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A PALYNOLOGICAL STUDY OF THE FAMILY GRAMINEAE FROM KARACHI-PAKISTAN

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Abstract

A palynological study of 64 species belonging to 40 genera of the family Gramineae from Karachi was conducted. The family is stenopalynous and the pollen are spheroidal, usually monoporate, rarely diporate, smooth, mostly annulate and operculate. On the basis of sculpturing pattern 3 groups are recognized viz., (i) areolate, (ii) scabrate (iii) scabrate-areolate. Each group is further divided on the basis of proximity of the granules (scabrae). Various quantitative characters were also statistically tested.

Introduction

Gramineae one of the largest families of flowering plants, comprising of 620 genera and c. 10000 species is widely dispersed in all the regions of the world (Willis, 1973). In Pakistan, it is represented by 158 genera and 492 species (Stewart, 1972; Cope, 1982). Jafri (1966) reported 43 genera and 72 species from Karachi, while Cope (1982) in the taxonomic revision of the family for the Flora of Pakistan enumerated 48 genera and 86 species from the area.

Grass family is a natural and fairly homogenous taxon. It is remarkable in the constancy of its basic characters. Pollen also do not show much deviation from this contention and has long been recognized as remarkably uniform. Therefore palynology plays a little role in the taxonomy of this family (Wodehouse, 1935; Rowley, 1960). However according to Wodehouse (1935) two characters viz., grain size and sexine pattern are of some significance. Firbas (1937) used the grain size as a basic character to separate wild and cultivated grasses. Rowley (1960) while studying the fine structure of some of the grass pollen used the arrangement of the spinules on the ektexine as a key character for delimiting various taxa.

Faegri & Iversen (1964) in their study of grass pollen, found two different types of sexine i.e., scabrate and areolate. Anderson & Bertelsen (1972) and Grant (1972) also used these two types to distinguish various members of the tribe Triticeae, *Zea* and *Tripsacum*, respectively. Page (1978) in his scanning electron microscopic survey of grass pollen further divided these two basic types on the basis of the proximity of granules, whether they are closely or widely spaced, while the fused type are differentiated on the basis of height of granules. Chaturvedi (1971) has reported 4 types of grains in *Sac-*

charum robustum viz., (i) normal monoporate grains (ii) double grains with two pores on either side of the dumbell shaped pollen grains (iii) single diporate grains and (iv) double grains with single pore. There does not appear to be any report on the palynological aspects of the family Gramineae from Pakistan. A palynological study of the grasses of Karachi was therefore carried out to correlate the various quantitative characters and sculpturing pattern within the different tribes of Gramineae.

Materials and Method

Pollen grains of 64 species belonging to 40 genera were obtained from freshly collected specimens, where fresh material was not available herbarium specimens were used. All the specimens have been deposited in Karachi University Hebarium (KUH). A list of vouchers is given in Appendix I.

Slides of pollen grains were prepared by the classical acetolysis technique devised by Erdtman (1952). Since grass pollen tend to collapse after acetolysis due to the presence of a thin and delicate exine as also found with acetic acid only distilled water was used. Anthers were removed and crushed in a centrifuge tube with distilled water. The material was sieved and centrifuged for 2-3 minutes only, and the water was decanted. For light and scannng microscopy the material was divided into two parts. For SEM, the material was mounted on metallic stubs with a fine jet and coated with gold in a conventional vacuum coater, and examined with a Jeol scanning microscope (JSM-T200). For light microscopic studies, the remaining part of the material was centrifuged for 2-3 minutes in 50% glycerine. After decanting the liquid, the material was mounted in glycerine jelly, prepared according to the method of Kisser (1937).

For light microscoy, 15 pollen grains for each species were observed under compound microscope Erma No. 244825 and the following measurements were taken: (i) longest diameter, (i) Length and breadth of the pore (iii) Exine thickness (iv) Annulus thickness and diameter (v) Scabrae size (vi) Areolae length and breadth (Measurements of iv-vi were taken with SEM). Terminology followed here is that of Kremp (1965), Andersen & Bertelsen (1972), Page (1978) and Solonomon (1983).

Results

The pollen grains in Gramineae are fairly uniform, with an average diameter (26.8-) 18.89-35.57 (-37.18) µm, ± spheroidal, rarely oblate (only in *Cymbopogon martinii*); usually monoporate, but diporate grains may also be present as in *Cenchrus pennisetiformis;* operculate or non-operculate, annulate, annulus 0.83-3.12 µm thick, 3.42-10.0 µm in diameter. Sometimes annulus reduced or even absent. Pore (2.14-) 2.01-3.57 (-4.29) x (0.71-) 0.70-2.47 (-3.57) µm. Exine (0.71-) 0.72-1.43 (2.86) µm thick, usually sexine as

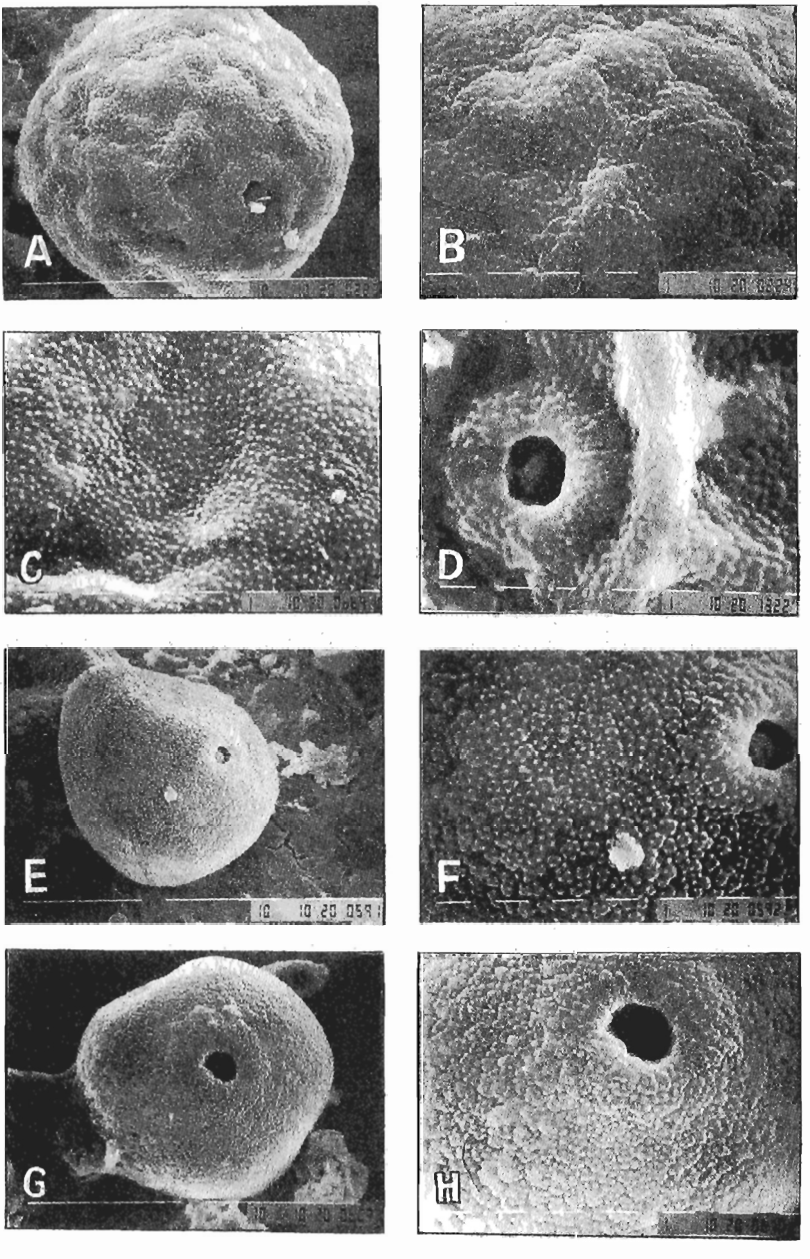

Fig. 1. Scanning electron micrographs of grass pollen. *Cenchrus biflorus:* A. entire grain, B. sculpturing pattern, *Panicum turgidum:* C. sculpturing pattern, *Digitaria violascens:* D. sculpturing pattern, *Panicum antidotale:* E. entire grain, F. scupturing pattern, *Eragrostis tenella:* G. entire grain, H. sculpturing pattern. (scale: Fig. A, E, G bar = 10 μm and Fig. B, C, D, F, H bar = 1 μm).

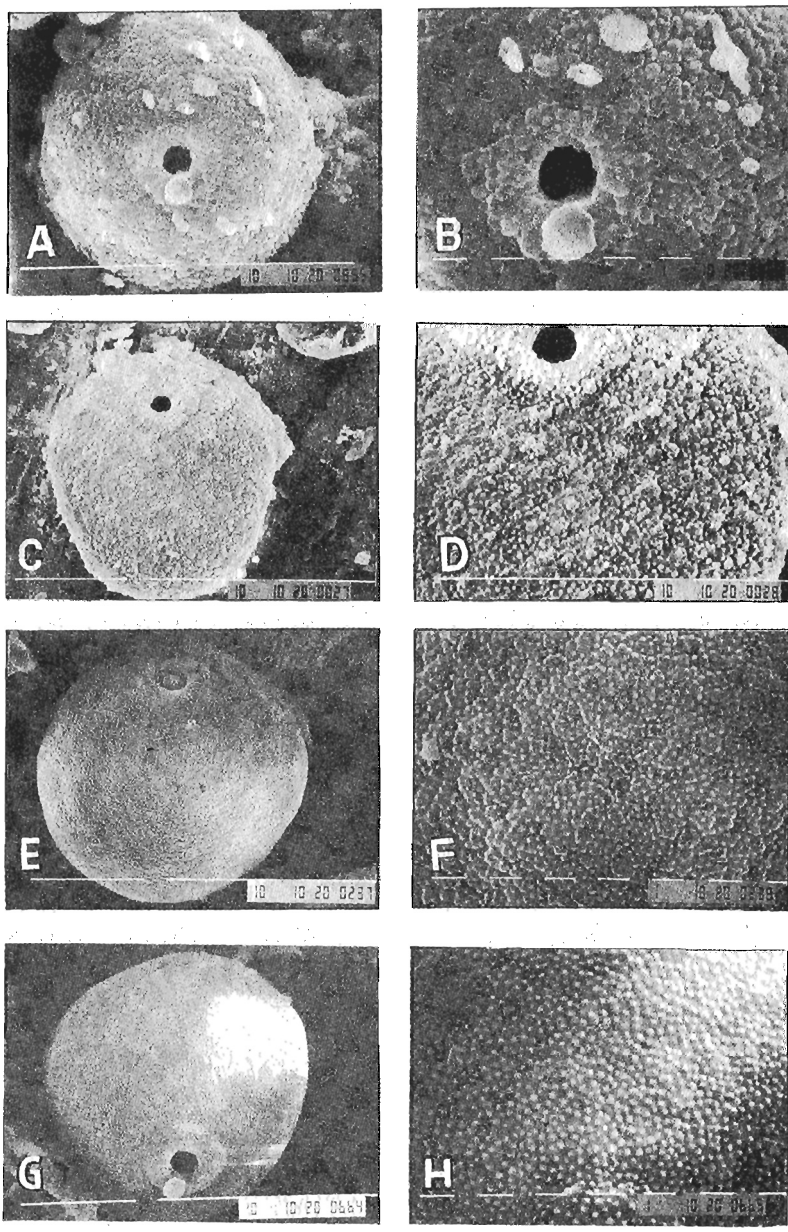

Fig. 2. Scanning electron micrographs of grass pollen. *Eragrostis pilosa:* A. entire grain, B. sculpturing pattern, *Octhochloa compressa:* C. entire grain, D. sculpturing pattern, *Cymbopogon jawarancusa:* E. entire grain, F. sculpturing pattern, *Lasiurus scindicus*: G. entire grain, H. sculpturing pattern (scale: Fig. A, C, D, E, G bar = 10 μm and Fig. B, F, H, bar = 1 μm).

thick as nexine or sexine thicker than nexine or vice versa. Sculpturing pattern areolate, scabrate or scabrate-areolate. Scabrae 0.05-0.20 μm, grouped on small (0.40 x 0.10 – 0.60 x 0.30 μm), medium (0.90 x 0.40 – 1.3 x 0.60 μm.) or large (1.5 x 0.80 – 1.7 x 0.10 μm.), regularly or irregularly shaped areolae. Insicions present or absent, if present wide or narrow. Granules closely, medium or widely spaced. A detailed description of all the taxa studied is given in Table 1.

Discussion

Gramineae is a stenopalynous family and the pollen show very little character differences, not only at the specific but also at the generic or even at the tribal level. Two main types of the pollen are recognized on the basis of the sculpturing pattern (i) scabrate, (ii) areolate, the third intermediate type i.e. scabrate-areolate have also been observed in few cases. Of the 64 species, 62 wild species showed an areolate pattern, only three species have scabrate, and three have intermediate pattern (Table 1). Present findings are in conformity with Faegri & Iversen (1964), who found that the wild grasses and cereals had predominantly areolate sculpturing. These two basic types have been further subdivided into separate and fused subtypes on the basis of the proximity of the granules (scabrae) both on the smooth surface, as well as on the islands (areolae) as done previously by Andersen & Berltsen (1972) in cereals and wild grasses of tribe Triticeae. The separate subtype can be further classified into closely medium or widely spaced type while in case of fused subtypes the differences seems to be indicated by the height of the granules, which may be in high or low relief. Nevertheless the taxonomic significance of grass pollen is very limited as demonstrated by Page (1978). This is also evident from Table 1, that at the tribe level; on the basis of the granule pattern and sculpturing type; even if arranged in sequence; the tribes form no definite order. All type of granule patterns occur within the same tribe. In tribe Paniceae (12 genera, 24 species), areolate sculpturing was present (Fig. 1, D-F) except in *Panicum turgidum* (Fig. 1, C) and *Paspalidium geminatum* which have scabrate sculpturing and *Cenchrus biflorus* having scabrate-areolate sculpturing (Fig. 1 A&B). All the three types of separate granule pattern i.e. closely, medium and widely spaced type are present within the tribe. Tribe Eragrostideae (7 genera, 12 species) seems to be fairly uniform and have only areolate type (Fig. 1, G-H, 2 A-D), with separate and fused granule pattern. The former is further segregated by having closely and medium spaced type, and the later is with groups in high relief. However, the individual species of this tribe cannot be further delimited on the basis of sculpturing pattern. Tribe Andropogoneae (8 genera 12 species) has predominantly areolate sculpturing (Fig. 2, G&H, Fig 3 A-D), while *Dichanthium annulatum* and *Saccharum griffithii* have scabrate-areolate type. All the further subdivisions of separate type were also met, while the fused type with groups in low relief was also present. In Sporoboleae (2 genera, 4 species; Fig. 3 A&B), Chlorideae (3 genera, 4 species, Fig. 3 C&D), Aveneae (2 genera, 2 species; Fig. 3 G&H), Zoysieae (2 genera, 2 species, Fig. 3 E&F), and Arundineae (2

Table 1. Pollen characteristics of the family Gramineae.

Taxa	Tribe	Size in µm	Op.	Annulus µm		Pore Size µm		Exine thickness	BSP	GP
				D	T	Length	Breadth	µm		
		Mean SE				Mean SE	Mean SE	Mean SE		
Cenchrus pennisetiformis	Paniceae	34.49 ± 0.41	–	5.5	1.0	3.19 ± 0.18	2.28 ± 0.13	1.43	Ar.	SCST.
Cenchrus setigerus	"	31.55 ± 0.58	+	5.7	2.34	2.64 ± 0.06	1.30 ± 0.15	1.38 ± 0.03	"	"
Cenchrus ciliaris	"	35.87 ± 0.35	–	4.16	1.38	2.77 ± 0.07	1.66 ± 0.11	1.52 ± 0.06	"	"
Setaria pumila	"	24.02 ± 0.44	–	reduced		2.88 ± 0.04	0.99 ± 0.11	1.41 ± 0.05	"	"
Urochloa panicoides	"	32.50 ± 0.50	+	5.0	2.0	2.86	2.19 ± 0.16	1.43	"	"
Paspalidium punctatum	"	24.59 ± 0.31	–	reduced		2.31 ± 0.07	2.33 ± 0.08	1.43	"	"
Digitaria violascens	"	32.21 ± 0.18	+	6.0	2.0	2.74 ± 0.05	1.43	1.33 ± 0.04	"	"
Pennisetum glaucum	"	32.98 ± 0.44	–	5.88	1.47	2.14 ± 0.03	1.18 ± 0.09	1.43	"	"
Echinochloa colona	"	31.83 ± 0.22	+	4.5	2.0	2.53 ± 0.10	1.68 ± 0.18	1.36 ± 0.09	"	"
Leptothrium senegalense	Zoysieae	22.30 ± 0.45	–	reduced		2.64 ± 0.08	0.89 ± 0.08	1.16 ± 0.04	"	"
Desmostachya bipinnata	Eragrostideae	32.31 ± 0.33	+	3.88	1.10	2.09 ± 0.08	0.71	1.43	"	"
Halopyrum mucronatum	"	30.03 ± 0.30	–	4.05	1.35	2.86	1.83 ± 0.18	1.43	"	"
Eragrostis tenella	"	19.73 ± 0.25	–	6.08	1.90	2.95 ± 0.11	1.20 ± 0.17	1.33 ± 0.06	"	"
Eragrostis cilianensis	"	24.21 ± 0.25	+	5.40	1.89	2.71 ± 0.04	0.19 ± 0.06	1.43	"	"
Eragrostis ciliaris	"	18.78 ± 0.19	+	reduced		2.81 ± 0.03	0.84 ± 0.07	1.43	"	"
Dactyloctenium aegyptium	"	31.07 ± 0.49	+	10	2.0	2.83 ± 0.23	1.97 ± 0.16	1.26 ± 0.07	"	"
Dactyloctenium scindicum	"	26.21 ± 0.36	–	absent		2.83 ± 0.23	1.76 ± 0.11	1.43	"	"
Eleusine indica	"	24.97 ± 0.33	–	reduced		2.29 ± 0.07	1.52 ± 0.11	1.43	"	"
Cymbopogon martinii	Andropogoneae	35.26 ± 0.16	+	4.72	1.94	2.69 ± 0.05	1.60 ± 0.08	1.43	"	"
Saccharum griffithii	"	35.17 ± 0.19	–	8.22	2.22	3.16 ± 0.10	2.47 ± 0.21	1.43	"	"
Sorghum halepense	"	30.69 ± 0.41	–	7.50	2.50	2.50 ± 0.05	0.84 ± 0.07	1.43	"	"
Dichanthium annulatum	"	29.93 ± 0.38	+	4.76	1.60	2.76 ± 0.13	1.95 ± 0.17	1.43	"	"
Dichanthium foveolatum	"	32.80 ± 0.18		reduced		3.57 ± 0.25	1.68 ± 0.27	1.43	"	"
Hackelochloa granularis	"	22.59 ± 0.15	–	6.75	1.35	2.59 ± 0.07	0.82 ± 0.04	1.19 ± 0.04	"	"
Lasiurus scindicus	"	30.03	–	7.02	2.70	2.95 ± 0.41	1.01 ± 0.10	1.43	"	"
Mnesithea laevis	"	25.33 ± 0.31	+	4.83	1.61	2.59 ± 0.07	0.82 ± 0.04	1.19 ± 0.04	"	"
Cynodon dactylon	Chlorideae	34.15 ± 0.27	+	4.91	1.50	2.71 ± 0.05	1.43	1.43	"	"
Phalaris minor	Aveneae	35.08 ± 0.19	+	5.94	2.70	2.83 ± 0.02	1.08 ± 0.19	1.14 ± 0.03	"	"
Arundo donax	Arundineae	24.78 ± 0.36	–	Absent		2.83 ± 0.13	1.37 ± 0.18	1.43	"	"
Sporobolus arabicus	Sporoboleae	24.02 ± 0.39	–	5.40	1.35	2.74 ± 0.06	1.40 ± 0.17	1.43	"	"
Sporobolus coromandelianus	"	21.16 ± 0.39	–	4.0	1.0	2.37 ± 0.07	0.99 ± 0.41	1.43	"	"

Sporobolus helvolus	"	30.31 ± 0.20	–	5.31	0.85	2.78 ± 0.03	2.78 ± 0.13	1.18 ± 0.13	"	SMST
Urochondra setulosa	"	24.21 ± 0.21	–	reduced		2.86	2.74 ± 0.17	1.43	"	"
Setaria intermedia	Paniceae	25.93 ± 0.16	–	3.52	1.17	2.86	1.97 ± 0.08	1.43	"	"
Setaria verticillata	"	25.54 ± 0.16	–	4.16	0.83	2.34 ± 0.09	1.08 ± 0.50	1.43	"	"
Panicum turgidum	"	34.89 ± 0.27	+	4.05	1.62	2.86	1.97 ± 0.20	1.43	Scab.	"
Panicum antidotale	"	30.60 ± 0.38	+	4.28	1.42	2.93 ± 0.17	1.42 ± 0.16	1.43	Ar.	"
Cenchrus biflorus	"	24.69 ± 0.18	–	6.0	2.0	2.58 ± 0.51	1.54 ± 0.14	0.34 ± 0.05	Ar.-Scab.	"
Eriochloa fatmensis	"		–	6.38	1.94	2.01 ± 0.04	1.50 ± 0.07	1.43	Ar.	"
Echinochloa crus-galli	"	33.55 ± 0.19	–	6.60	1.0	2.86	1.08 ± 0.09	1.28 ± 0.04	"	"
Brachiaria eruciformis	"	31.26 ± 0.19	+	5.71	1.42	2.90 ± 0.24	1.11 ± 0.19	1.16 ± 0.05	"	"
Paspalum paspalodes	"	33.64 ± 0.50	+	6.25	3.12	2.95 ± 0.20	2.11 ± 0.18	1.43	"	"
Digitaria nodosa	"	30.98 ± 0.22	–	7.14	1.42	2.90 ± 0.14	1.97 ± 0.20	1.21 ± 0.04	"	"
Digitaria ciliaris	"	35.87 ± 0.35	+	4.50	1.50	2.71 ± 0.07	1.66 ± 0.11	1.43	"	"
Eragrostis minor	Eragrostideae	26.02 ± 0.28	–	reduced	–	2.95 ± 0.15	1.18 ± 0.19	1.43	"	"
Octhochloa compressa	"	26.46 ± 0.40	–	4.16	1.38	1.54 ± 0.08	2.62 ± 0.11	1.43	"	"
Saccharum ravennae	Andropogoneae	25.25 ± 0.16	–	7.29	2.70	2.25 ± 0.09	1.08 ± 0.10	1.43	"	"
Chrysopogon aucheri	"	28.31 ± 0.28	+	3.42	0.85	2.69 ± 0.03	2.86	1.43	"	"
Cymbopogon jwarancusa	"	31.93 ± 0.40	+	6.57	2.0	2.54 ± 0.04	1.54 ± 0.16	1.43	"	"
Cymbopogon commutatus	"	35.27 ± 0.47	–	reduced		2.90 ± 0.04	1.95 ± 0.13	1.43	"	"
Chloris barbata	Chlorideae	25.45 ± 0.31		7.05	2.94	2.74 ± 0.14	1.57 ± 0.11	1.43	Ar.	"
Phragmites karka	Arundineae	25.54 ± 0.32	–	4.33	1.0	2.59 ± 0.12	1.33 ± 0.13	1.28 ± 0.07	"	"
Aeluropus lagopoides	Aleuropodeae	29.36 ± 0.49	–	3.71	2.85	2.78 ± 0.05	2.03 ± 0.18	1.43	Scab.	"
Paspalidium geminatum	Paniceae	33.64 ± 0.30	+	5.0	1.13	2.86	1.50 ± 0.15	1.43	Scab.	SWST
Tricholaena teneriffae	"	27.07 ± 0.24	–	4.25	1.06	2.83 ± 0.02	1.57 ± 0.09	1.43	Ar.	"
Brachiaria ramosa	"	29.55 ± 0.41	–	4.34	1.09	2.50 ± 0.16	2.23 ± 0.10	1.21 ± 0.04	"	"
Tragus roxburghii	Zoysiceae	24.21 ± 0.88	+	4.86	1.08	2.76 ± 0.06	1.11 ± 0.15	1.43	"	"
Aristida mutabilis	Aristideae	28.21 ± 0.03	+	5.42	1.07	2.81 ± 0.005	1.54 ± 0.03	1.21 ± 0.008	Ar.-Scab.	"
Chloris quinquesetica	Chlorideae	25.26 ± 0.22	–	6.12	3.06	2.05 ± 0.16	1.25 ± 0.10	1.20 ± 0.02	Ar.	FGHR
Tetrapogon tenellus	"	30.88 ± 0.27	–	4.54	1.18	2.69 ± 0.14	2.26 ± 0.20	1.43	"	"
Eragrostis pilosa	Eragrostideae	21.83 ± 0.18	–	7.0	2.2	2.66 ± 0.09	0.19 ± 0.14	1.43	"	"
Denebra retroflexa	"	23.64 ± 0.73	–	Reduced		2.38 ± 0.09	0.76 ± 0.03	1.47 ± 0.04	"	FRGR
Polypogon monspeliensis	Aveneae	27.55 ± 0.07	+	"		2.47 ± 0.05	1.28 ± 0.13	1.43	"	"
Eriochloa procera	Paniceae	28.31 ± 0.20	+	In the form of ring		2.76 ± 0.04	1.47 ± 0.11	1.43	Psilate	

Key to abbreviations: Ar. = Areolate, Ar.-Scab. = Areolate-Scabrate, BSP = Basis sculpturing pattern, D = Diameter, FGHR =Fused grops in high relief, FGLR = Fused groups in low relief, GP. = Granule patterning, OP. = Operculum, Scab. = Scabrate, SCST. = Separate closely spaced type, SMST. = Separate medium spaced type, SWST. = Separate widely spaced type, T = Thickness.

genera, 2 species), only areolate sculpturing was observed, while in Sporoboleae, Zoysieae and Chlorideae granule patterning is separate with closely and medium spaced type. In Aveneae separate type with closely and widely spaced subtype is present, while in Arundineae only separate medium spaced type was found (Fig. 4, C&D). In Aeluropodeae and Aristideae (1 genus, 1 species each) sculpturing was scabrate with separate widely spaced granule pattern (Fig. 4 A&B). However, *Eriochloa procera* is unique in having an unsculpturing pattern.

In general, pollen are spheroidal, except in *Cymbopogon martinii* which has oblate grains. Firbas (1937) demonstrated that the pollen of wild grasses measured 20-30 µm and that of cereals were over 35 µm. However, Faegri & Iversen (1975) considered 40 µm as a dividing line between the two. Our findings are similar with Firbas (1937) as the pollen size ranges from (26.18-) 18.89-35.57 (-37.18) µm. In all the tribes studied so far, there seems to be all sorts of overlapping as far as the size of the grains was concerned. However Andropogoneae have the largest grains (29.05-32.49 µm) followed by Paniceae (28.18-32.08 µm), Aveneae (25.75-35.75 µm), Sporoboleae (22.8-34.96 µm), Arundineae (22.88–28.60 µm), Zoysieae (18.50-27.17 µm), Chlorideae (18.59–31.46 µm) and Eragrostideae (14.30-37.18 µm) respectively. Eragrostideae is unique by having the smallest as well as the largest grains. Grains are usually monoporate, however, in few species diporate and double grains with single pore were also observed (Table 2). Nevertheless such grains were larger than the normal monoporate ones, however, the pore size did not differ much, but the position and the interpore distance varied from grain to grain. Erdtman (1952) and Chaturvedi (1971) have already reported 0-7 pores in Triticale and diporate single and double grains in *Saccahrum robustum,* respectively. Chaturvedi (1971) attributed the double grains as the non separation of individual grains during microsporogenesis, resulting with pores on the same face, or diporate single grains on the same pole, or double monoporate grains due to polyploidy. Similarly Gould (1957) while working on 9 different species of Andropogoneae, indicated a direct correlation between the chromosome number and pollen size.

The diporate characteristic is not confined to a particular tribe or a genus, they are scattered in several tribes e.g., Paniceae (5 species) Andropogoneae (2 species), Aveneae and Zoysieae (1 species each) have diporate grains (Fig. 4, E-H) which is absent from all the other tribes.

Operculate and non operculate grains were found in all the tribes. However, at the generic level, few genera like *Panicum* (2 species) and *Dichanthium* (2 species) showed exclusively operculate grains, with *Sporobolus* (3 species) and *Saccharum* (2 species) having non operculate grains only. In other genera both operculate and non operculate grains were present.

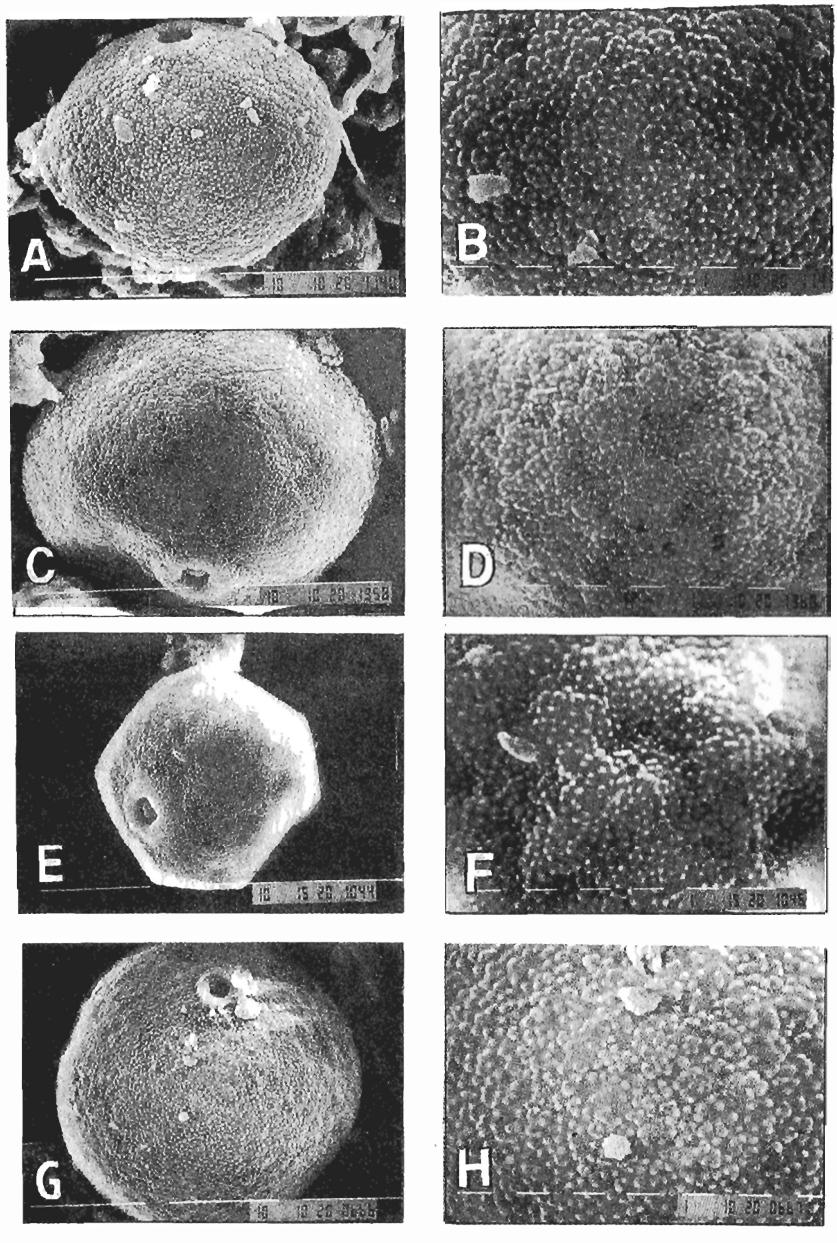

Fig. 3. Scanning electron micrographs of grass pollen. *Sporobolus helvolus:* A. entire grain, B. sculpturing pattern, *Cynodon dactylon:* C. entire grain, D. sculpturing pattern. *Tragus roxburgii :* E. entire grain, F. sculpturing pattern, *Polypogon monspeliensis:* G. entire grain, H. sculpturing pattern. (Scale: Fig. A, C, E, G bar = 10 μm and Fig. B, D, F, H bar = 1 μm).

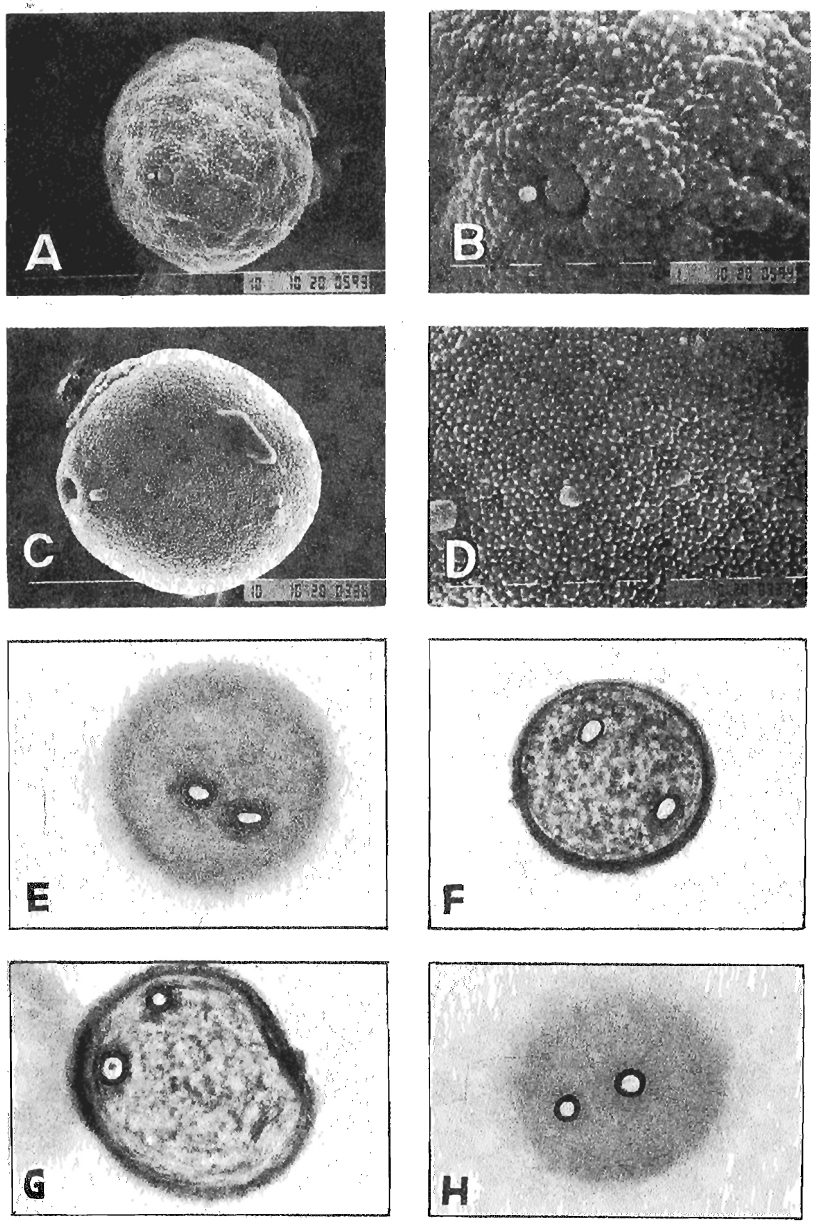

Fig. 4. Scanning electron micrographs of grass pollen. *Aristida mutabilis:* A. entire grain, B. sculpturing pattern, *Phragmitis karka:* C. entire grain, D. sculpturing pattern. Light micrographs of diporate grains of grasses. *Digitaria violascens:* E. same face, *Tragus roxburgii:* F. same face, *Polypogon monspeliensis*: G. same pole, H. same face. (Scale: Fig. A, C, bar = 10 μm and Fig. B, D bar = 1 μm Fig. E, F, G, H = 800 x).

Table 2. Some characteristic features of diporate grains.

TAXA	Diporate grains		Grain size µm		Interpore distance µm		Position of pores
	Single grains	Double grains	Single grain	Double grain	Single grain	Double grain	
Cenchrus penisetiformis	+	–	31.18 x 37.75	–	2.86	–	At the same pole
Cenchrus setigerus	–	+	–	25.74 x 24.31	–	2.50	At the same face
Setaria intermedia	–	+	–	27.17 x 25.70	–	4.29	At the same face
Digitaria violascence	–	+	–	34.32	–	3.57	"
Echinochloa colona	+	–	c. 32.89	–	2.86	–	"
Dactyloctenium scindicum	–	+	–	30.03	–	4.29	At the same pole
Sorghum halepense	–	+	–	32.69 x 35.75	–	4.29	"
Tragus roxburghii	+	–	c. 27.17	–	5.57	-	"
Polypogon monspeliensis	+	+	c. 28.60	30.03	2.86	2.86	At the same pole as well as at the same face.

+ present; – absent

It is interesting to note that not a single tribe can be characterized by the annulus. Three annulus types i.e., (i) well developed, (ii) reduced and (iii) completely absent can be recognized. Few genera like *Cenchrus, Digitaria, Echinochloa, Brachiaria, Panicum, Saccharum, Sporobolus* and *Chloris* have exclusively well developed annulus. In the remaining genera studied so far a mixture of all the three types was present. There is a continuous variation in the thickness (0.83-3.12 μm) and the diameter (3.42-10.0 μm) of the annulus which offers no assistance in the delimitation of the various species. Similarly no correlation exists between the presence of the operculum and the presence or absence of a well developed or reduced annulus, or vice versa. Operculate and non operculate condition may be present in any combinations with the annulus.

Exine thickness ranged from (0.71-) .72-1.43 (-2.86) μm. In most of the species sexine was as thick as nexine, but in a few cases viz., *Pennisetum glaucum, Hackelochloa granularis, Lasiurus scindicus, Phlaris minor, Arundo donax, Eriochloa fatmensis, Sporobolus helvolus, Phragmitis karka, Digitaria nodosa. Eragrostis pilosa, Dichanthium foveolatum, Urochloa panicoides* and *Eragrostis cilianensis* sexine was thicker than nexine, while in *Eragrostis ciliaris, Digitaria violascens, Digitaria ciliaris* and *Panicum antidotale* nexine was thicker than sexine.

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APPENDIX I – LIST OF VOUCHER SPECIMENS

TAXA	LOCALITY	COLLECTOR
Cenchrus penisetiformis	Karachi University Campus, Botany Department.	*Tahmeena Siddiqui* *Tahmeena Siddiqui* 45 (KUH)
Cenchrus setigerus	Safari Park, Karachi.	*Tahmeena Siddiqui* 117 (KUH)
Cenchrus ciliaris	Cape Monze.	*Tahmeena Siddiqui* 81 (KUH)
Setaria pumila	Gijju.	*Tahmeena Siddiqui* 137 (KUH)
Urochloa panicoides	Karachi University Campus, near Girls Hostel.	*Abrar Hussain* s.n. (KUH)
Paspalidium punctatum	Karachi University Campus, I.B.A. Department.	*Tahmeena Siddiqui* 79 (KUH)
Digitaria violascens	North Nazimabad, Karachi.	*Saood Omer* s.n. (KUH)
Pennisetum glaucum	Buffer Zone, Karachi.	*M. Qaiser* s.n. (KUH)
Echinochloa colona	Karachi University Campus, Biochemistry Department.	*Tahmeena Siddiqui* 115 (KUH)
Leptothrium senegalense	Karachi University Camus, near Boys Hostel.	*Abrar Hussain* s.n. (KUH)
Desmostachya bipinnata	Thatta Cement Factory.	*Tahmeena Siddiqui* 112 (KUH)
Halopyrum mucronatum	Cape Monze.	*Tahmeena Siddiqui* 58 (KUH)
Eragrostis tenella	Darsano Chano.	*Tahmeena Siddiqui* 83 (KUH)
Eragrostis cilianensis	Karachi Univesity Campus, near Boys Hostel.	*Tahmeena Siddiqui* 128 (KUH)
Eragrostis ciliaris	Karachi University Campus, Biochemistry Department.	*Tahmeena Siddiqui* 48 (KUH)
Dactyloctenium aegyptium	Karachi University Campus, near Main Library.	*Tahmeena Siddiqui* 43 (KUH)
Dactyloctenium scindicum	Ibid.	*Tahmeena Siddiqui* 73 (KUH)
Eleusine indica	Karachi University Campus, near Main Library.	*Abrar Hussain* s.n. (KUH)
Panicum antidotale	Karachi University Campus, near I.R. Department.	*Tahmeena Siddiqui* 56 (KUH)
Cenchrus biflorus	Karachi University Campus, Botany Department.	*Tahmeena Siddiqui* 55 (KUH)
Eriochloa fatmensis	Karachi University Campus, near Boys Hostel.	*Tahmeena Siddiqui* 150 (KUH)
Echinochloa crus-galli	Thatta Cement Factory.	*Tahmeena Siddiqui* 111 (KUH)
Erachiaria eruciformis	Karachi University Campus, Botany Department.	*Tahmeena Siddiqui* 118 (KUH)
Paspalum paspalodes	Safari Park, Karachi.	*Tahmeena Siddiqui* 90 (KUH)
Digitaria nodosa	Karachi University Campus, Zoology Department.	*Tahmeena Siddiqui* 87 (KUH)
Digitaria ciliaris	Karachi University Campus, I.B.A. Department.	*Tahmeena Siddiqui* 147 (KUH)
Eragrostis minor	North Nazimabad.	*Saood Omer* s.n. (KUH)
Octhochloa compressa	Karachi University Campus, Botany Department.	*Tahmeena Siddiqui* 42 (KUH)
Saccharum ravennae	Safari Park, Karachi.	*Tahmeena Siddiqui* 164 (KUH)

Chrysopogon aucheri	Karachi University Campus, I.B.A. Department.	*Tahmeena Siddiqui* 66 (KUH)
Cymbopogon jwarancusa	Cape Monze.	*Tahmeena Siddiqui* 65 (KUH)
Cymbopogon commutatus	Karachi University Campus, near Girls Hostel.	*Abrar Hussain* s.n. (KUH)
Chloris barbata	Karachi University Campus, Botany Department.	*Tahmeena Siddiqui* 50 (KUH)
Pharagmites karka	Safari Park, Karachi.	*Tahmeena Siddiqui* 88 (KUH)
Aeluropus lagopoides	Sandspit, Karachi.	*Tahmeena Siddiqui* 76 (KUH)
Paspalidium geminatum	Karachi University Campus, I.B.A. Department.	*Tahmeena Siddiqui* 100 (KUH)
Tricholaena teneriffae	Darsano Chano, Karachi.	*Tahmeena Siddiqui* 80 (KUH)
Brachiaria ramosa	Karachi University Campus, Botany Department.	*Abrar Hussain* s.n. (KUH)
Tragus roxburghii	Karachi University Campus, near Boys Hostel.	*Tahmeena Siddiqui* 125 (KUH)
Cymbopogon martini	Drigh Colony.	*Razia Ahmed* s.n. (KUH)
Saccharum griffithii	Thatta Cement Factory.	*Tahmeena Siddiqui* 82 (KUH)
Sorghum halepense	Karachi University Campus, Agricultural Research Institute.	*Abrar Hussain* s.n. (KUH)
Dichanthium annulatum	Karachi University Campus, Botany Department.	*Tahmeena Siddiqui* 44 (KUH)
Dichanthium faveolatum	Ibid.	*Tahmeena Siddiqui* 59 (KUH)
Hackelochloa granularis	Cultivated fields near Pakistan Hotel, Malir.	*Abrar Hussain* s.n. (KUH)
Lasiurus scindicus	Karachi University Campus, near Girls Hostel.	*Surrayya Khatoon* s.n. (KUH)
Mnesithea laevis	Begar mori.	*Tahmeena Siddiqui* 165 (KUH)
Cynodon dactylon	Karachi University Campus, Biochemistry Department.	*Tahmeena Siddiqui* 40 (KUH)
Phalaris minor	Karachi University Campus, Agricultural Research Institute.	*Tahmeena Siddiqui* 121 (KUH)
Arundo donax	Safari Park, Karachi.	*Wajad Ahmed* s.n. (KUH)
Sporobolus arabicus	Karachi University Campus, near Girls Hostel.	*Tahmeena Siddiqui* 67 (KUH)
Sporobolus coromandelianus	Karachi University Campus, near Boys Hostel	*Tahmeena Siddiqui* 159 (KUH)
Sporobolus helvolus	Karachi University Campus, Staff Town.	*Saood Omer* s.n. (KUH)
Urochondra setulosa	Cape Monze.	*Tahmeena Siddiqui* 75 (KUH)
Setaria intermedia	Karachi University Campus, I.B.A. Department.	*Tahmeena Siddiqui* 116 (KUH)
Setaria verticillata	Karachi University Campus, near Main Library.	*Tahmeena Siddiqui* 114 (KUH)
Panicum turgidum	2 miles from Hub on way to Sonmiani.	*Ali et al* 1247 (KUH)
Aristida mutabilis	Karachi University Campus, Arts Faculty.	*Ali et al*47 (KUH)
Chloris quinquesetica	Safari Park, Karachi.	*Ali et al*167 (KUH)

Tetrapogon tenellus	Karachi University Campus, near Boys Hostel.	*Abrar Hussain* s.n. (KUH)
Eragrostis pilosa	Karachi University Campus, near Boys Hostel.	*Abrar Hussain* s.n. (KUH)
Dinebra retroflexa	Darsano Chano.	*Tahmeena Siddiqui* 84 (KUH)
Polypogon monspeliensis	Karachi University Campus, near Main Library.	*Tahmeena Siddiqui* 113 (KUH)
Eriochloa procera	North Nazimabad, Karachi.	*Saood Omer* s.n. (KUH).