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MACRO AND MICROMORPHOLOGY OF THE SEEDS (CARYOPSES) IN THE TRIBES ANDROPOGONEAE AND ERAGROSTIDEAE (POACEAE) FROM KARACHI-PAKISTAN

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Abstract

Caryopsis of 18 species belonging to 13 genera of 2 tribes i.e., Andropogoneae and Eragrostideae (Poaceae) from Karachi-Pakistan were studied by light and scanning electron microscopy. Micro and macromorphological characters of caryopsis like size, shape, apex, base, ribs, surface and stylopodium were studied. Both the tribes were characterized usually by having stylopodium and basal hilum but this data could not be utilized alone to distinct both the tribes. However, it was found that each genus and species had specific set of caryopsis characters. The data was also analyzed numerically. It was found useful to find out the taxonomic relationship at specific level. However, the findings based on numerical analysis were not significant enough at tribal and generic levels.

Key words: Poaceae, Andrapogoneae, Eragrostideae, Caryopses, SEM.

Introduction

Agrostology is the branch of systematic botany that deals with the grasses, especially their identification, classification and evolution. There are approximately 780 genera and 12,000 species of family Poaceae (Graminae) Worldwide, making it the 5th largest family of Angiosperms out of them 158 genera and 492 species and 26 tribes found in Pakistan (Cope, 1982) and out of them 73 species belonging to 43 genera of grasses found in Karachi (Jafri, 1966). Whereas the tribe Andropogoneae is represented by 9 genera and Eragrostideae by 8 genera in Karachi (Cope, 1982). The fruit (caryopsis) is one chambered and one seeded, in which the seed coat is fused to the ovarian wall, except for the funiculus.

Seeds are a vital part of life on Earth (Jensen, 1998). Seeds play an important role in perpetuation of species. Therefore, plants adopt strategies for production of maximum seed and efficient seed dispersal strategies. In floras and other taxonomic works, seeds are often overlooked, although they are generally stable in external morphology because they are little affected by external environmental conditions as they grow and mature within the fruit. They form link between subsequent generations. The data of caryopsis structure provide relevant information on the natural or phylogenetic classification, despite the number of investigations carried out is not as high as the number in the vegetative organ anatomy. Seed structure is an important indicator of systematic position of species (Duke, 1961). There are various reports available regarding to seed morphology such as, caryopsis morphology and classification in the tribe Triticeae was reported from Washington where morphological variation was observed in non-embryo characters (Terrell & Peterson, 1993). Similarly, caryopsis morphology of tribe Chloroideae was reported from South China and various characters such as stylopodium and hilum were significantly used to delimit the taxa at various levels (Liu *et al*., 2005). In addition to gross morphology of seeds, sculpturing details of outer seed coat are quite variable among different species and can be of systematic importance. Furthermore, seed coat patterns are important characteristic for species identification, and delimiting species (Gandhi *et al*., 2011). Similarly, Gandhi *et al*., (2013) studied morphological features of 9 species of *Eragrostis* (Eragrostideae) from India and found that the data was useful for taxonomic delimitation. Moreover, seed morphology on some grasses and sedges was studied from Cholistan desert, Pakistan, by using Light microscope (Jamil *et al*., 2013). In addition, caryopsis micromorphology of *Sorghum* species (Poaceae) was reported where caryopsis shape, size, stylopodium and sculpture patterns provided the taxonomic evidence that *Sorghum* was highly heterogeneous taxa (Liu *et al*., 2005). Khan *et al*., (2022) studied caryopsis of 15 grass species and found that the data obtained was taxonomically significant. Recently. caryopsis micrpmorphological study of the tribe Paniceae from Karachi-Pakistan was conducted by Abid *et al*., (2022) where they found the data was significant enough to support the taxonomic delimitation of species within the tribe.

Although, there are various reports available on various taxa of the family Poaceae from various parts of the World but no comprehensive and detailed account on caryopsis of the tribes Andropogoneae and Eragrostideae from our region or even from any region of the World is available. Thus, the present studies are carried out to find out the macro and micro-morphological caryopsis characters with the help of light microscope and scanning electron microscope that may help in taxonomic delimitation of various taxa of the tribes Andropogoneae and Eragrostideae reported from Karachi.

Material and Method

Seeds were collected from Karachi University Herbarium (KUH) (Appendix I) About 5-10 specimens per species and 5-10 seeds per specimen (based on availability) were analyzed for morphological characters under light microscope (SMZ 800, Nikon Type 102), and

scanning electron microscope (JSM-6380A). For scanning microscopy, dry seeds were directly mounted on metallic stub with double adhesive tape and coated with gold for a period of 5 minutes in the sputtering chamber and were observed under SEM (Ather *et al*., 2013). The terminology used in accordance with Lawrence (1970), Radford *et al*., (1974), and Stearn (1983) with subtle modifications. Numerical analysis was also carried out to find out the relationship and variations of taxa within the tribes. Hierarchical clustering was performed by using Euclidean distance index with the computer package (Anon., 2011). Each taxon was treated as an operational taxonomic unit (OTU). Macro and micro morphological characters of caryopsis viz., size, shape, apex, base, surface, color, ribs, hilum and stylopodium. Characters were recorded as presence or absence and coded as 1 or 0 respectively and the average values of the quantitative characters were directly used (Tables 2 & 3, Figs. 4 & 5).

Appendix-I. List of voucher specimens.

S. No.	Name of taxa	Collector, number & herbarium
1.	*Bothriochloa ischaemum*	R.R. Stewart *s.n.* (KUH); Kamal Akhtar and M. Qaiser 556 (KUH); Tahir Ali 876 (KUH); M. Qaiser and S. Omer *s.n.* (KUH); Jan Alam and Fazal-e-Khaliq 2979bj (KUH); A. Ghafoor and S. Omer *s.n.* (KUH).
2.	*Chrysopogon aucheri*	Sultan ul Abedin 2746 (KUH); A. Ghafoor and S. Omer 2347 (KUH); Tahir Ali and G.R. Sarwar 2781 (KUH).
3.	*Cymbopogon jwarancusa*	Bushreen and Nadeem 55 (KUH); M. Qaiser, S.I. Ali and Saud Omer 7161 (KUH).
4.	*Cymbopogon martini*	J.F. Duthie *s.n.* (KUH); Razia Ahmed 138 (KUH).
5.	*Dactyloctenium aegyptium*	Nadeem, Moin, Zeenat and Bushreen 48 (KUH); G.R.Sarwar and Zamarud 1580 (KUH); S.M.H.Jafri *s.n.* (KUH); Mr.Abrar Hussain *s.n.* (KUH); S.M.H.Jafri 4057 (KUH); Mr.Abrar Hussain *s.n.* (KUH); Kamal A.Malik, M.Qaiser, Saud Omer and Gohar Khan 2207 (KUH); A.Ghafoor and Tahir Ali 3744 (KUH); R.R.Stewart *s.n.* (KUH).
6.	*Desmostachya bipinnata*	S.A. Farooqi 2231 (KUH); Mohindra Nath 2024 (KUH); Tehmeena Siddiqui 112 (KUH).
7.	*Dicanthium annulatum*	R.R. Stewart 27382 (KUH); A. Ghafoor and Saud Omer 2275 (KUH); Miss Khush e Gul *s.n.* (KUH); M. Qaiser and Sultan ul Abedin 5694 (KUH); M. Qaiser, A. Ghafoor and Abrar Hussain 3948 (KUH); Dr. S.A. Farooqui and Sultan ul Abedin 416 (KUH); Abdul Ghafoor 5275 (KUH); Tehmeena Siddiqui 44 (KUH); M. Qaiser and Sultan ul Abedin 5756 (KUH).
8.	*Eleusine compressa*	Abrar Hussain *s.n.* (KUH).
9.	*Eleusine indica*	Tahir Ali and A. Ghafoor 3977 (KUH); A. Ghafoor and S. Omer 3469a (KUH); P. Maheshwari *s.n.* (KUH); Nadeem, Bushreen and Zeenat 6 (KUH); Miss Khadija Gul *s.n.* (KUH); R.R. Stewart *s.n.* (KUH); Mr. Abrar Hussain *s.n.* (KUH); Mr. Abrar Hussain *s.n.* (KUH); Sultan ul Abedin 9187 (KUH); Rubina Akhtar 11063 (KUH).
10.	*Elionurus royleanus*	*Coll. ignot. s.n.* (KUH); Kamal Akhtar and S. Nazimuddin 716 (KUH); Yasin Nasir *s.n.* (KUH); A. Rashid 1066 (KUH); Miss Khadija Aziz *s.n.* (KUH).
11.	*Eragrostis ciliaris*	Bushreen and Zeenat 27 (KUH); Mr. Abrar Hussain *s.n.* (KUH); Sultan ul Abedin 9780 (KUH); S.M.H. Jafri 4031 (KUH); Mr. Abrar Hussain *s.n.* (KUH); S. Khatoon 431 (KUH); S.M.H. Jafri 1531 (KUH); Mr. Abrar Hussain *s.n.* (KUH); Yasin Nasir *s.n.* (KUH); S. Khatoon 366 (KUH).
12.	*Eragrostis pilosa*	Bushreen and Zeenat 34 (KUH); S.M.H. Jafri A 4033 (KUH); Mr. Abrar Hussain *s.n.* (KUH); Dr.S.M.H. Jafri 106 (KUH); Tahir Ali and Tufail Ahmed 1605 (KUH); A. Ghafoor and Moin 544, 3469a (KUH); *Coll.ignot. s.n.* (KUH); J.F. Duthie 7710 (KUH); Alma L. Moldenke, Harold N. Moldenke 208949 (KUH).
13.	*Eragrostis poaeoides*	Mr. Abrar Hussain *s.n.* (KUH); S.A. Farooqi and M. Qaiser 2350 (KUH); Mr. Abrar Hussain *s.n.* (KUH); Saeeda Qureshi *s.n.* (KUH); Saeeda Qureshi *s.n.* (KUH); Mr. Abrar Hussain *s.n.* (KUH); Miss Firdous *s.n.* (KUH); Mr. Abrar Hussain *s.n.* (KUH); Mr. Abrar Hussain *s.n.* (KUH).
14.	*Eragrostis tanella*	Saduruddin, Zeenat, Moin, Nadeem and Bushreen 89 (KUH); Bushreen and Zeenat 28 (KUH); J.F. Duthie 7705 (KUH); Bushreen, Moin and Zeenat 141 (KUH); Miss Khadija Aziz *s.n.* (KUH); G.S. Puri 41 (KUH); Bushreen, Nadeem and Moin 77 (KUH); *Coll.ignot. s.n.* (KUH).
15.	*Hackelochloa granularis*	Abrar Hussain 152 (KUH); R.R. Stewart 15082 (KUH); Yasin Nasir *s.n.* (KUH); Miss Khadija Aziz *s.n.* (KUH).
16.	*Halophyrum mucronatum*	Abdul Ghafoor and S. Omer 1836 (KUH); S.M.H. Jafri 1540 (KUH); Mr. Siraj A. Rizvi *s.n.* (KUH).
17.	*Lasiurus hirsutus*	Mumtaz Begum *s.n.* (KUH); S.I. Ali *s.n.* (KUH).
18.	*Sehima ischaemoides*	S.M.H. Jafri 4120 (KUH).

Observations

General caryopses character of the tribe andropogoneae: Caryopses 0.6-4 x 0.1-1.5mm, lanceolate, oblanceolate, oblong, oblong-ovate, obovate, elliptic, apex acute, obtuse-slightly mucronate, mucronate-obtuse, rounded, retuse, retuse-obtuse, base cuneate, cuneate-rounded, obliquely cuneate, cordate, truncate-obtuse, rounded, dusty brown, dusty brown and egg yellow at apex, egg yellow, orange-yellow, reddish brown, dusty brown-reddish brown, light brown, orange-brown, dark brown, hilum basal, surface ruminately lineate along with scalariform, undulately scalariform, scalariform-ruminate, ruminate along with densely scalariform, ruminate, ruminately reticulate, ruminately scalariform along with sulcate or rugose and foveate, densely undulate, roughly reticulate-foveate, stylopodium present.

The tribe is represented by 8 genera within the area of study.

Key to the genera

1 + Caryopsis lanceolate or oblanceolate 2
- Caryopsis not as above 3
2 + Caryopsis lanceolate, with base cuneate base ..... *Elionurus*
- Caryopsis oblanceolate, with obtuse-truncate base ..... *Chrysopogon*
3 + Caryopsis oblong 4
- Caryopsis not as above 5
4 + Caryopsis apex and base rounded, colour reddish brown ..... *Lesiurus*
- Caryopsis apex retuse, base obliquely cuneate, colour egg yellow ..... *Sehima*
5 + Caryopsis 0.6-0.7mm long, surface roughly reticulate-foveate ..... *Hackelochloa*
- Caryopsis ≥ 1mm long,, surface not as above 6
6 + Caryopsis apex retuse-obtuse, rarely mucronate, surface undulately scalariform ..... *Dicanthium*
- Caryopsis apex and surface not as above 7
7 + Caryopsis apex obtuse, colour light brown, surface ruminate ..... *Bothriochloa*
- Caryopsis apex rounded-mucronate, mucronate-retuse, colour reddish-brown, orange-brown or dark brown, surface ruminately scalariform along with sulcate, rugose and foveate ..... *Cymbopogon*

Elionurus Kunth ex Willd.

Caryopses 1.8-3 x 0.5-1mm, lanceolate, apex obtuse-slightly mucronate, base cuneate, dusty brown, hilum basal, surface ruminately lineate along with scalariform, stylopodium present (Table 1, Fig. 1).

Represented by single species viz., *Elionurus royleanus* Nees ex A. Rich.

Chrysopogon Trin.

Caryopses 3.1-4 x 0.8-1mm, oblanceolate, apex mucronate-obtuse, base truncate-obtuse, dusty brown and egg yellow at apex, hilum basal, surface scalariform-ruminate, stylopodium present (Table 1, Fig. 1).

Represented by single species viz., *Chrysopogon aucheri* (Boiss.) Boiss.

Lasiurus Boiss.

Caryopses 1.8 x 1.2mm, oblong, apex rounded, base rounded, reddish brown, hilum basal, ruminate along with densely scalariform, stylopodium present (Table 1, Fig. 1).

Represented by single species viz., *Lasiurus hirsutus* (Vahl) Boiss.

***Sehima* Forssk.**

Caryopses 2.8 x 1.5mm, oblong, apex retuse, base obliquely cuneate, egg yellow, hilum basal, surface ruminately reticulate and densely undulate, stylopodium present (Table 1, Fig. 1).

Represented by single species viz., *Sehima ischaemoides* Forssk.

Hackelochloa O. Ktze.

Caryopses 0.6-0.7 x 0.1-0.5mm, elliptic, apex acute, base cuneate, orange-yellow, hilum basal, surface roughly reticulate-foveate, stylopodium absent (Table 1, Fig. 1).

Represented by single species viz., *Hackelochloa granularis* (Linn.) O. Ketz.

Dicanthium Willemet

Caryopses 1.2-2 x 0.5-0.9mm, obovate, apex retuse-obtuse and sparsely mucronate, base cuneate-rounded, dusty brown-reddish brown, hilum basal, surface undulately scalariform, stylopodium present (Table 1, Fig. 1).

Represented by single species viz., *Dicanthium annulatum* (Forssk.) Stapf.

Bothriochloa O. Ktze.

Caryopses 1.8-2 x 0.6-1mm, obovate, apex obtuse, base cuneate, light brown, hilum basal, surface ruminate, stylopodium present (Table 1, Fig. 1).

Represented by single species viz., *Bothriochloa ischaemum* (Linn.) Keng.

Cymbopogon Spreng.

Caryopses 1-1.9 x 0.5-01mm, oblong-ovate or obovate, apex rounded-mucronate or retuse, base truncate-obtuse or cordate or cuneate, reddish brown or orange-brown or dark brown, hilum basal or indistict, surface ruminately scalariform along with sulcate or rugose and foveate, stylopodium present (Table 1, Fig. 2).

Represented by 2 species viz., *Cymbopogon jwarancusa* (Jones) Schult. and *C. martini* (Roxb.) Wats.

Table 1. Caryopses morphological characters of the family Poaceae.

Name of taxa	Size (mm)		Shape	Apex	Base	Colour	Ribs/Depressions		Hilum	Surface	Stylopodium
	Length	Breadth					Number	Position			
Bothriochloa ischaemum	1.8-02	0.6-01	Obovate	Obtuse	Cuneate	Light brown	Absent	Absent	Basal	Ruminate	Present
Chrysopogon aucheri	3.1-4	0.8-1	Oblanceolate	Macronate-obtuse	Obtuse-truncate	Dusty brown and egg yellow at apex	Absent	Absent	Basal	Scalariform-ruminate	Present
Cymbopogon jwarancusa	1.7-1.9	0.5-0.8	Obovate	Rounded – mucronate	Cuneate and obtuse	Reddish brown	Absent	Absent	Basal	Ruminately scalariform along with sulcate	Present
Cymbopogon martini	1-1.5	0.5-01	Oblong- ovate	Mucronate-retuse	Obtuse-truncate, and cordate	Orange-brown and dark brown	01	Longitudinal depression	Indistinct	Rugose and foveate	Present
Dactyloctenium aegyptium	0.8-01	0.5-0.8	Rhomboid-deltoid	Obtuse	Truncate-curved	Reddish brown	Absent	Absent	Basal	Verrucately sulcate along with appressedly ruminate	Absent
Desmostachya bipinnata	0.5-1	0.1-0.5	Ovate	Accuminate	Oblique	Black-brown	01	Depression	Basal	Roughly scalariform and undulate	Present
Dicanthium annulatum	1.2-2	0.5-0.9	Obovate	Retuse-obtuse and sparsely mucronate	Cuneate-rounded	Dusty brown-reddish brown	Absent	Absent	Basal	Undulately scalariform	Present
Eleusine compressa	1.5	0.4-0.5	Oblanceolate - Oblong	Murcronate-accuminate	Attenuate-oblique	Reddish Brown	01	Longitudinal faint Rib	Indistinct	Striate-Sulcate	Present
Eleusine indica	01-1.5	0.5-0.8	Oblong	Rounded	Obtuse-slightly cuneate	Black	01	Longitudinal-depression	Basal	Ruminately ribbed along with densely tuberculate.	Absent
Elionurus royleanus	1.8-3	0.5-1	Lanceolate	Slightly mucronate - Obtuse	Cuneate	Dusty brown	Absent	Absent	Basal	Ruminately lineate along with scalariform	Present
Eragrostis ciliaris	0.4-0.5	0.1	Elliptic	Obtuse	Cuneate	Reddish brown	Absent	Absent	Basal	Sulcate along with undulately reticulate and appressedly colliculate.	Present
Eragrostis pilosa	0.2-1	0.1-0.2	Transversely cuneate and oblong	Mucronate	Cuneate	Reddish brown	Absent	Absent	Basal	Reticulate-foveate along with appressedly colliculate	Present
Eragrostis poaeoides	0.2-0.6	0.1-0.3	Ovate	Mucronate-obtuse	Rounded	Reddish brown	Absent	Absent	Basal	Scalariform along with undulately foveate	Present
Eragrostis tanella	0.5-0.9	0.1	Oblong	Rounded	Transversely cuneate	Reddish brown	Absent	Absent	Basal	Lineate within the scalariform	Present
Hackelochloa granularis	0.6-0.7	0.1-0.5	Elliptic, orbicular	Acute	Cuneate	Orange-yellow	Absent	Absent	Basal	Roughly reticulate-foveate	Absent
Halophyrum mucronatum	02-03	0.9-1.3	Obovate-oblanceolate	Macronate	Cuneate	Black	01	Longitudinal depression	Basal	Scalariform	Present
Lasiurus hirsutus	1.8	1.2	Oblong	Rounded	Rounded	Reddish brown	Absent	Absent	Basal	Ruminate along with densely scalariform	Present
Sehima ischaemoides	2.8	1.5	Oblong	Retuse	Obliquely cuneate	Egg yellow	Absent	Absent	Basal	Ruminately reticulate and densely undulate	Present

Key to the species

1 + Caryopses surface ruminately scalariform along with sulcate with reddish brown colour …… *C. jwarancusa*
- Caryopses surface rugose and foveate with orange-brown or dark brown colour …..... *C. martini*

General caryopses character of the tribe eragrostideae: Caryopses 0.2-1.5 x 0.1-1.3mm, rhomboid-deltoid, elliptic, transversely cuneate, ovate, oblong, obovate-oblanceolate, oblong-oblanceolate, apex obtuse, mucronate-accuminate, acuminate, mucronate, base oblique, attenuate-oblique, obtuse-slightly cuneate, truncate-curve, cuneate, rounded, transversely cuneate, reddish brown, black-brown, black, hilum basal, surface verrucately sulcate along with appressedly ruminate, sulcate along with undulate, reticulate and appressedly colliculate, reticulate-foveate, scalariform along with foveate, lineate within the scalariform, scalariform, roughly scalariform and undulate, striate-sulcate, ruminately ribbed or not ribbed along with densely tuberculate, stylopodium present or absent.

The tribe is represented by 5 genera in the study area.

Key to the genera

1 + 1+Ribs absent ……..… 2
- Ribs present ……..……... 3
2 + 2+Caryopses shape rhomboid-deltoid, stylopodium absent ……..... *Dactyloctenium*
- Caryopses shape not as above, stylopodium present ...……. *Eragrostis*
3 + 3+Caryopses shape ovate, apex acuminate ...……. *Desmostachya*
- Caryopses shape and apex not as above ...……...…… 4
4 + 4+Caryopses surface scalariform ...……...…….. *Halopyrum*
- Caryopses surface striate-sulcate, ruminately-ribbed along with densely tuberculate …….. *Elesine*

Dactyloctenium Willd.

Caryopses 0.8-01 x 0.5-0.8mm, rhomboid-deltoid, apex obtuse, base truncate-curve, reddish brown, hilum basal, verrucately sulcate along with appressedly ruminate, stylopodium absent (Table 1, Fig. 2).

Represented by single species viz., *Dactyloctenium aegyptium* (Linn.) Willd.

Eragrostis Wolf

Caryopses 0.2-1 x 0.1-0.3mm, elliptic or transversely cuneate or ovate or oblong, apex obtuse, mucronate, rounded, base cuneate, rounded, transversely cuneate, hilum basal, reddish brown, surface sulcate along with undulate, reticulate and appressedly colliculate, reticulate-foveate, scalariform along with foveate, lineate within the scalariform, stylopodium present (Table 1, Figs. 2).

Represented by 4 species viz., *Eragrostis ciliaris* (Linn.) R. Br., *E. pilosa* (Linn.) P. Beauv., *E. poaeoides* P. Beauv. and *E. tanella* (Linn.) P. Beauv.

Key to the species

1 + Caryopses surface sulcate ……..……..……..…… *E. ciliaris*
- Caryopses surface other than sulcate …..……..……..…….. 2
2 + Caryopses with rounded base …… *E. poaeoides*
- Caryopses with cuneate base ……..…..……..……..……. 3
3 + Caryopses surface lineate within the scalariform ……..…… *E. tanella*
- Caryopses surface reticulate-foveate along with appressedly colliculate ……..……. *E. pilosa*

Desmostachya Stapf

Caryopses 0.5-1 x 0.1-0.5mm, ovate, apex acuminate, base oblique, black-brown, depression present, hilum basal, surface roughly scalariform and undulate, stylopodium present (Table 1, Fig. 3).

Represented by single species viz., *Desmostachya bipinnata* (Linn.) Stapf

Halophyrum Stapf.

Caryopses 0.2-0.3 x 0.9-1.3mm, obovate-oblanceolate, apex mucronate, base cuneate, black, depression, hilum basal, surface scalariform, stylopodium present (Table 1, Figs. 3).

Represented by single species viz., *Halophyrum mucronatum* (Linn.) Stapf

Eleusine Gaertn.

Caryopses 1-1.5 x 0.4-0.8mm, oblong-oblanceolate, apex mucronate-accuminate or rounded, base attenuate-oblique or obtuse-slightly cuneate, faint rib or depression, hilum basal or indistinct, reddish brown or black, surface striate-sulcate or ruminately ribbed along with densely tuberculate, stylopodium present or absent (Table 1, Fig. 3).

Represented by 2 species viz., *Eleusine compressa* (Forssk.) Hilu and *E. indica* (Linn.) Gaertn.

Key to the species

1 + Caryopses reddish brown ……..…….... *E. compressa*
- Caryopses black ……..……. *E. indica*

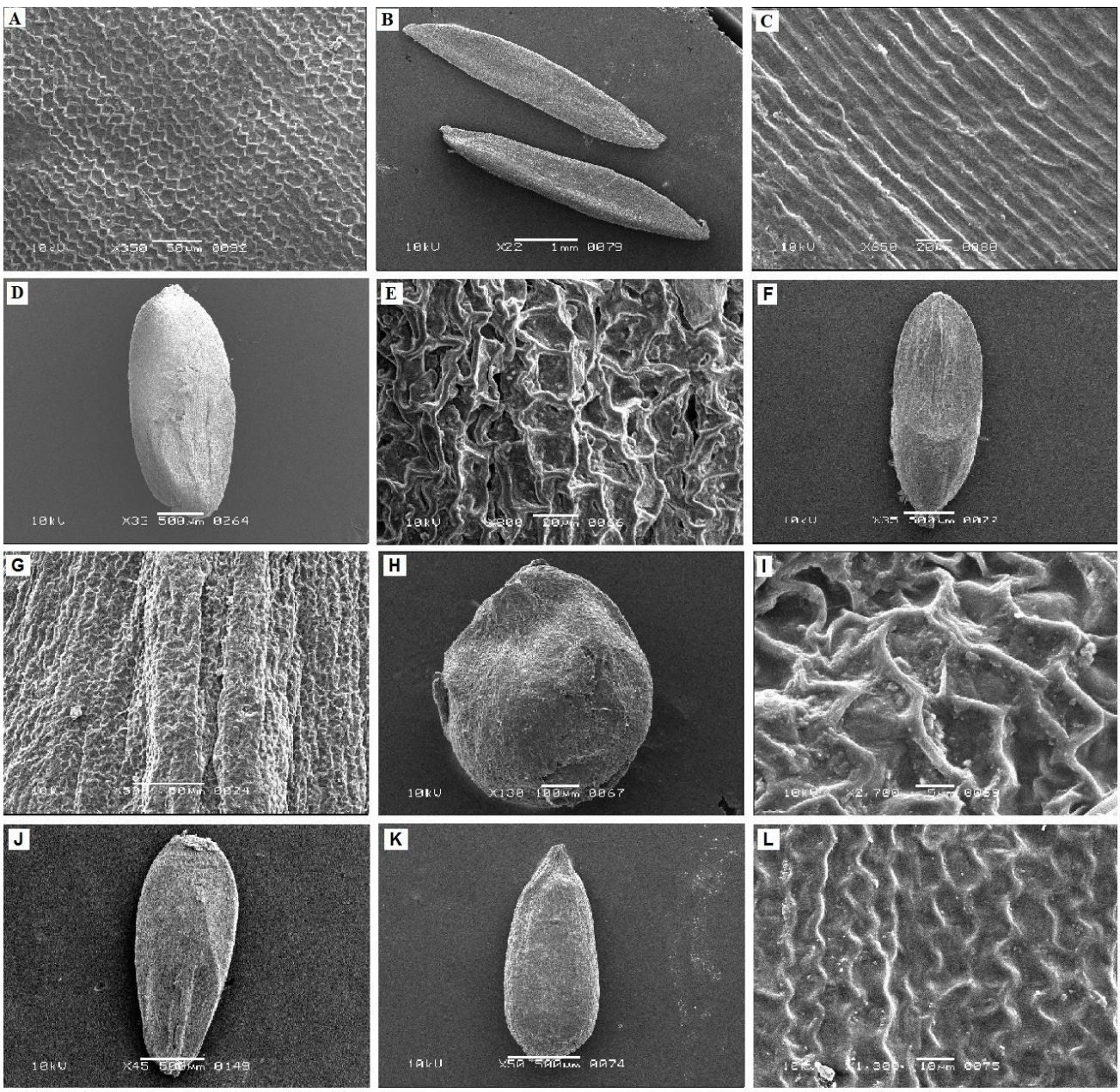

Fig. 1. Micrographs of Caryopsis*: Elionurus royleanus* A, seed surface; *Chrysopogon aucheri* B, seed, C, seed surface; *Lasiurus hirsutus* D, seed, E, seed surface; *Sehima ischaemoides* F, seed, G, seed surface; *Hackelochloa granularis* H, seed, I, seed surface; *Dicanthium annulatum* J, seed; *Bothriochloa ischaemum* K, seed, L, seed surface (Scale bars: B = 1mm; C; I= 5µm, L = 10 µm; G = 20µm; A, E = 50µm; H= 100 µm; D, F, J, K=500µm).

Results and Discussion

Seeds of angiospermic plants both dicots and monocots have long been used for taxonomic delimitation of taxa due to considerable variation in their macro and micromorphological features. Similarly, caryopsis of Poaceae has valuable characters which are used by various workers for taxonomic delimitation within the family.

Taxonomists across the globe classify the various taxa of Poaceae including the tribes, Andropogoneae and Eragrostideae (Cope *et al*., 1982; Chen *et al*., 2006; Mabberley, 2008; Khan *et al*., 2022) and from Karachi (Jafri, 1966; Cope, 1982). While classifying various taxa within the tribes of Poaceae detailed seed characteristics were not included especially micromorphology was not used as a tool for classification in any Flora. Present study focused on the detailed macro and micromorphological features of caryopsis of the tribes Andropogoneae and Eragrostideae within Poaceae.

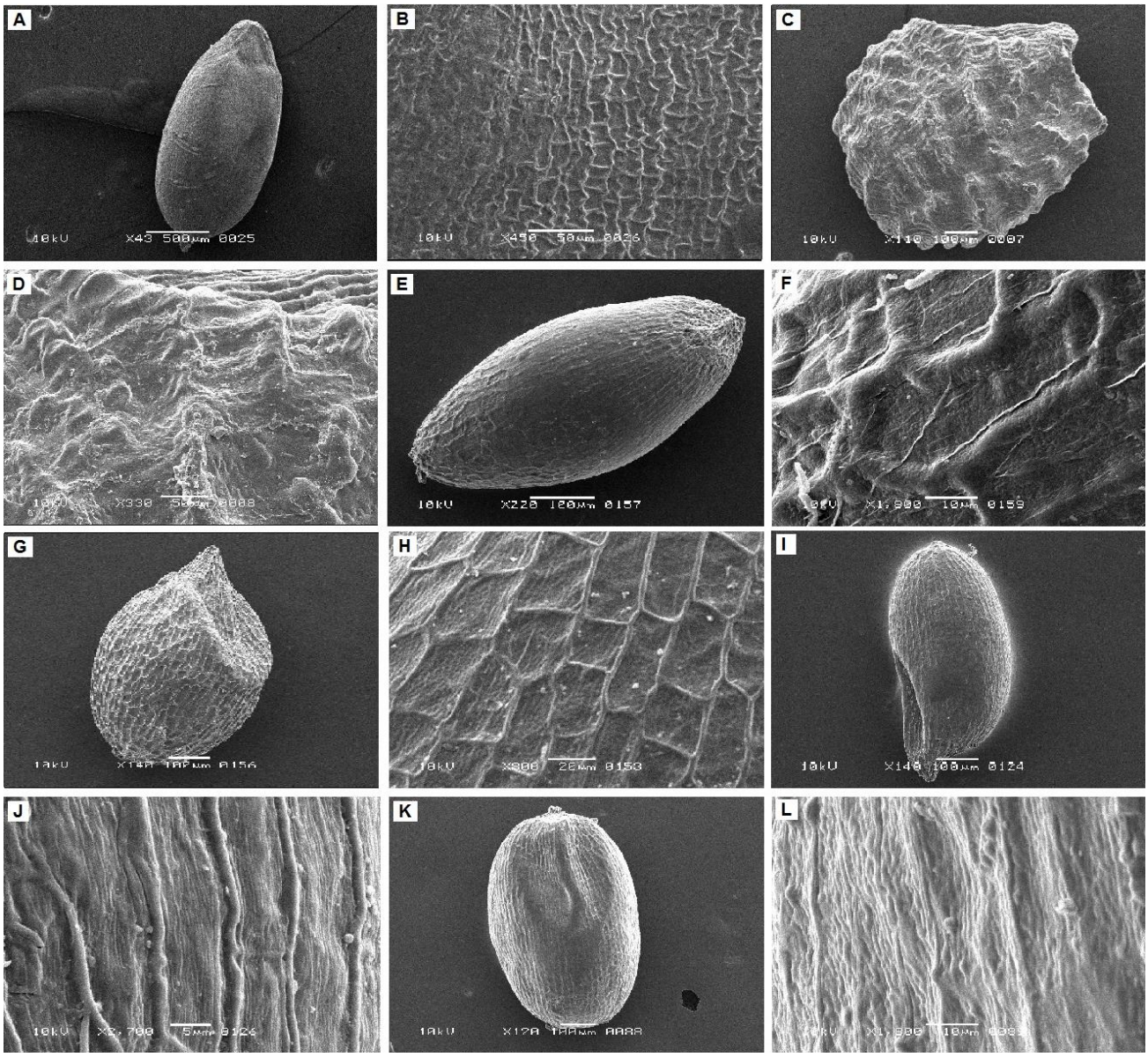

Fig. 2. *Cymbopogon jwarancusa* A, seed, B, seed surface; *Dactyloctenium aegyptium* C, seed, D, seed surface; *Eragrostis ciliaris* E seed, F, seed surface; *Eragrostis poaeoides* G, seed, H, seed surface; *E. tanella* I, seed, J, seed surface; *E. pilosa* K, seed, L, seed surface (Scale bars: F, J, G, L= 10µm; H = 20µm, B, D = 50 µm; C, E, G, I, K = 100µm; A, = 500µm).

Nine species belonging to 8 genera were studied in the tribe Andropogoneae from Karachi. It was found that every genus had specific set of caryopsis characters to distinguish from each other. The tribe can be bifurcated into two main groups based on caryopsis shape. Group one comprised of 2 genera i.e., *Elionurus* and *Chrysopogon*. Further, they can be separated from each other by distinct caryopsis shape and base viz., lanceolate caryopsis with cuneate base in former and oblanceolate shape with obtuse-truncate base in later. The second group comprised of 6 genera i.e., *Lasiurus*, *Sehima*, *Hackelochloa*, *Dicanthium*, *Bothriochloa* and *Cymbopogon*. Among these genera *Lasiurus* and *Sehima* can be separated on the basis of oblong caryopsis. Cope (1982) also described oblong caryopsis in *Lasiurus*. They both remain distinct from each other by rounded apex and base and reddish-brown caryopsis in *Lasiurus* and retuse apex, obliquely cuneate base and egg yellow caryopsis in *Sehima*. Within remaining 4 genera, *Hackelochloa* can be singled out due to its smaller size caryopsis (0.6-0.7mm) with roughly reticulate-foveate surface. Similarly, *Dicanthium* remained separate due to caryopsis surface undulately scalariform *Bothriochloa* by ruminate caryopsis surface and *Cymbopogon* by ruminately scalariform, sulcate, rugose and foveate surface. Moreover, the 2 species of *Cymbopogon* can be separated from each other by ruminately scalariform, sulcate caryopsis surface in *C. jwarancusa* and rugose, foveate caryopsis surface in *C. martini*.

In the tribe Eragrostideae 9 species belonging to 5 genera were studied. Genera within this tribe can be bifurcated on the basis of presence or absence of ribs. Ribs were absent in *Dactyloctenium* and *Eragrostis*. Between them *Dactyloctenium* had rhomboid-deltoid shaped caryopses with no stylopodium and *Eragrostis* had stylopodium. While, the 3 genera with ribs on caryopses

included *Desmostachya*, *Halopyrum* and *Elesine*. Among them, *Desmostachya* remained distinct by its ovate caryopsis with acuminate apex. The remaining 2 genera were separated by their caryopsis surfaces viz., scalariform surface in *Halopyrum* and striate-sulcate, densely tuberculate caryopsis surface in *Elusine*. Within the genera of this tribe only *Eragrostis* was represented by 4 species i.e., *E. ciliaris*, *E. poaeoides*, *E. tanella* and *E. pilosa*. Amongst them *E. ciliaris* stands out due to its elliptic shape and sulcate along with undulately reticulate surface pattern (Vivek *et al*., 2015). *E. poaeoides* remained distinct due to its obtuse caryopsis base (Lazarides, 1997). The remaining 2 species *E. tanella* and *E. Pilosa* can be differentiated by their distinct caryopsis surfaces such as, lineate scalariform in *E. tanella* and reticulate foveate along with appressedly colliculate in *E. pilosa.*

The data obtained by numerical analysis of caryopsis features strongly support the gross morphological findings at specific level but the caryopsis features did not fully support the generic delimitation alone.

By the ongoing discussion, it can be concluded that caryopsis characteristics fully support the morphological findings of the studied taxa and are significant enough to delimit the taxa within the tribes Andropogoneae and Eragrostideae.

Table 2. List of characters, scored for the cluster analysis for the species of the tribes Andropogoneae and Eragrostideae listed in table 3.

S. No.	Character description
	Size
1.	Length (mm)
2.	Breadth (mm)
	Shape
3.	Obovate: Absent (0), Present (1)
4.	Oblanceolate: Absent (0), Present (1)
5.	Oblong- ovate: Absent (0), Present (1)
6.	Rhomboid-deltoid: Absent (0), Present (1)
7.	Ovate: Absent (0), Present (1)
8.	Oblanceolate - Oblong: Absent (0), Present (1)
9.	Oblong: Absent (0), Present (1)
10.	Lanceolate: Absent (0), Present (1)
11.	Elliptic: Absent (0), Present (1)
12.	Transversely cuneate: Absent (0), Present (1)
13.	Orbicular: Absent (0), Present (1)
14.	Obovate-oblanceolate: Absent (0), Present (1)
	Apex
15.	Obtuse: Absent (0), Present (1)
16.	Macronate-obtuse: Absent (0), Present (1)
17.	Rounded –mucronate: Absent (0), Present (1)
18.	Mucronate-retuse: Absent (0), Present (1)
19.	Accuminate: Absent (0), Present (1)
20.	Retuse-obtuse: Absent (0), Present (1)
21.	Sparsely mucronate: Absent (0), Present (1)
22.	Murcronate-accuminate: Absent (0), Present (1)
23.	Rounded: Absent (0), Present (1)
24.	Slightly mucronate - Obtuse: Absent (0), Present (1)
25.	Mucronate: Absent (0), Present (1)
26.	Acute: Absent (0), Present (1)
27.	Retuse: Absent (0), Present (1)
	Base
28.	Cuneate: Absent (0), Present (1)
29.	Rounded: Absent (0), Present (1)
30.	Transversely cuneate: Absent (0), Present (1)
31.	Obliquely cuneate: Absent (0), Present (1)
32.	Obtuse-truncate: Absent (0), Present (1)
33.	Obtuse: Absent (0), Present (1)
34.	Truncate-curved: Absent (0), Present (1)
35.	Cordate: Absent (0), Present (1)
36.	Oblique: Absent (0), Present (1)
37.	Cuneate-rounded: Absent (0), Present (1)
38.	Attenuate-oblique: Absent (0), Present (1)
39.	Obtuse-slightly cuneate: Absent (0), Present (1)
	Colour
40.	Light brown: Absent (0), Present (1)
41.	Dusty brown: Absent (0), Present (1)
42.	Egg yellow: Absent (0), Present (1)
43.	Reddish brown: Absent (0), Present (1)
44.	Orange-brown: Absent (0), Present (1)
45.	Dark brown: Absent (0), Present (1)
46.	Black-brown: Absent (0), Present (1)
47.	Dusty brown-reddish brown: Absent (0), Present (1)
48	Black: Absent (0), Present (1)
49.	Orange-yellow: Absent (0), Present (1)
50.	**Ribs**: Absent (0), Present (1)
	Surface
51.	Ruminate: Absent (0), Present (1)
52.	Scalariform-ruminate: Absent (0), Present (1)
53.	Ruminately scalariform: Absent (0), Present (1)
54.	Sulcate: Absent (0), Present (1)
55.	Rugose: Absent (0), Present (1)
56.	Foveate: Absent (0), Present (1)
57.	Verrucately sulcate: Absent (0), Present (1)
58.	Appressedly ruminate: Absent (0), Present (1)
59.	Roughly scalariform: Absent (0), Present (1)
60.	Undulate: Absent (0), Present (1)
61.	Undulately scalariform: Absent (0), Present (1)
62.	Striate-Sulcate: Absent (0), Present (1)
63.	Ruminately ribbed: Absent (0), Present (1)
64.	Densely tuberculate: Absent (0), Present (1)
65.	Ruminately lineate: Absent (0), Present (1)
66.	Scalariform: Absent (0), Present (1)
67.	Undulately reticulate: Absent (0), Present (1)
68.	Appressedly colliculate: Absent (0), Present (1)
69.	Reticulate-foveate: Absent (0), Present (1)
70.	Undulately foveate: Absent (0), Present (1)
71.	Lineate within the scalariform: Absent (0), Present (1)
72.	Roughly reticulate-foveate: Absent (0), Present (1)
73.	Densely scalariform: Absent (0), Present (1)
74.	Densely undulate: Absent (0), Present (1)
75.	Ruminately reticulate: Absent (0), Present (1)
76.	**Stylopodium**: Absent (0), Present (1)

Table 3. Data matrix of Andropogoneae and Eragrostideae species scored for 76 characters present in table 2.

S. No.	Name of taxa	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1.	*Bothriochloa ischaemum*	1.9	0.8	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
2.	*Chrysopogon aucheri*	3.6	0.9	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
3.	*Cymbopogon jwarancusa*	1.8	0.7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
4.	*Cymbopogon martini*	1.3	0.8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
5.	*Dactyloctenium aegyptium*	0.9	0.7	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
6.	*Desmostachya bipinnata*	0.7	0.3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
7.	*Dicanthium annulatum*	1.6	0.7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
8.	*Eleusine compressa*	1.5	0.5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
9.	*Eleusine indica*	1.3	0.7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
10.	*Elionurus royleanus*	2.4	0.7	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
11.	*Eragrostis ciliaris*	0.5	0.1	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
12.	*Eragrostis pilosa*	0.6	0.2	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
13.	*Eragrostis poaeoides*	0.4	0.2	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
14.	*Eragrostis tanella*	0.7	0.1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
15.	*Hackelochloa granularis*	0.7	0.3	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
16.	*Halophyrum mucronatum*	2.5	1.1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
17.	*Lasiurus hirsutus*	1.8	1.2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
18.	*Sehima ischaemoides*	2.8	1.5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3. (Cont'd.).

S. No.	Name of taxa	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
1.	*Bothriochloa ischaemum*	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
2.	*Chrysopogon aucheri*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1
3.	*Cymbopogon jwarancusa*	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
4.	*Cymbopogon martini*	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0
5.	*Dactyloctenium aegyptium*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
6.	*Desmostachya bipinnata*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
7.	*Dicanthium annulatum*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
8.	*Eleusine compressa*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0
9.	*Eleusine indica*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0
10.	*Elionurus royleanus*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
11.	*Eragrostis ciliaris*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
12.	*Eragrostis pilosa*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
13.	*Eragrostis poaeoides*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
14.	*Eragrostis tanella*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
15.	*Hackelochloa granularis*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
16.	*Halophyrum mucronatum*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
17.	*Lasiurus hirsutus*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
18.	*Sehima ischaemoides*	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

Table 3. (Cont'd.).

S. No.	Name of taxa	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
1.	*Bothriochloa ischaemum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2.	*Chrysopogon aucheri*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
3.	*Cymbopogon jwarancusa*	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4.	*Cymbopogon martini*	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5.	*Dactyloctenium aegyptium*	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.	*Desmostachya bipinnata*	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
7.	*Dicanthium annulatum*	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
8.	*Eleusine compressa*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
9.	*Eleusine indica*	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
10.	*Elionurus royleanus*	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1
11.	*Eragrostis ciliaris*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1
12.	*Eragrostis pilosa*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1
13.	*Eragrostis poaeoides*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1
14.	*Eragrostis tanella*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
15.	*Hackelochloa granularis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
16.	*Halophyrum mucronatum*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
17.	*Lasiurus hirsutus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
18.	*Sehima ischaemoides*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1

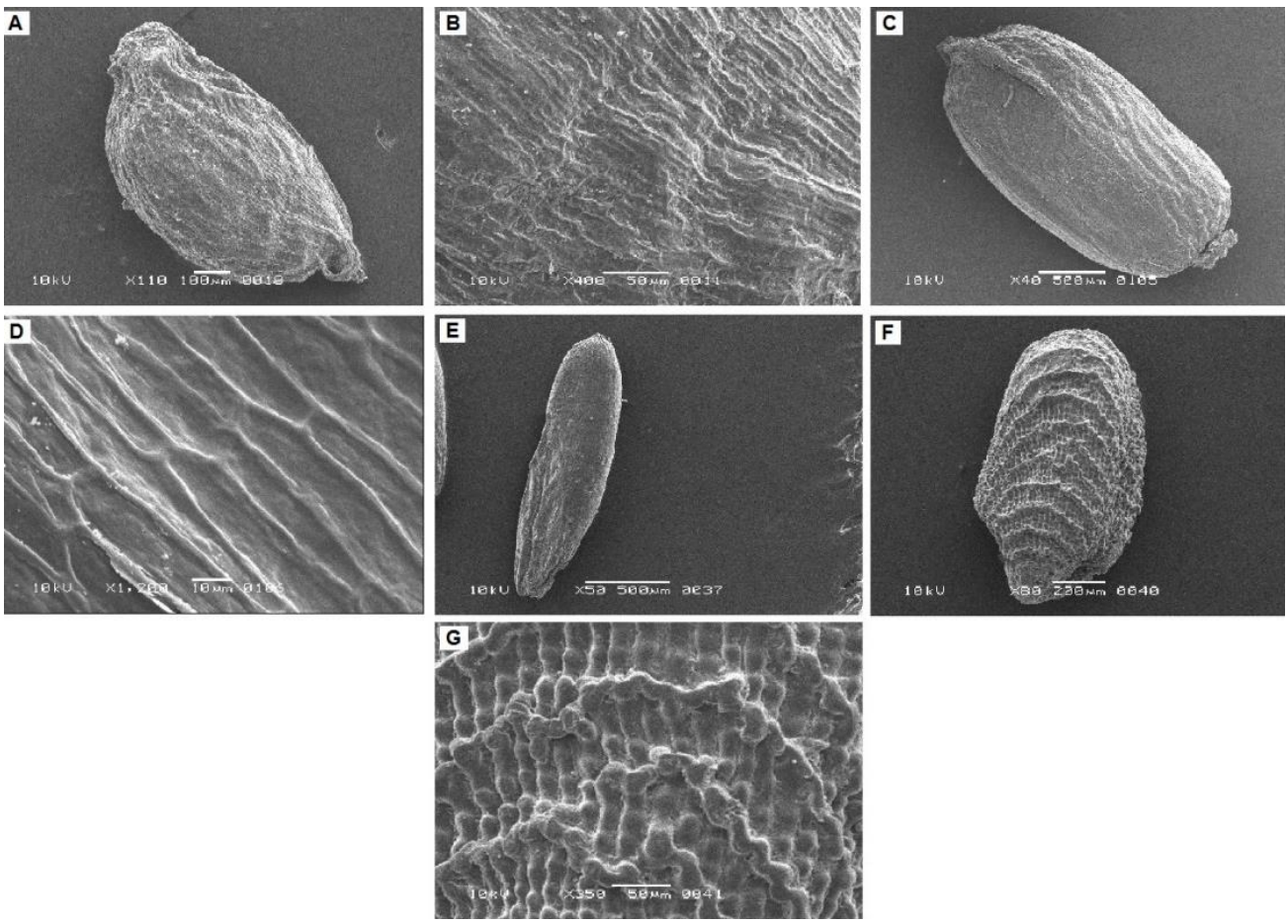

Fig. 3. Micrographs of Caryopsis*: Desmostachya bipinnata* A, seed, B, seed surface; *Halophyrum mucronatum* C seed, D, seed surface; *Eleusine compressa* E, seed; *Eleusine indica* F, seed, G, seed surface (Scale bars: = 10µm; = 20µm; B, D, G = 50µm; A = 100µm; F = 200µm; C, E = 500µm).

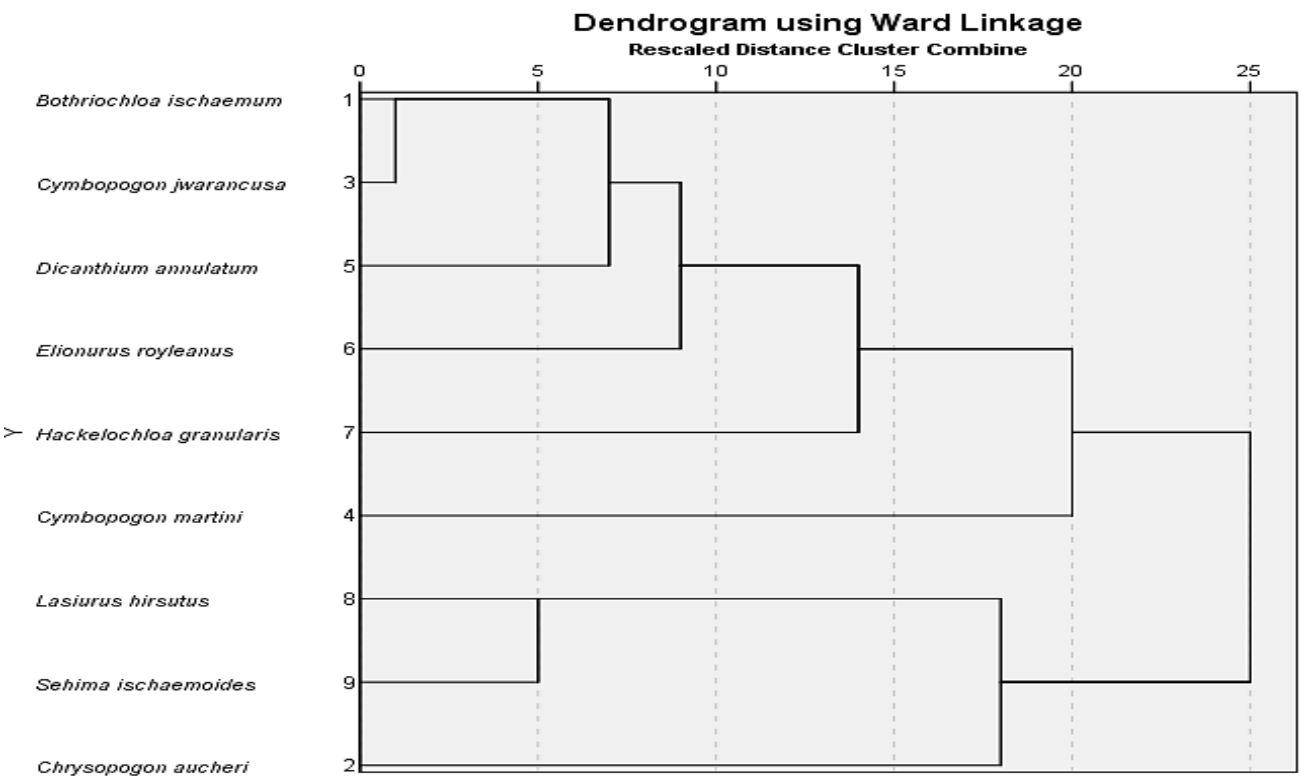

Fig. 4. Dendrogram showing the relationship of the species within the tribe Andropogoneae.

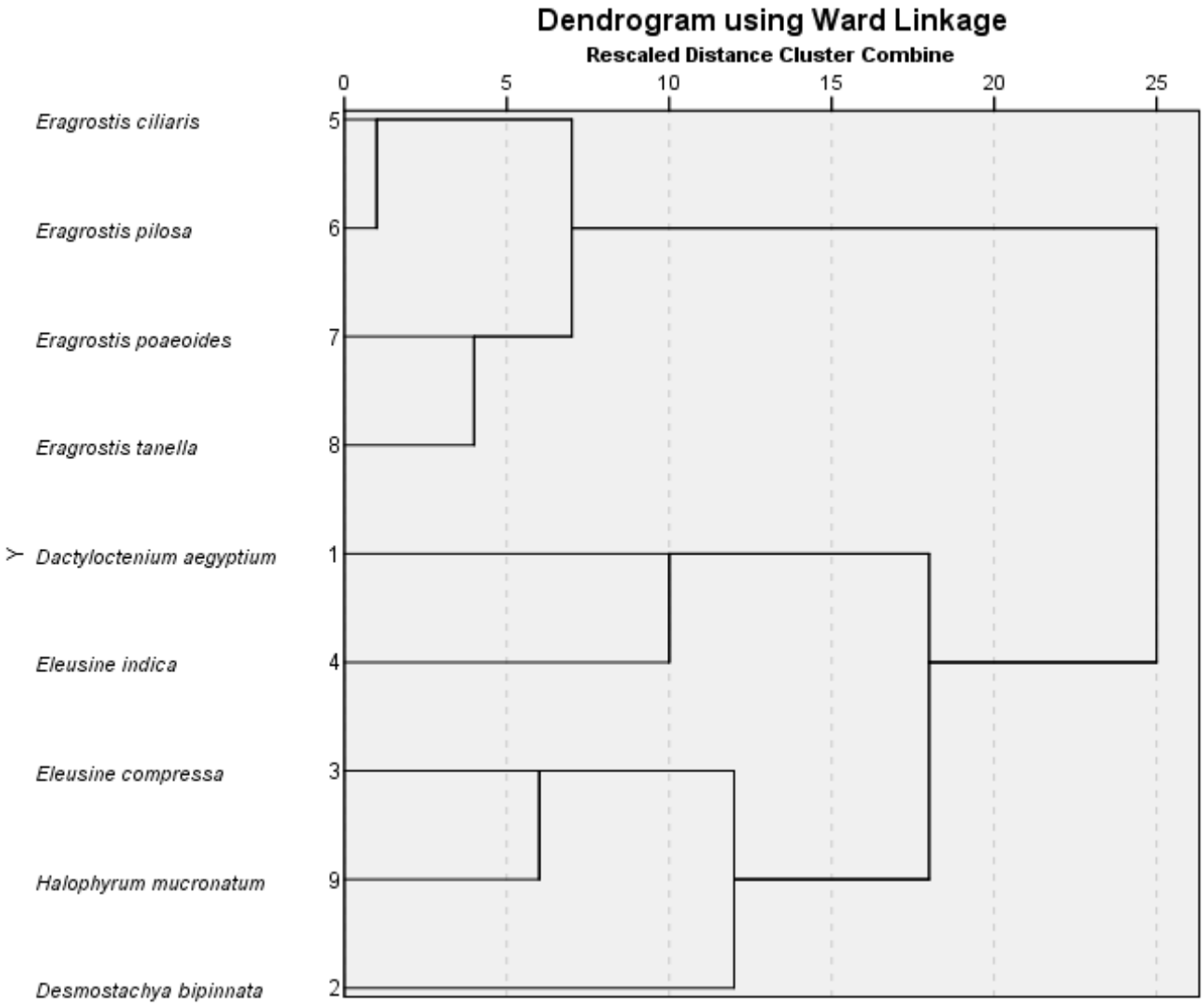

Fig. 5. Dendrogram showing the relationship of the species within the tribe Eragrostideae.

References

Abid, R., S. Riaz, S. Jannat and A. Ali. 2022. Macro and micromorphology of the seeds (caryopsis) in the tribe Paniceae (Poaceae) from Karachi-Pakistan. *Int. J. Biol. Biotech*., 19(4): 585-595.

Ahmed, F., M.A. Khan, M. Ahmad, M. Zafar, A. Nazir and S.K. Manwat. 2008. Taxonomic studies of grasses and their indigenous uses in salt range area of Pakistan. *Afr. J. Biotech.*, 8(2): 231-249.

Anonymous. 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.

Ather, A., R. Abid and M. Qaiser. 2013. The seed atlas of Pakistan-IX. Orobanchaceae. *Pak. J. Bot*., 45(5): 1677-1692.

Chen, S.L., D.Z. Li and G.H. Zhu. 2006. Flora of China (Poaceae vol. 22) Beijing, China: Science Press.

Cope, T.A. 1982. Poaceae, No. 143. In: *Flora of Pakistan*. (Eds.): Nasir, E. and S.I. Ali. Stewart Herbarium, Gordon College, Rawalpindi and Dept. Bot. Karachi University.

Duke, J.A. 1961. Preliminary revision of the genus Drymaria. *Ann. Missouri Bot. Garden*, 48: 173-268.

Gandhi, D., A. Albert and N. Pandya. 2013. Morphometric analysis of caryopses in nine species of Eragrostis (Poaceae) from India using SEM and light microscopy. *Telopea J. Plant Sys.*, 15: 87-97.

Gandhi, D., S. Albert and N. Pandya. 2011. Morphological and micromorphological characterization of some legume seeds from Gujarat, India. *Env. Exp. Biol.*, 9: 105-113.

Jafri, S.M.H. 1966. Flora of Karachi. et. S.M.H. Jafri. The book corporation of Karachi.

Jamil, S., A. Pirzada, M.K. Alam and H.M. Waris. 2013. Seed Morphometry of Some Grasses and Sedges from Cholistan Desert, Pakistan. *Arch. D. Sci*., 66: 128-133.

Jensen, H. 1998. Bibliography on seed morphology. Balkema, A.A. Rotterdam, Netherland.

Khan, B., R. Khan, A. Rashid, A. Ullah and S.Z.U. Abidin. 2022. Detailed macro and micromorphology of grasses caryopsis using scanning electron and light microscopy. *Micro. Res. Tech*., 85(3): 1028-1034.

Lawrence, G.H.M. 1970. Taxonomy of vascular plants, Toronto, Ontario, New York, The MaCmillan Company, CollierMaCmillan Canada, LT.

Lazarides, M. 1997. A revision of Eragrostis (Eragrostideae, Eleusininae, Poaceae) in Australia. *Aust. Syst. Bot*., 10: 77-187.

Liu, Q., N.X. Zhao, G. Hao, X.Y. Hu and Y.X. Liu. 2005. Caryopsis morphology of the Chloridoideae (Gramineae) and its systematic implications. *Bot. J. Linn. Soc*., 148: 57-72.

Mabberley, D.I. 2008. The Plant Book. Cambridge: NY: University Press.

Radford, A.E., W.C. Dickison, J.R. Massey and C.R. Bell. 1974. *Vascular Plants Systematics.* Harper & Row, New York, Evanston, San Francisco, London.

Stearn, W.T. 1983. Botanical Latin, 3rd edition. David and Charles. Britain.

Terrell, E.E. and P.M. Peterson. 1993. Caryopsis Morphology and Classification in the Triticeae (Pooideae: Poaceae). *Smith. Cont. B.*, 83: 1-25.

Vivek, C.P., G.V.S. Murthy, G. Gnanasekaran, K.A.A. Kabeer and V.J. Nair. 2015. A study on the caryopses morphology of the grass genus Eragrostis in India. *Nelumbo*., 57: 1-10.

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