cells wide and 7 cells in height. Lateral to the keel on both sides are 3 large basic type of bundles on each side. *Mesophyll* chlorenchyma radiate. *Bulliform* cells sporobolus type. *Bundle sheath* double.

8. *Eragrostis tenella* (Linn.) P. Beauv: *Leaf sheath* smooth, shorter than internodes, leaf sheaths have firm clasp over the culm, heavily bearded at the mouth; *ligule* a fringe of diverging hairs; *leaf blades* linear, narrow, tapering to a fine point, 3.5 cm. to 11.5 cm. long and 2.3 cm. in. breadth, abaxial surface as well as adaxial surface glabrous and smooth. *Abaxial epidermis of leaf* (Fig. 1, K) consists of two type of cells. *Long cells* walls very thin, wavy. *Short cells* solitary in intercostal region as well as in costal regions, paired short cells also occur in costal region. *Microhairs* length is 49.5 μ . *Prickle hairs* present. *Stomata* 186 per mm.²; subsidiary cells conical as well as low dome-shaped. *Anatomy of leaf* (Fig. 2, F): *keel* slightly conspicuous with a single vascular bundle. *Adaxial surface* ribs moderately rounded, fairly narrow shallow grooves. *Sclerenchyma*: adaxial girder 3-7 cells wide, 3 cells high, abaxial girder 10 cells wide, 2-3 cells high, lateral to keel on both sides are 2 large bundles. *Mesophyll* chlorenchyma radiate. *Bulliform cells* sporobolus type. *Bundle Sheath* double.

9. *Eragrostis uniolooides* (Retz.) Nees ex Steud: *Leaf sheath* glabrous, smooth. *Ligule* a narrow ciliated rim; *leaf blade* linear, tapering apex, 8-15 cm. long, leaves aggregate with persistent coriaceous sheath, flat, smooth, *Abaxial epidermis of leaf* consists of two type of cells. *Long cells* slightly wavy. *Short cells* solitary in costal as well as in the intercostal region. *Silica bodies* saddle-shaped. *Microhairs* were not seen. *Stomata* 154 per mm.², subsidiary cells low dome-shaped. *Anatomy of leaf*: conspicuous keel with single vascular bundle. *Adaxial surface* ribs moderately rounded separated from one another by deep V-shaped grooves. *Sclerenchyma*: adaxial girder 3 cells wide, 2 cells in height, abaxial girder 8 cells wide and 3 cells in height, lateral to keel on both side are 3 large bundles. *Mesophyll* not clear in the available material but appears to be slightly radiate. *Bulliform cells* sporobolus type. *Bundle sheath* inner complete, outer incomplete in the studied material.

Fig. 1 Transverse section of culm and abaxial epidermis of *Eragrostis* P. Beauv. A. *E. Ciliaris*; B *E. gangetica* (Portion of culm magnified); C. *E. japonica*; D. *E. nigra* (Portion of culm magnified); E. *E. pilosa*; F. *E. pilosa* (Portion of culm magnified); G. *E. viscosa*; H. *E. viscosa* (Portion of culm magnified).

I. *E. ciliaris*; J. *E. poaeoides*; K. *E. tenella*; L. *E. viscosa*.



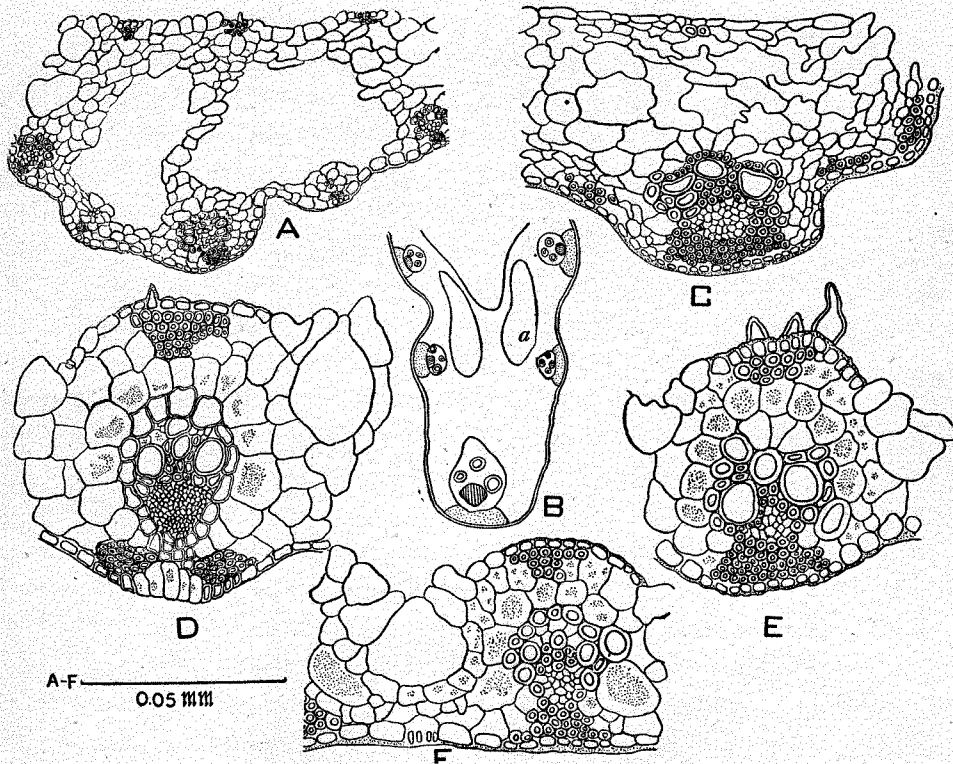


Fig. 2 Transversal section of lamina of *Eragrostis* P. Beauv, A. *E. diarrhena*; B. *E. nigra* (Topographic at maturity); C. *E. nigra* (young stage); D. *E. poaeoides*; E. *E. pilosa*; F. *E. tenella*. a. aerenchyma.

10. *Eragrostis viscosa* (Retz.) Trin: *Leaf sheath* loose, striate, glandular with a ring of stiff hairs at the neck; *ligule* with a fringe of long cilia; *leaf blade* linear, stiff, pointed rigid tips, 1.5 cm to 5.7 cm long, convolute, glandular microscopic glands are present. *Abaxial epidermis of the leaf* (Fig. 1, L) consists of two type of cells. *Long cells* sinuations intermediate. *Short cells* solitary in costal as well as in intercostal region. *Silica bodies* saddle-shaped to cross-shaped. *Microhairs* length of the hair 54μ . *Stomata* 205 per mm^2 , subsidiary cells conical as well as low dome-shaped. *Anatomy of leaf*: keel slightly conspicuous with single vascular bundle. *Adaxial surface* ribs moderately rounded separate from one another by shallow grooves. *Sclerenchyma*: adaxial girder 3-4 cells wide, 4 cells in height, abaxial girder 8-10 cells wide, 2-3 cells in height, lateral to keel on both side 2 veins with large bundle. *Mesophyll* inconspicuously radiate. *Bulliform cells* sporobolus type. *Bundle sheath* double.

The key of the above species based on culm and leaf characteristics is given below:

- A. Keel with more than one vascular bundle, and two aerenchyma are formed of the anastomose mesophyll cells.
- B. Leaf blade lanceolate, leaf sheath with long stiff hairs at its mouth....
.....*E. nigra*
- BB. Leaf blade linear, leaf sheath without the long hairs.....*E. diarrhena*
- AA. Keel with a single vascular bundle, mesophyll without any aerenchyma.
- B. The lower sclerenchyma girder divided into two by the enlarged epidermal cells..... *E. poaeoides*
- BB. Continuous lower sclerenchyma girder.
- C. Leaf sheath without hairs.
- D. Broad parenchymatous hypodermis in culm.....*E. japonica*
- DD. General type of culm structure..... *E. unioloides*
- CC. Leaf sheath with hairs.
- D. General type of culm structure.
- E. Very long microhairs 76.5 μ , stomata many, 240 per mm², papillae absent.....*E. ciliaris*
- EE. Intermediate length of hairs 49.5 μ , stomatal frequency 186 per mm², papillae present.....*E. tenella*
- DD. Culm with modifications in the original structure.
- E. Sclerenchyma with ribs and deep grooves towards the pith side, vascular bundles elongated in T. S.....*E. pilosa*
- EE. Sclerenchyma of culm wavy towards the pith side, vas. bundles not elongated.
- F. Abaxial girder 13-14 cell in breadth, 3 cells in height, adaxial girder 8-9 cells in breadth, 3 cells in height*E. gangetica*
- FF. Abaxial girder 8-10 cells in breadth, 2-3 cells in height, adaxial girder 3-4 cells in breadth, 4 cells in height*E. viscosa*

Conclusion

In conclusion it may be said that in the genus *Eragrostis* the morphology and anatomy of culm and leaf as well as those of the abaxial epidermis seem to be useful like those of floral morphology for the identification of the different species. However, it is not possible, with the present state of our knowledge, to say of the vegetative and anatomical characters could also be equally diagnostic at the generic level for the separation of the genus as of they have proved to be for those of different species of the genus *Eragrostis*.

Summary

The morphology and anatomy of culm and leaf of 10 species of *Eragrostis*

have been described.

Culms grow erect from a curved or prostrate base, solid while young becomes hollow on maturity. Its anatomy agrees in general with that of other herbaceous monocots.

The leaf consists of a sheath, ligule and blade. Different species are characteristic, with differences in the form of epidermal cells, silica bodies, microhairs and stomata. The transverse section of lamina shows an epidermis followed by hypodermis of sclerenchymatous cells enveloping a mesophyll of parenchymatous cells. The vascular bundles lie in the middle of the mesophyll. The hypodermal strands or girders vary in their width and height. Below the grooves of adaxial epidermis bulliform cells are formed.

An artificial key of the species has been prepared on variations in morphological and anatomical characters.

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