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SEED MORPHOLOGY AND ITS TAXONOMIC SIGNIFICANCE IN THE FAMILY MALVACEAE

RUBINA ABID*, AFSHEEN ATHER AND M. QAISER

Department of Botany, University of Karachi, Karachi-75270, Pakistan
**Corresponding author's email: rubinaku@yahoo.com*

Abstract

The seed morphological studies of 75 taxa belonging to 6 sub-families of the family Malvaceae were carried out from Pakistan. In Pakistan the family Malvaceae is represented by 6 sub-families viz., Byttnerioideae, Dombeyoideae, Malvoideae, Bombacoideae, Helicteroideae and Sterculioideae.

The seed macro and micro morphological characters are examined, using light (LM) and scanning electron microscopy (SEM). Detailed seed morphological descriptions, micrographs and keys based on seed characters are also provided. A variety in various quantitative and qualitative seed characters was observed. The micro-morphological characters of seeds are quite significant to strengthen the taxonomic decisions within the family Malvaceae at various levels.

The data obtained from the seed morphological characters were analyzed numerically to trace out the phylogenetic affinities for the taxa within the family Malvaceae from Pakistan.

Key words: Malvaceae, Seeds, Pakistan.

Introduction

The family Malvaceae comprises almost all life forms, from annual herbs to perennial trees represented by 243 genera and 4225 species. The family Malvaceae recognized as a large family and distributed all over the world mostly in warmer regions (Heywood, 1979; El Naggar, 2001; APG, 2014). On the basis of various reports including gross morphology (Bayer, 1995; Vogel, 2000), palynology (Erdtman, 1952; Litchfield, 1966; Nilsson & Robyns, 1986; Pires & Cristobal, 2001; Perveen *et al*., 2004; Perveen & Qaiser, 2009), anatomy (Kukachka & Rees, 1943; Metcalf & Chalk, 1950; Den Outer & Schütz, 1981), embryology (Davis, 1966; Johri *et al*., 1992) and molecular studies (Judd & Manchester, 1997; Alverson *et al*., 1999; Bayer, 1999; Bayer & Kubitzki, 2003; APG, 2014) the family Malvaceae and its traditionally allied families i.e., Bombacaceae, Sterculiaceae and Tiliaceae were merged within the expanded family Malvaceae and divided into 9 subfamilies viz., Grewioideae, Byttnerioideae, Tilioideae, Dombeyoideae, Malvoideae, Bombacoideae, Helicteroideae, Sterculioideae and Brownlowioideae. As far as seed morphology is concerned few reports are available to evaluate the taxonomic decisions (El Naggar, 2001; Utami & Shimizu, 2005; Bojnanský & Fargašová; 2007; Rajbhandary & Shrestha, 2010; Kanwal *et al.*, 2015; Ather *et al.*, 2013). But there is no detailed report available on the seed morphology of the family Malvaceae from the world as well as from the area under consideration except that of the subfamily Grewioideae of the family Malvaceae (Ather *et al.*, 2009). The purpose of the present report is multifold, first to provide the detail seed micro-morphological information of the family Malvaceae from Pakistan, secondly to utilize these information as an additional tool to strengthen the taxonomic delimitation and phenetic relationship of various taxa within the family Malvaceae.

Materials and Methods

Mature and healthy seeds of 75 taxa of the family Malvaceae were collected from the herbarium specimens. Mostly 10 plants/species and 10 seeds/plant were studied. The list of voucher specimens is deposited in KUH. Seed morphological characters examined under stereomicroscope (Nikon XN Model) and scanning electron microscope (JSM-6380A). For scanning electron microscopy dry seeds were directly mounted on metallic stub using double adhesive tape and coated with gold for a period of 6 minutes in sputtering chamber and observed under SEM. The terminology used is in accordance to Lawrence (1970), Radford *et al.* (1974) and Stearn (1983) with slight modifications. Numerical analysis was carried out to recognize the relationship and affinities of species within the family Malvaceae. Hierarchical clustering was performed by using Euclidean distance index with the computer package (Anon., 2012). Each taxon was treated as operational taxonomic unit (OTU). Macro and micro-morphological characters of seeds viz., size, shape, colour and surface patterns were used. Characters were recorded as presence or absence and coded as 1 or 0 respectively (Tables 2, 3) and the average values of the quantitative characters viz., seed length and breadth were directly used (Tables 2, 3).

Observations

General seeds characters of the family Malvaceae

Seeds 1-20 x 1-10 mm, oblong, elliptic, obliquely elliptic, obovate, ovate, deltoid, sub globose, reniform, broad reniform, compressed reniform, transversally obliquely elliptic, transversally elliptic-pyriform or transversely cuneate, ridged, depressed or not, apex acute, obtuse, rounded, truncate or obliquely truncate, base cuneate, obtuse, rounded, beaked, truncate, obliquely truncate or reniform, light brown, dark brown, dusty brown, orange brown, reddish brown, greenish brown, golden brown, blackish brown or black, surface reticulate, reticulate-foveate, appresedly reticulate, foveate, falsifoveate, sulcate, scrobiculate, rugose, rugosely foveate, rugosely falsifoveate, favulariate, lineate, verrucate, colliculate, striate, undulatly striate, rugosely striate or scalariform and transversely striate, glabrous or hairy, indumentum puberulose, stellate, scabrous, strigose, pilose, sericeous, velutinous, tomentose, wooly or glandular, strophiolate or non strophiolate, strophriole glabrous or pubescent, hilum terminal, sub terminal, lateral, basal or sub basal in position (Tables 1-3; Figs. 1-8; Plates 1-9).

Presently family Malvaceae is represented by six subfamilies (excluding Grewioideae) viz., Bombacoideae, Byttnreioideae, Dombeyoideae, Helicterioideae, Malvoideae and Sterculioideae.

Table 1. Seed morphological characters of the family Malvaceae.

Name of taxa	Size (mm)		Shape	Apex	Base	Colour	Surface	Indumentum	Strophiole	Hilum
	Length	Breadth								
Sub family Bombacoideae										
Bombox ceiba	6-7	5	Obovate, laterally ridged	Rounded	Cuneate	Greenish brown-dark brown	Reticulate	Sparsely pubescent	Absent	Basal
Sub family Bytternoideae, Tribe Theobromateae										
Guazuma ulmifolia	2.5	2	Sub globose	Rounded-truncate	Beaked	Light brown	Lineate, irregularly verrucate	Pubescent	Absent	Basal
Tribe Byttnerieae										
Kleinhovia hospita	3.53	3	Sub globose	Rounded	Truncate	Orangish brown	Rugose-scrobiculate	Sparsely pubescent	Absent	Basal
Sub family Dombeyoideae										
Dombeya acutangula	2.5	1.5	Oblong	Obtuse	Obliquely truncate	Reddish brown	Undulatly sriate	Glabrous	Absent	Sub terminal
D. mastersii	3	1.4	Elliptic, centrally depressed	Acute-obtuse	Obliquely truncate	Reddish brown	Undulatly sriate	Glabrous	Absent	Sub terminal
D. spectabilis	3.2	1.6	Obliquely elliptic	Acute	Cuneate	Light brown	Striate	Glabrous	Absent	Basal
D. wallichii	3.8	2	Obovate	Truncate	Cuneate	Brown dark and light patches	Undulatly sriate	Glabrous	Absent	Sub basal
Melhania denhamii	2.5	1.8	Ovate, depressed	Acute	Rounded-truncate	Orangish brown	Rugose	Glabrous	Absent	Terminal
M. futteyporensis	2.5	2	Ovate-deltoid, depressed	Acute	Truncate	Light brown	Foveate, verruate	Glabrous	Absent	Terminal
Subfamily Helicterioideae										
Helicteris isora	1.5	1	Deltoid, laterally ridged	Truncate	Obliquely truncate	Dark brown	Favulariate	Glabrous	Absent	Lateral
Subfamily Malvoideae, Tribe Gossypieae										
Gossypium arboreum	6-6.5	3-3.5	Transversally elliptic-pyriform	Rounded	Reniform	Greenish brown	Rugose	Hairy (white Wool)	Present, pubescent	Basal
G. herbaceum	7-8	4-4.5	Transversally elliptic-pyriform	Rounded	Reniform	Brown	Rugose	Hairy (creamy Wool)	Present, pubescent	Basal
Gossypium hirsutum	9-9.5	4-4.5	Transversally elliptic-pyriform	Rounded	Reniform	Dark brown	Rugose	Hairy (creamy Wool)	Present, pubescent	Basal
G. stocksii	3-3.5	5-6	Transversally elliptic-pyriform	Rounded	Reniform	Blackish brown	Rugose	Hairy (golden yellow wool)	Present, pubescent	Basal
Thespesia populnea	8-12	7-10	Obovate, ridge present centrally	Rounded	Reniform	Golden brown	Falsifoveate	Hairy (sericeous)	Present, glabrous	Basal
Tribe Hibisceae										
Hibiscus aristivalvis	2	2.5	Reniform	Rounded-truncate	Reniform	Dark brown	Reticulate-foveate, densely hairy, stellate concentricaly arranged	Hairy (stellate)	Present, glabrous	Basal
H. caesius	2-2.8	3-3.5	Reniform, centrally depressed	Obtuse	Reniform	Black	Reticulate	Hairy (strigose)	Present, glabrous	Basal
H. lobatus	1.8 x 2	2	Reniform, centrally depressed	Obtuse	Reniform	Light brown	Appressedly reticulate, verrucate	Sparsely hairy (scabrouse)	Present, glabrous	Basal
H. micranthus	2 x 3.5	3.5	Reniform, centrally depressed	Rounded	Reniform	Light brown	Rugose	Hairy on lateral side (golden orange wool)	Present, glabrous	Basal

Table 1 (Cont'd.).

Name of taxa	Size (mm)		Shape	Apex	Base	Colour	Surface	Indumentum	Strophiole	Hilum
	Length	Breadth								
H. mutabilis	2.4-2.5	1.2-1.4	Transversally obliquely elliptic	Rounded	Reniform	Dark brown	Rugose	Glabrous, hairy on dorsal side (sericeous)	Present, glabrous	Basal
H. obtusilobus	1.5-1.8	2-2.3	Reniform-cuneat	Obtuse	Reniform	Blackish brown	Reticulate-foveate, verrucate	Sparsely pubescent, (puberulose)	Present, pubescent	Basal
H. sabdariffa	4.8-5	2.5-4	Reniform, centrally depressed	Obliquely truncate	Reniform	Brown	Reticulate, verrucate	Sparsely hairy (stellate)	Present, glabrous	Basal
H. scindicus	2	3.5	Reniform-coma shape	Rounded	Reniform	Brown	Sulcate	Hairy (white wool)	Present, glabrous	Basal
H. syriacus	2.5-3.5	4-4.5	Reniform	Rounded-truncate	Reniform	Dark brown	Reticulate	Glabrous, hairy on lateral side (golden velutinous)	Present, glabrous	Basal
H. tiliaceus	3.2-3.8	4.8-5	Reniform	Rounded	Reniform	Dark brown	Reticulate	Hairy (glandular hairs)	Present, glabrous	Basal
H. trionum	1.7-2	2.2-2.5	Broad reniform	Rounded-obliquely truncate	Reniform	Dark brown	Reticulate	Hairy (glandular hairs)	Present, glabrous	Basal
Pavonia arabica	1.2-1.5	1.7-2.2	Transversally elliptic-pyriform, centrally and dorsally depressed	Rounded-truncate	Reniform	Brown	Reticulate	Sparsely pubescent, puberulose	Present, glabrous	Basal
P. glechomaefolia	1.5-2	2.5-2.8	Transversally elliptic-pyriform, centrally and dorsally depressed	Rounded	Reniform	Reddish brown	Reticulate-foveate	Sparsely pubescent, puberulose	Present, pubescent	Basal
P. grewioides	1.8-2	2.7-3	Transversally elliptic-pyriform	Rounded	Reniform	Reddish brown	Reticulate	Sparsely pubescent, puberulose	Present, glabrous	Basal
P. procumbens	1.5-2	2.2-2.5	Transversally elliptic-pyriform, centrally depressed	Rounded	Reniform	Dark brown	Rugose,	Hairy (strigose)	Present, glabrous	Basal
P. zeylonica	1.4-1.8	2.4-2.5	Transversally elliptic-pyriform, centrally and dorsally depressed	Truncate	Reniform	Dark brown	Reticulate-foveate	Sparsely pubescent, puberulose	Present, glabrous	Basal
Senra incana	3-3.5	2-2.5	Reniform	Rounded	Reniform	Brown	Rugose	Hairy (pilose)	Present, pubescent	Basal
Urena lobata	1.9-2.5	3-3.3	Transversally elliptic-pyriform	Rounded	Reniform	Dusty brown	Reticulate foveate	Sparsely pubescent, puberulose	Present, glabrous	Basal
	Tribe Malveae									
Abutilon alii	1.5	2	Reniform	Rounded	Reniform	Black	Falsifoveate	Hairy (strigose)	Present, pubescent	Basal
A. bidentatum var. *bidentatum*	1.8	2	Reniform	Rounded	Reniform	Dark brown	Rugose, verrucate	Glabrous	Present, glabrous	Basal
A. bidentatum var. *forrestii*	1.6	2	Reniform	Rounded	Reniform	Reddish brown	Foveate, verrucate	Glabrous	Present, glabrous	Basal

Table 1 (Cont'd.).

Name of taxa	Size (mm)		Shape	Apex	Base	Colour	Surface	Indumentum	Strophiole	Hilum
	Length	Breadth								
A. figarianum	1.9	2	Reniform	Rounded	Reniform	Blackish brown	Foveate, verrucate	Hairy (strigose)	Present, glabrous	Basal
A. fruticosum var. *fruticisum*	1.6	1.8	Reniform, centrally depressed	Obtuse	Reniform	Dark brown	Rugosely foveate	Hairy (scabrous)	Present, glabrous	Basal
A. fruticosum var. *microphyllum*	1	1.2	Reniform, dorsally depressed	Obtuse	Reniform	Light brown	Foveate, verrucate	Sparsely pubescent, (puberulose)	Present, glabrous	Basal
A. fruticosum var. *saidae*	1	1.3	Reniform, centrally depressed	Rounded	Reniform	Reddish brown	Reticulate-foveate, verrucate	Sparsely pubescent, (puberulose)	Present, glabrous	Basal
A. ghafoorianum	2	2.4	Reniform	Rounded	Reniform	Dark brown	Reticulate, verrucate	Glabrous	Present, glabrous	Basal
A. grandifolium	2	2.2	Reniform	Rounded	Reniform	Light brown	Reticulate within reticulation foveate, sparsely verrucate	Pubescent, (puberulose)	Present, glabrous	Basal
A. hirtum var. *hirtum*	1.5-2	2.5-3	Reniform, centrally depressed	Rounded	Reniform	Blackish brown	Rugosely falsifoveate	Pubescent, (puberulose)	Present, glabrous	Basal
A. hirtum var. *heterotrichum*	1.2	1.7	Reniform, depressed on dorsal upper side	Obtuse	Reniform	Reddish brown	Rugose	Sparsely pubescent, (puberulose)	Present, glabrous	Basal
A. indicum	1.9-2	2.5	Reniform, depressed laterally throughout dorsal side	Rounded	Reniform	Dark brown	Rugose, verrucate	Sparsely pubescent, (puberulose)	Present, hairy	Basal
A. karachianum	2	2.5	Broadly reniform, centrally depressed	Rounded	Reniform	Golden brown and blackish brown	Foveate	Sparsely pubescent, (puberulose)	Present, pubescent	Basal
Abutilon muticum	2	2.2	Reniform, slightly depressed upper side	Rounded	Reniform	Dark brown	Reticulate-foveate, verrucate	Hairy (pilose)	Present, hairy	Basal
A. pakistanicum	1.8	2	Reniform	Rounded	Reniform	Reddish brown	Falsifoveate	Hairy (scabrous)	Present, glabrous	Basal
A. pannosum	2	2.5	Reniform	Rounded	Reniform	Golden brown	Reticulate-foveate, verrucate	Hairy throughout dorsal side (tomentose)	Present, hairy	Basal
A. sepalum	2	2.5	Reniform	Rounded	Reniform	Dark brown	Reticulte-foveate, verrucate	Hairy (pilose)	Present, hairy	Basal
A. theophrasti	2.5	2.7-3.5	Compressed reniform	Obtuse	Reniform	Blackish brown	Reticulate	Glabrous	Present, pubescent	Basal
Alcea lavateraeflora	2.5	3.8	Reniform-transversally elliptic-pyriform, centrally depressed	Rounded	Reniform	Dusty brown	Reticulate-foveate, verrucate	Sparsely pubescent, (puberulose)	Present, glabrous	Basal
A. pallida	2	2.5	Reniform-transversally elliptic-pyriform, centrally depressed	Rounded	Reniform	Dusty brown	Reticulate-foveate, verrucate	Sparsely pubescent, (puberulose)	Present, glabrous	Basal
A. rosea	2.5	3.6	Reniform-transversally elliptic-pyriform	Rounded	Reniform	Reddish brown	Reticulate-foveate, verrucate	Hairy upperside (tomentose)	Present, glabrous	Basal
Althaea cannabina	2.5	3	Boardly reniform	Rounded-truncate	Reniform	Dark brown	Reticulate, sparsely verrucate	Glabrous	Present, glabrous	Basal

Table 1 (Cont'd.).

Name of taxa	Size (mm)		Shape	Apex	Base	Colour	Surface	Indumentum	Strophiole	Hilum
	Length	Breadth								
A. ludwigii	1.2	1.6	Boardly reniform	Rounded-truncate	Reniform	Brown	Favulariate	Glabrous	Present, glabrous	Basal
Malva mauritiana	1.6-2	2	Boardly reniform, centrally depressed	Rounded	Reniform	Dark brown	Scalariform and transversely densely striate	Glabrous	Present, glabrous	Basal
M. microcarpa	1.2-1.5	1.2-1.5	Boardly reniform, centrally and dorsally depressed	Rounded	Reniform	Reddish brown	Scalariform and transversely densely striate	Glabrous	Present, glabrous	Basal
M. mohileviensis	1.2-1.3	1.6-1.7	Boardly reniform	Rounded	Reniform	Orangish brown	Scalariform and transversely densely striate	Glabrous	Present, glabrous	Basal
M. neglecta	1.3-1.5	1.6-1.7	Boardly reniform, centrally depressed	Rounded	Reniform	Reddish brown	Scalariform and transversely densely striate	Glabrous	Present, glabrous	Basal
M. nicaeensis	1.4-2	2-2.3	Boardly reniform, centrally and dorsally depressed	Rounded	Reniform	Light brown	Scalariform and transversely densely striate	Glabrous	Present, glabrous	Basal
M. parviflora	1.2-1.5	1.3-1.6	Boardly reniform, centrally depressed	Rounded	Reniform	Dusty brown	Scalariform and transversely densely striate	Glabrous	Present, glabrous	Basal
M. qaiseri	1.6	1.6	Boardly reniform, centrally depressed	Rounded	Reniform	Dark brown	Scalariform and transversely densely striate	Glabrous	Present, glabrous	Basal
M. sylvestris	1.5-1.6	1.5-1.6	Boardly reniform	Rounded	Reniform	Brown	Scalariform and transversely densely striate	Glabrous	Present, glabrous	Basal
M. verticillata var. *verticillata*	1.2-1.9	1.3-2.2	Reniform, laterally depressed	Rounded	Reniform	Orangish brown	Scalariform and transversely densely striate	Glabrous	Present, glabrous	Basal
Malvastram coromendelianum	1.3-1.6	1.7-1.9	Boardly reniform	Rounded	Reniform	Dark brown	Reticulate within reticulation reticulate-foveate	Glabrous	Present, glabrous	Basal
Sida cordata var. *cordata*	1-1.3	1.5-1.7	Transversally cuneate, centrallyand dorsally depressed	Rounded	Rounded	Dark brown	Rugosely striate, verrucate	Glabrous	Present, glabrous	Basal
S. cordata var. *nasirii*	1-1.5	1.6-1.8	Transversally cuneate, centrally depressed	Rounded	Reniform	Brown	Rugose	Glabrous	Present, glabrous	Basal
Sida cordifolia	1.5-2	2.3-2.5	Reniform, centrally depressed	Obliquely truncate	Reniform	Dusty brown	Reticulate	Glabrous	Present, pubescent	Basal
S. ovata	1.5-1.8	1.6-1.9	Broad reniform, centrally depressed	Rounded	Reniform	Dark brown	Reticulate-foveate	Glabrous	Present, glabrous	Basal
S. taigii	1.5-2	1.7-2	Reniform, centrally depressed	Rounded	Reniform	Backish brown	Reticulate-foveate	Glabrous	Present, pubescent	Basal
S. yumanensis	1.2-1.6	1.7-2	Transversally caneate	Rounded	Reniform	Brown	Foveate, verrucate	Glabrous	Present, glabrous	Basal
					Subfamily Sterculoideae					
Firmiana pallens	8	6	Oblong	Rounded	Obtuse	Light brown	Falsifoveate	Glabrous	Absent	Sub basal
Sterculia foetida	20	10	Oblong	Rounded	Obtuse	Light brown	Rugosely falsifoveate	Glabrous	Absent	Basal
S. villosa	8	4.5-5	Oblong	Rounded	Obtuse	Black	Colliculate	Glabrous	Absent	Basal

Table 2. List of characters, scored for the cluster analysis for the taxa of the family Malvaceae listed in table 3.

S. No.	Characters description
1	Seed length (mm)
2	Seed breadth (mm)
	Shape
3	Oblong: Absent (0), Present (1)
4	Ovate: Absent (0), Present (1)
5	Obovate: Absent (0), Present (1)
6	Elliptic: Absent (0), Present (1)
7	Transversally elliptic-pyriform: Absent (0), Present (1)
8	Obliquely elliptic: Absent (0), Present (1)
9	Transversally obiquely elliptic: Absent (0), Present (1)
10	Reniform: Absent (0), Present (1)
11	Boardly reniform: Absent (0), Present (1)
12	Compressed reniform: Absent (0), Present (1)
13	Sub globose: Absent (0), Present (1)
14	Deltoid: Absent (0), Present (1)
15	Transversally cuneate: Absent (0), Present (1)
16	Depressed/Non depressed: Non depressed (0), Depressed (1)
17	Riged: Absent (0), Present (1)
	Apex
18	Acute: Absent (0), Present (1)
19	Obtuse: Absent (0), Present (1)
20	Rounded: Absent (0), Present (1)
21	Truncate: Absent (0), Present (1)
22	Obliquely truncate: Absent (0), Present (1)
	Base
23	Obtuse: Absent (0), Present (1)
24	Cuneate: Absent (0), Present (1)
25	Beaked: Absent (0), Present (1)
26	Reniform: Absent (0), Present (1)
27	Rounded: Absent (0), Present (1)
28	Truncate: Absent (0), Present (1)
29	Obliquely truncate: Absent (0), Present (1)
	Colour
30	Black: Absent (0), Present (1)
31	Light brown: Absent (0), Present (1)
32	Dark brown: Absent (0), Present (1)
33	Reddish brown: Absent (0), Present (1)
34	Blackish brown: Absent (0), Present (1)
35	Dusty brown: Absent (0), Present (1)
36	Golden brown: Absent (0), Present (1)
37	Greenish brown: Absent (0), Present (1)
38	Orangish brown: Absent (0), Present (1)
	Surface
39	Reticulate: Absent (0), Present (1)
40	Appressedly reticulate: Absent (0), Present (1)
41	Foveate: Absent (0), Present (1)
42	Reticulate-foveate: Absent (0), Present (1)
43	Falsifoveate: Absent (0), Present (1)
44	Favulariate: Absent (0), Present (1)
45	Rugose: Absent (0), Present (1)
46	Sulcate: Absent (0), Present (1)
47	Scalariform: Absent (0), Present (1)
48	Striate: Absent (0), Present (1)
49	Undulatly sriate: Absent (0), Present (1)
50	Lineate: Absent (0), Present (1)
51	Scrobiculate: Absent (0), Present (1)
52	Verrucate: Absent (0), Present (1)
53	Colliculate: Absent (0), Present (1)
	Indumentum
54	Seeds glabrous: Absent (0), Present (1)
55	Seeds hairy: Absent (0), Present (1)
	Type of indumentum
56	Puberulose/Pubescent: Absent (0), Present (1)
57	Pilose: Absent (0), Present (1)
58	Scabrous: Absent (0), Present (1)
59	Sericeous: Absent (0), Present (1)
60	Stellate: Absent (0), Present (1)
61	Strigose: Absent (0), Present (1)
62	Tomentose: Absent (0), Present (1)
63	Velutinous: Absent (0), Present (1)
64	Wooly: Absent (0), Present (1)
65	Glandular hairs: Absent (0), Present (1)
66	**Strophiole**: Absent (0), Present (1)
67	Strophiole glabrous: Absent (0), Present (1)
68	Strophiole hairy: Absent (0), Present (1)
	Hilum
69	Basal: Absent (0), Present (1)
70	Sub basal: Absent (0), Present (1)
71	Terminal: Absent (0), Present (1)
72	Sub terminal: Absent (0), Present (1)
73	Lateral: Absent (0), Present (1)

Table 3. Data matrix of the family Malvaceae scored for 73 characters present in table 2.

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
Subfamily Bombaeoideae																									
Bombax ceiba	7	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0
Subfamily Bythnerioideae																									
Guazuma ulmifolia	2.5	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	1
Kleinhovia hospita	3.53	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
Subfamily Dombeyoideae																									
Dombeya acutangula	2.5	1.5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
D. mastersii	3	1.4	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0
D. spectabilis	3.2	1.6	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
D. wallichii	3.8	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
Melhania denhamii	2.5	1.8	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0	0	0	0
M. futteyporensis	2.5	2	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	0
Subfamily Helicterioideae																									
Helicteris isora	1.5	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
Subfamily Malvoideae, Tribe Gossypieae																									
Gossypium arboretum	6.5	3.5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
G. herbaceum	8	4.5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
G. hirsutum	9	4.5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
G. stocksii	3.5	6	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Thespesia populnea	12	10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
Tribe Hibisceae																									
Hibiscus aristivalvis	2	2.5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
H. caesius	2.8	3.5	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
H. lobatus	1.8	2	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
H. micranthus	2	3.5	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
H. mutabilis	2.5	1.4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
H. obtusilobus	1.8	2.3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0

Table 3 (Cont'd.).

Name of Taxa	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
	Subfamily Bombaeoideae																								
Bombax ceiba	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
	Subfamily Bythnerioideae																								
Guazuma ulmifolia	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Kleinhovia hospita	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
	Subfamily Dombeyoideae																								
Dombeya acutangula	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
D. mastersii	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
D. spectabilis	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
D. wallichii	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Melhania denhamii	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
M. futteyporensis	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	Subfamily Helicterioideae																								
Helicteris isora	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	Subfamily Malvoideae, Tribe Gossypieae																								
Gossypium arboretum	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
G. herbaceum	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
G. hirsutum	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
G. stocksii	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Thespesia populnea	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	Tribe Hibisceae																								
Hibiscus aristivalvis	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
H. caesius	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
H. lobatus	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
H. micranthus	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
H. mutabilis	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
H. obtusilobus	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Table 3 (Cont'd.).

Name of Taxa	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73
Subfamily Bombaeoideae																							
Bombax ceiba	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Subfamily Bythnerioideae																							
Guazuma ulmifolia	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Kleinhovia hospita	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Subfamily Dombeyoideae																							
Dombeya acutangula	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
D. mastersii	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
D. spectabilis	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
D. wallichii	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Melhania denhamii	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
M. futteyporensis	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Subfamily Helicterioideae																							
Helicteris isora	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Subfamily Malvoideae, Tribe Gossypieae																							
Gossypium arboretum	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0	0	0	0
G. herbaceum	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0	0	0	0
G. hirsutum	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0	0	0	0
G. stocksii	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0	0	0	0
Thespesia populnea	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0	1	0	0	0	0
Tribe Hibisceae																							
Hibiscus aristivalvis	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	0	1	0	0	0	0
H. caesius	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	1	0	1	0	0	0	0
H. lobatus	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
H. micranthus	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0
H. mutabilis	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	1	1	0	1	0	0	0	0
H. obtusilobus	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0

Table 3 (Cont'd.).

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
H. sabdariffa	5	4	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
H. scindicus	2	3.5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
H. syriacus	3.5	4.5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
H. tiliaceus	3.8	5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
H. trionum	2	2.5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0
Pavonia arabica	1.5	2.2	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0
P. glechomaefolia	2	2.8	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
P. grewioides	2	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
P. procumbens	2	2.5	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
P. zeylonica	1.8	2.5	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
Senra incana	3	2.5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Urena lobata	2.5	3.3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	Tribe Malveae																								
Abutilon alii	1.5	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
A. bidentatum var. *bidentatum*	1.8	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
A. bidentatum var. *forrestii*	1.6	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
A. figarianum	1.9	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
A. fruticosum var. *fruticosum*	1.6	1.8	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
A. fruticosum var. *microphyllum*	1	1.2	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
A. fruticosum var. *saidae*	1	1.3	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
A. ghafoorianum	2	2.4	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
A. grandifolium	2	2.2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
A. hirtum var. *hirtum*	2	2	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
A. hirtum var. *heterotrichum*	1.2	1.7	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
A. indicum	2	2.5	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
A. karachianum	2	2.5	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0
A. muticum	2	2.2	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
A. pakistanicum	1.8	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

Table 3 (Cont'd.).

Name of Taxa	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
H. sabdariffa	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
H. scindicus	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
H. syriacus	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
H. tiliaceus	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
H. trionum	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0
Pavonia arabica	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
P. glechomaefolia	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
P. grewioides	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
P. procumbens	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
P. zeylonica	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Senra incana	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Urena lobata	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	Tribe Malveae																								
Abutilon alii	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
A. bidentatum var. *bidentatum*	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
A. bidentatum var. *forrestii*	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
A. figarianum	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
A. fruticosum var. *fruticosum*	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
A. fruticosum var. *microphyllum*	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
A. fruticosum var. *saidae*	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
A. ghafoorianum	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
A. grandifolium	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
A. hirtum var. *hirtum*	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
A. hirtum var. *heterotrichum*	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
A. indicum	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
A. karachianum	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
A. muticum	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
A. pakistanicum	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

Table 3 (Cont'd.).

Name of Taxa	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73
H. sabdariffa	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	0	1	0	0	0	0
H. scindicus	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0
H. syriacus	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	0	0
H. tiliaceus	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0
H. trionum	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0
Pavonia arabica	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
P. glechomaefolia	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0
P. grewioides	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
P. procumbens	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	1	0	1	0	0	0	0
P. zeylonica	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
Senra incana	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0
Urena lobata	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
	Tribe Malveae																						
Abutilon alii	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	1	1	0	0	0	0
A. bidentatum var. *bidentatum*	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
A. bidentatum var. *forrestii*	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
A. figarianum	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	1	1	0	1	0	0	0	0
A. fruticosum var. *fruticosum*	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
A. fruticosum var. *microphyllum*	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
A. fruticosum var. *saidae*	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
A. ghafoorianum	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
A. grandifolium	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
A. hirtum var. *hirtum*	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
A. hirtum var. *heterotrichum*	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
A. indicum	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0
A. karachianum	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0
A. muticum	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0
A. pakistanicum	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0

Table 3 (Cont'd.).

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
Abutilon pannosum	2	2.5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
A. sepalum	2	2.5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
A. theophrosti	2.5	3.5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
Alcea lavateraeflora	2.5	3.8	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
A. pallida	2	2.5	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
A. rosea	2.5	3.6	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Althaea connabina	2.5	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0
A. ludwigii	1.2	1.6	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Malva mauritiana	2	2	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0
M. microcarpa	1.5	1.5	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0
M. mohileviensis	1.2	1.7	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
M. neglecta	1.5	1.7	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0
M. nicaesis	2	2.3	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0
M. parviflora	1.5	1.6	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0
M. qaiseri	1.6	1.6	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0
M. sylvestris	1.6	1.6	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
M. verticillata var. *verticillata*	1.9	2.2	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
Malvastram coromedelianum	1.6	1.9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Sida cordata var. *cordata*	1.3	1.7	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0
S. cordata var. *nasirii*	1.5	1.8	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0
S. cordifolia	2	2.5	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
S. ovata	1.8	1.9	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0
S. taigii	2	2	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
S. yunnanensis	1.6	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
	Subfamily Sterculioideae																								
Firmiana pallens	8	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
Sterculia foetida	20	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
S. villosa	8	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0

Table 3 (Cont'd.).

Name of Taxa	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Abutilon pannosum	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
A. sepalum	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
A. theophrosti	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Alcea lavateraeflora	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
A. pallida	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
A. rosea	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Althaea connabina	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
A. ludwigii	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Malva mauritiana	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
M. microcarpa	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
M. mohileviensis	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0
M. neglecta	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
M. nicaesis	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
M. parviflora	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
M. qaiseri	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
M. sylvestris	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
M. verticillata var. *verticillata*	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0
Malvastram coromedelianum	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Sida cordata var. *cordata*	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
S. cordata var. *nasirii*	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
S. cordifolia	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
S. ovata	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
S. taigii	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
S. yunnanensis	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
	Subfamily Sterculioideae																								
Firmiana pallens	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Sterculia foetida	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
S. villosa	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3 (Cont'd.).

Name of Taxa	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73
Abutilon pannosum	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	1	1	0	0	0	0
A. sepalum	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0
A. theophrosti	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0
Alcea lavateraeflora	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
A. pallida	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
A. rosea	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0
Althaea connabina	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
A. ludwigii	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
Malva mauritiana	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
M. microcarpa	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
M. mohileviensis	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
M. neglecta	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
M. nicaesis	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
M. parviflora	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
M. qaiseri	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
M. sylvestris	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
M. verticillata var. *verticillata*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
Malvastram coromedelianum	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
Sida cordata var. *cordata*	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
S. cordata var. *nasirii*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
S. cordifolia	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0
S. ovata	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
S. taigii	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0
S. yunnanensis	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0
Subfamily Sterculioideae																							
Firmiana pallens	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Sterculia foetida	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
S. villosa	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

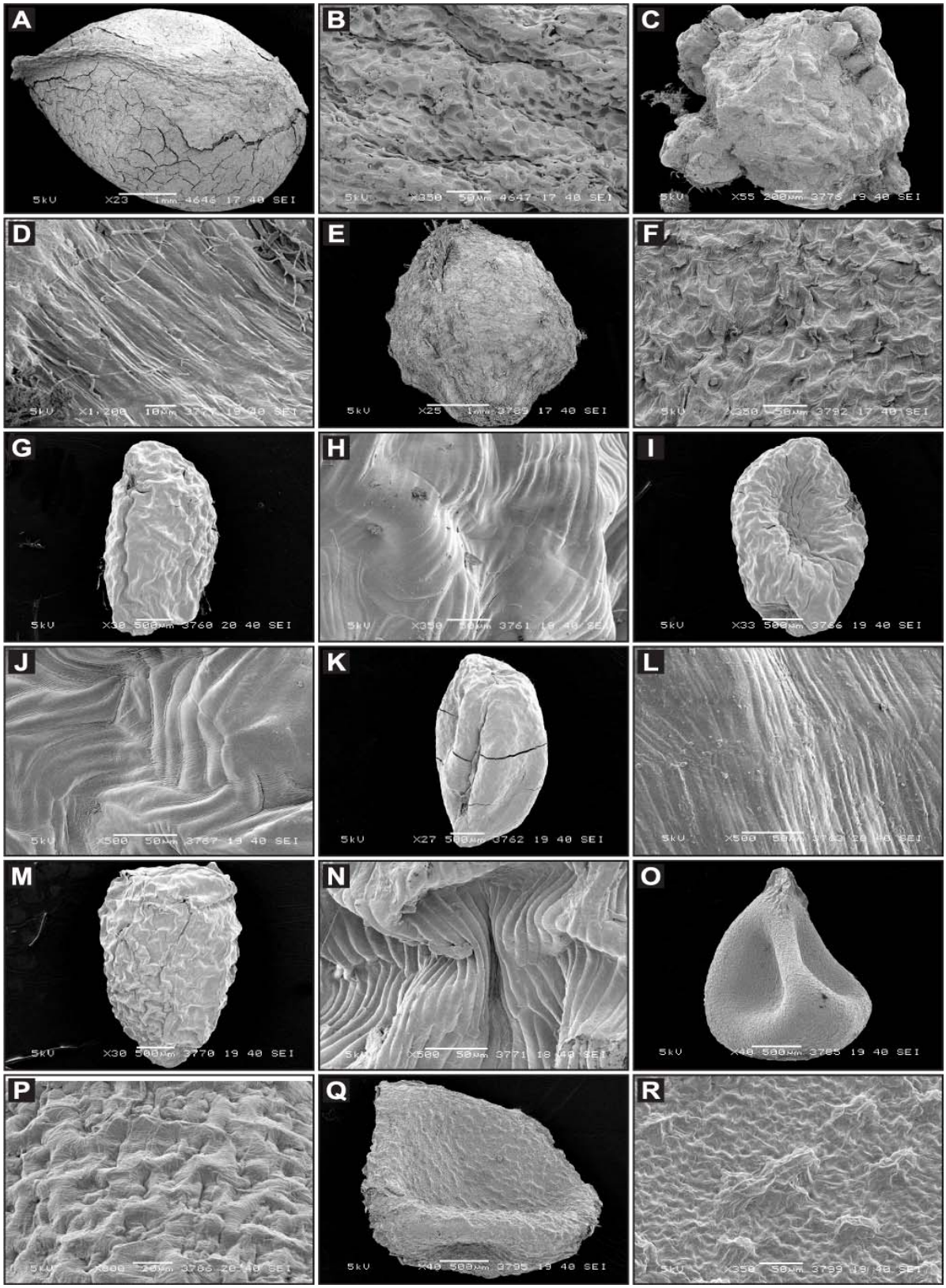

Plate 1. Scanning electron micrographs. *Bombax ceiba*: A, seed; B, surface. *Guazuma ulmifolia*: C, seed; D, surface. *Kleinhovia hosipta*: E, seed: F, surface. *Dombeya acutangula*: G, seed; H, surface. *D. mastersii*: I, seed; J, surface. *D. spectabilis*: K, seed; L, surface. *D. wallichii:* M, seed; N, surface. *Melhania denhamii*: O, seed; P, surface. *M. futteyporensis*: Q, seed; R, surface (scale bars: A, E= 1mm; G, I, K, M, O, Q= 500µm; C= 200µm; B, F, H, J, L, N, R= 50µm; D, P= 10µm).

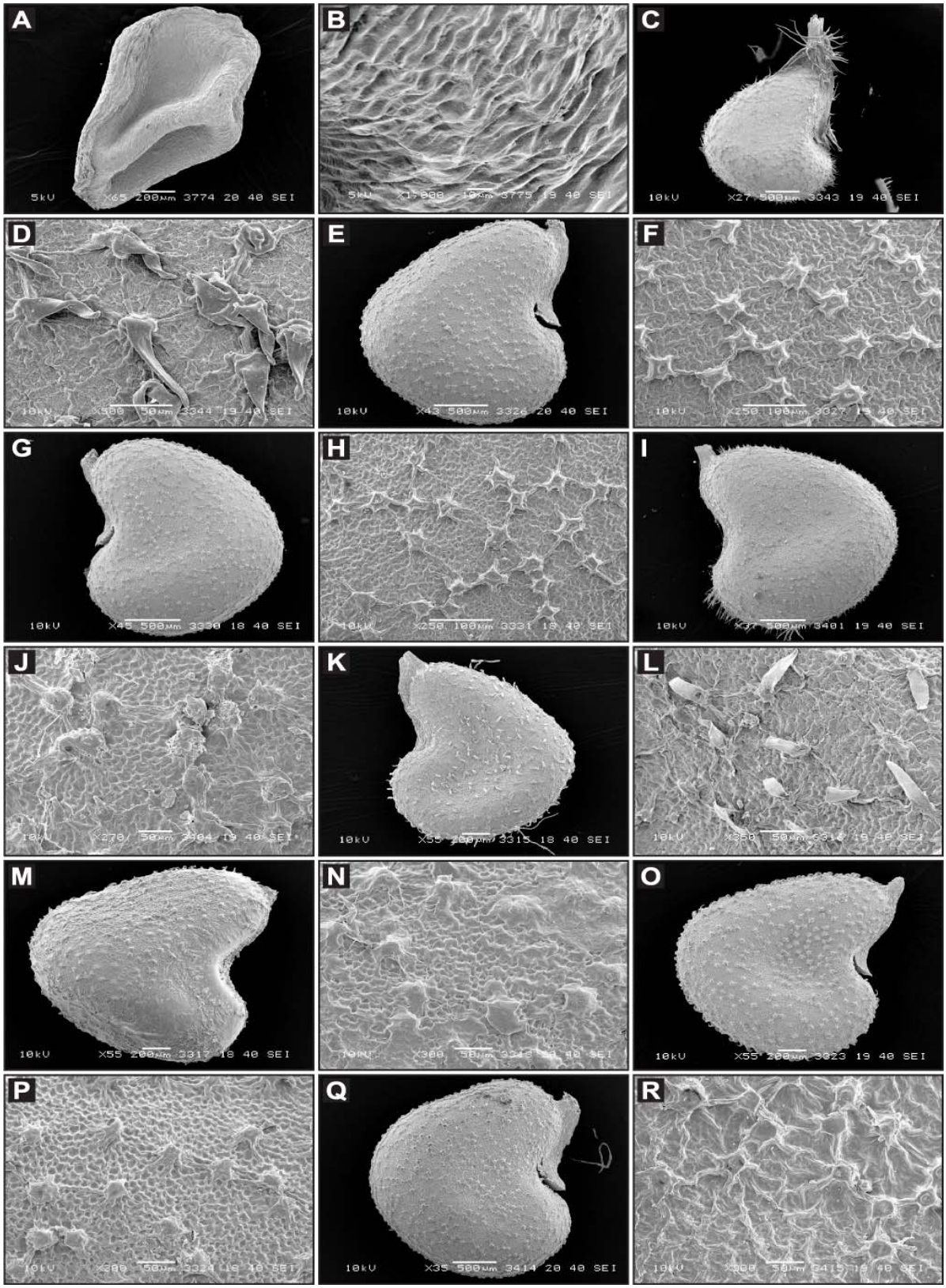

Plate 2. Scanning electron micrographs. *Helicteris isora:* A, seed; B, surface. *Abutilon alii:* C, seed; D, surface. *A. bidentatum* var. *bidentatum*: E, seed; F, surface. *A. bidentatum* var. *forrestii:* G, seed; H, surface. *A. figarianum*: I, seed; J, surface. *A. fruticosum* var. *fruticosum:* K, seed; L, surface. *A. fruticosum* var. *microphyllum*: M, seed; N, surface *A. fruticosum* var. *saidae:* O, seed; P, surface. *A. ghafoorianum*: Q, seed; R, surface (scale bars: C, E, G, I, Q= 500µm; A, K, M, O= 200µm; F, H= 100µm; D, J, L, N, P, R= 50µm; B= 10µm).

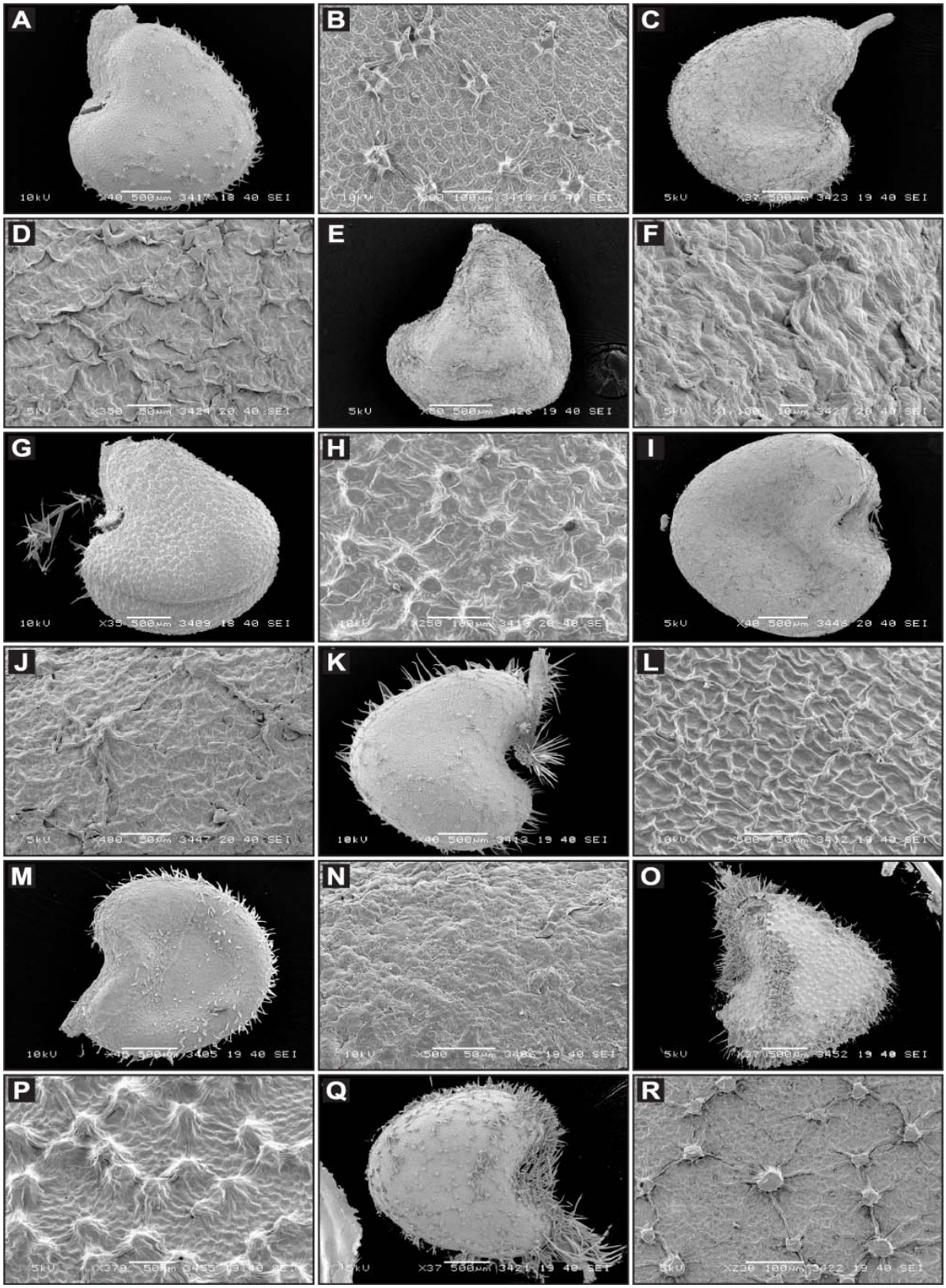

Plate 3. Scanning electron micrographs. *Abutilon grandifolium*: A, seed; B, surface. *A. hirtum* var. *hirtum*: C, seed; D, surface. *A. hirtum* var. *heterotrichum*: E, seed; F, surface. *A. indicum*: G, seed; H, surface. *A. karachianum*: I, seed; J, surface. *A. muticum*: K, seed; L, surface. *A. pakistanicum*: M, seed; N, surface. *A. pannosum*: O, seed; P, surface. *A. sepalum*: Q, seed; R, surface (scale bars: A, C, E, G, I, K, M, O, Q= 500µm; B, H, R= 100µm; D, J, L, N, P= 50µm; F= 10µm).

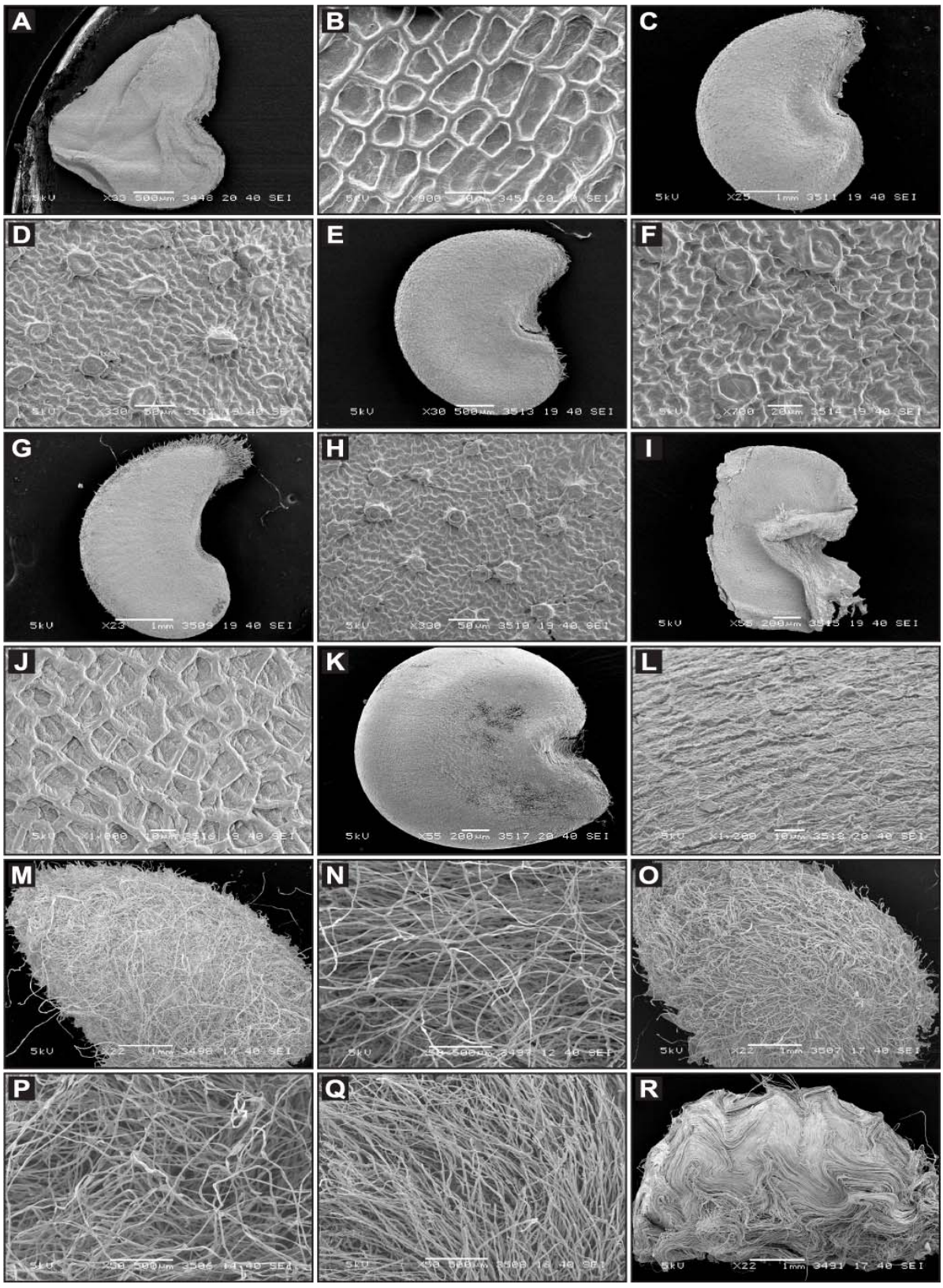

Plate 4. Scanning electron micrographs. *Abutilon theophrasti*: A, seed; B, surface. *Alcea lavateraeflora*: C, seed; D, surface. *A. pallida*: E, seed; F, surface. *A. rosea*: G, seed; H, surface. *Althaea cannabina*: I, seed; J, surface. *A. ludwigii*: K, Seed; L, surface. *Gossypium arboreum*: M, seed; N, hairs. *G. herbaceum*: O, seed; P, hairs. *G. hirsutum*: Q, hairs. *G. stocksii*: R, seed (scale bars: C, G, M, O, P= 1mm; A, E, N, P, Q= 500µm; I, K= 200µm; D, H= 50µm; B, F= 20µm; J, L= 10µm).

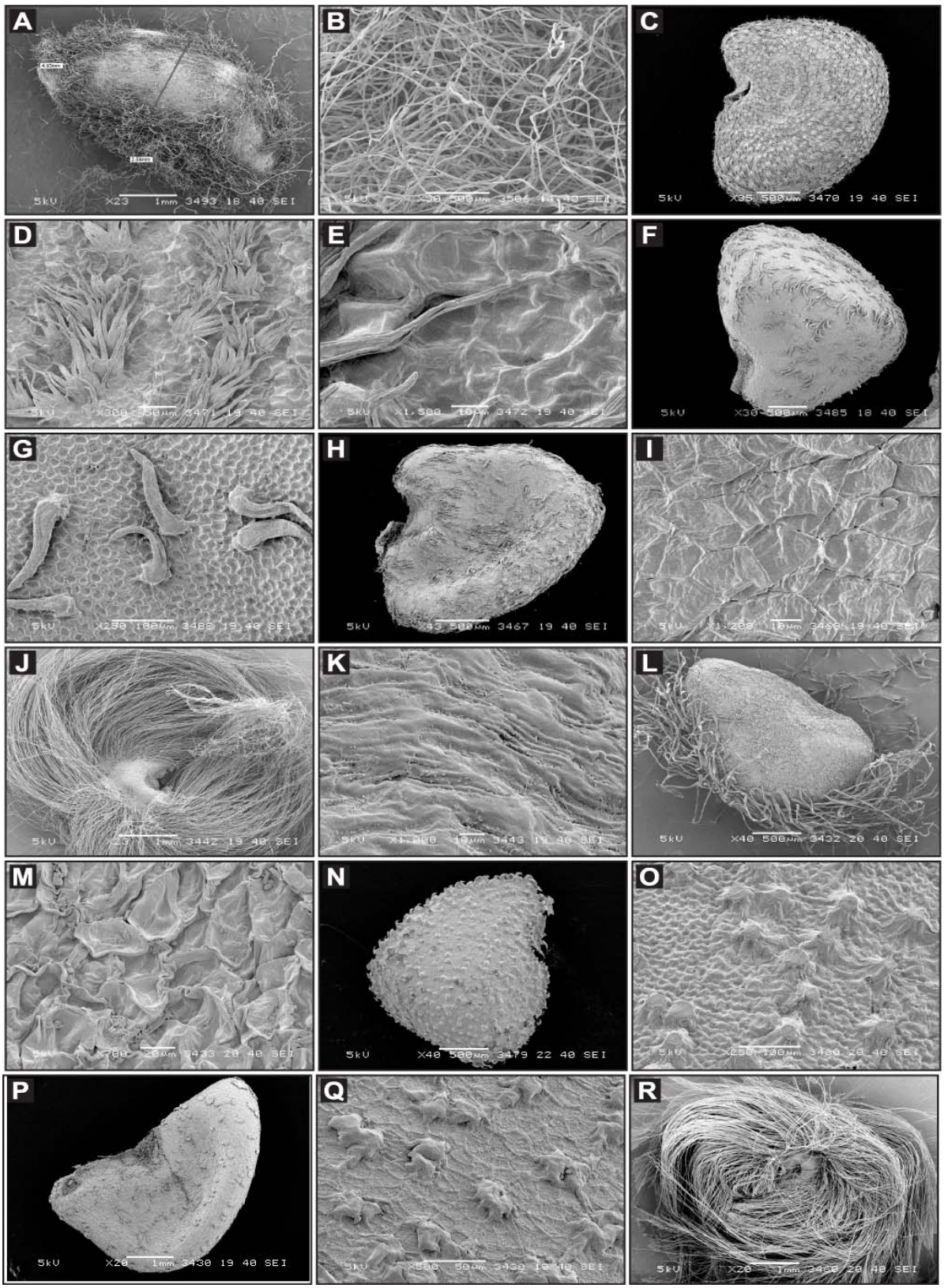

Plate 5. Scanning electron micrographs. *Gossypium stocksii*: A, seed; B, hairs. *Hibiscus aristivalvis*: C, seed; D, E, surface. *H. caesius*: F, seed; G, surface. *H. lobatus*: H, seed; I, surface. *H. micranthus*: J, seed; K, surface. *H. mutabilis*: L, seed; M, surface. *H. obtusilobus*: N, seed: O, surface. *H. sabdariffa*: P, seed; Q, surface. *H. scindicus*: R, seed (scale bars: A, J, P, R= 1mm; B, C, F, H, L, N= 500µm; G, O= 100µm; D, Q= 50µm; M= 20µm; E, I, K= 10µm).

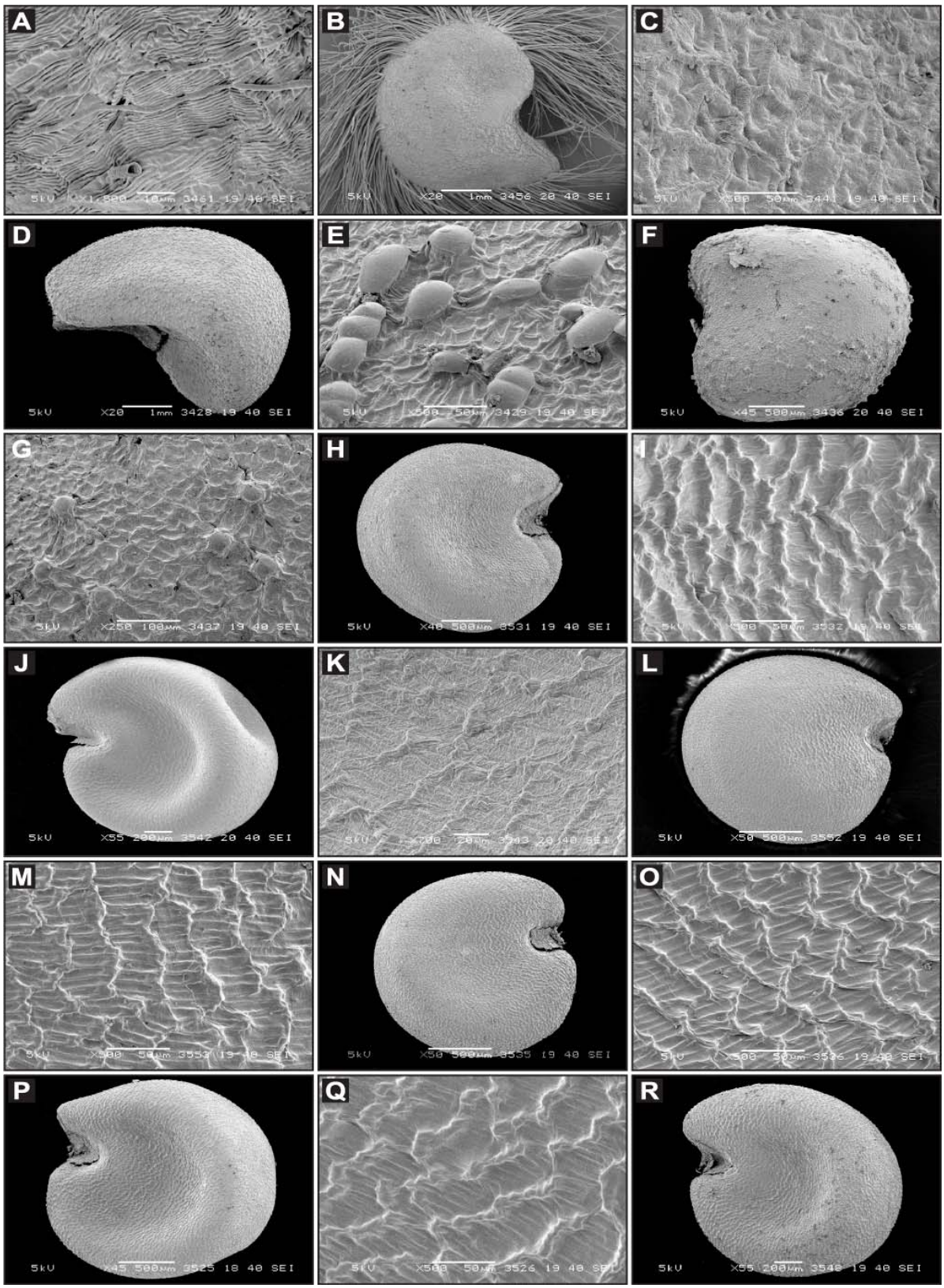

Plate 6. Scanning electron micrographs. *Hibiscus scindicus*: A, surface. *H. syriacus*: B, seed; C, surface. *H. tilliaceus*: D, seed; E, surface. *H. trionum*: F, seed; G, surface. *Malva mauritiana*: H, seed: I, surface. *M. microcarpa*: J, seed; K, surface. *M. mohileviensis*: L, seed; M, surface. *M. neglecta*: N, seed; O, surface. *Malva nicaeensis:* P, seed; Q, surface. *M. parviflora:* R, seed (scale bars: B, D= 1mm; F, H, L, N, P= 500µm; J, R= 200µm; G= 100µm; C, E, I, M, O, Q= 50µm; K= 20µm; A= 10µm).

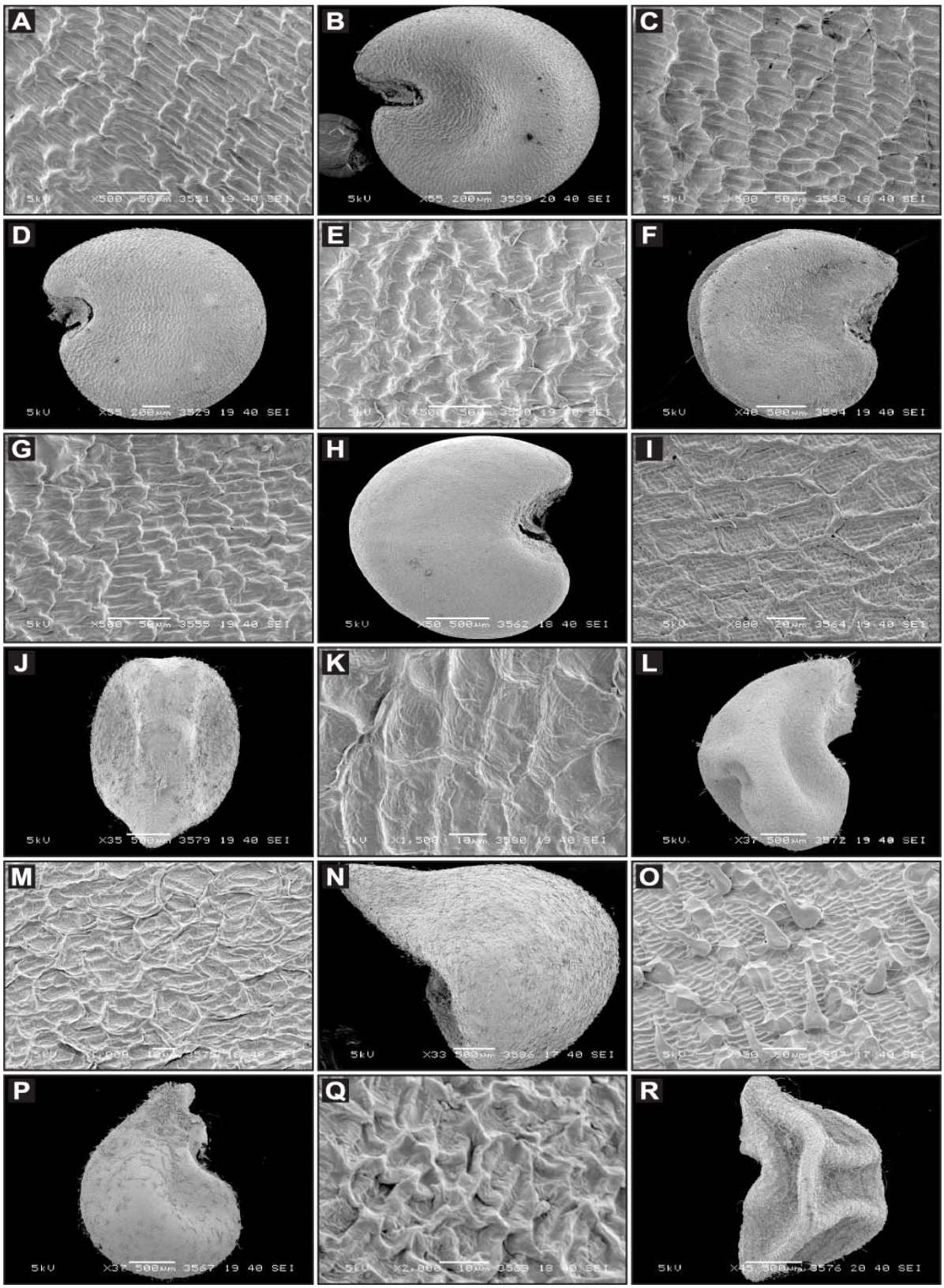

Plate 7. Scanning electron micrographs. *Malva parviflora:* A, surface. *M. qaiseri:* B, seed; C, surface. *M. sylvestris:* D, seed; E, surface. *M. verticillata* var. *verticillata:* F, seed: G, surface. *Malvastram coromendelianum*: H, seed; I, surface. *Pavonia arabica* J, seed; K, surface. *P. glechomaefolia*: L, seed; M, surface. *P. grewioides:* N, seed: O, surface. *P. procumbens:* P, seed; Q, surface. *P. zeylanica:* R, seed (scale bars: F, H, J, L, N, P, R=500µm; B, D=200µm; A, C, E, G, O= 50µm; I= 20µm; K, M, Q= 10µm).

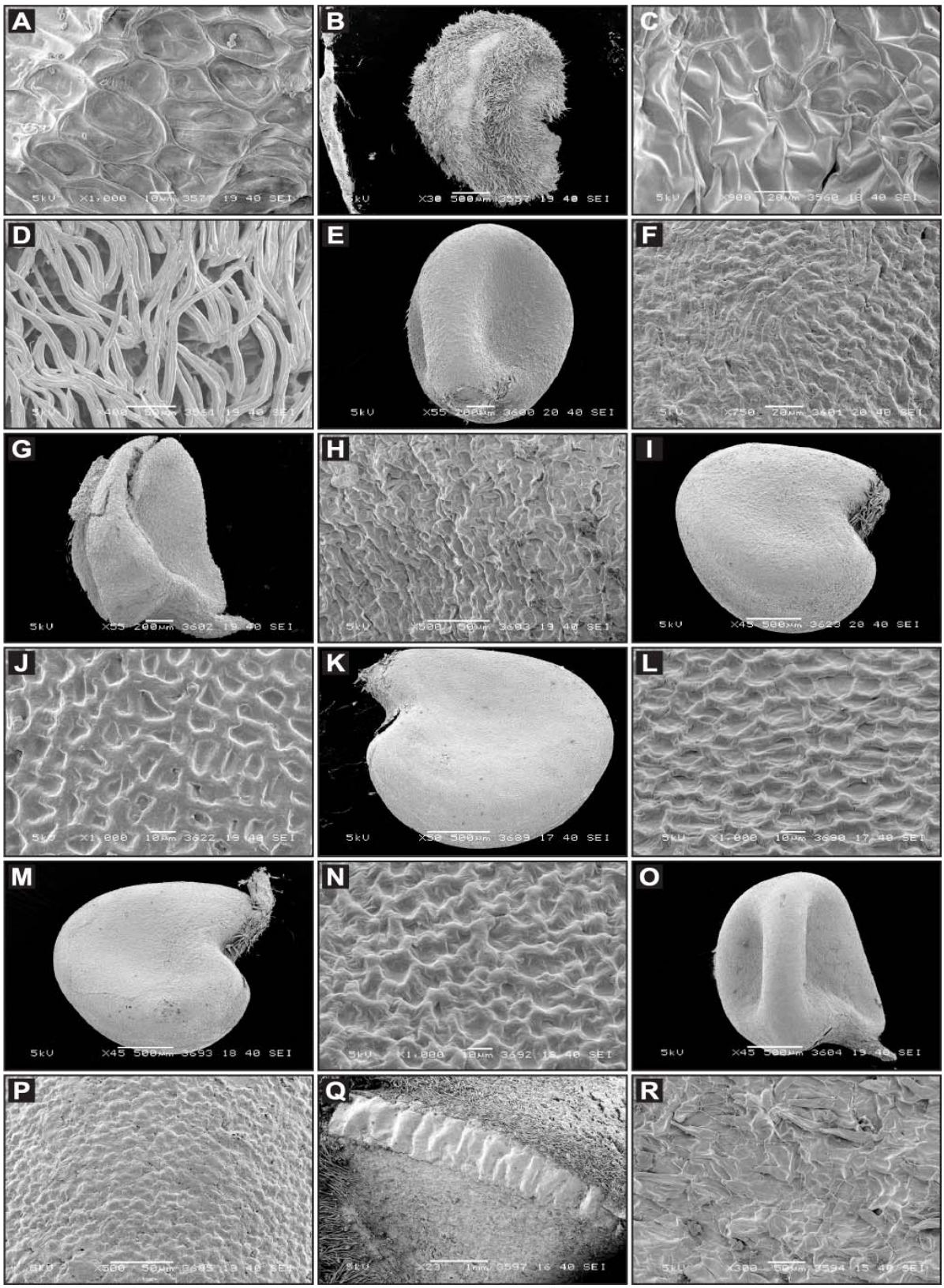

Plate 8. Scanning electron micrographs. *Pavonia zeylanica:* A, surface. *Senra incana:* B, seed; C, surface; D, hairs. *Sida cordata* var. *cordata:* E, seed; F, surface. *Sida cordata* var. *nasirii:* G, seed. *Sida cordata* var. *nasirii:* H, surface. *S. cordifolia:* I, seed; J, surface. *S. ovata:* K, seed; L, surface. *S. taigii:* M, seed; N, surface. *S. yunnanensis:* O, seed; P surface. *Thespesia populnea:* Q, seed; R, surface (scale bars: Q= 1mm; B, I, K, M, O= 500 µm; E, G= 200µm; D, H, P, R= 50 µm; C, F= 20 µm; A, J, L, N= 10 µm).

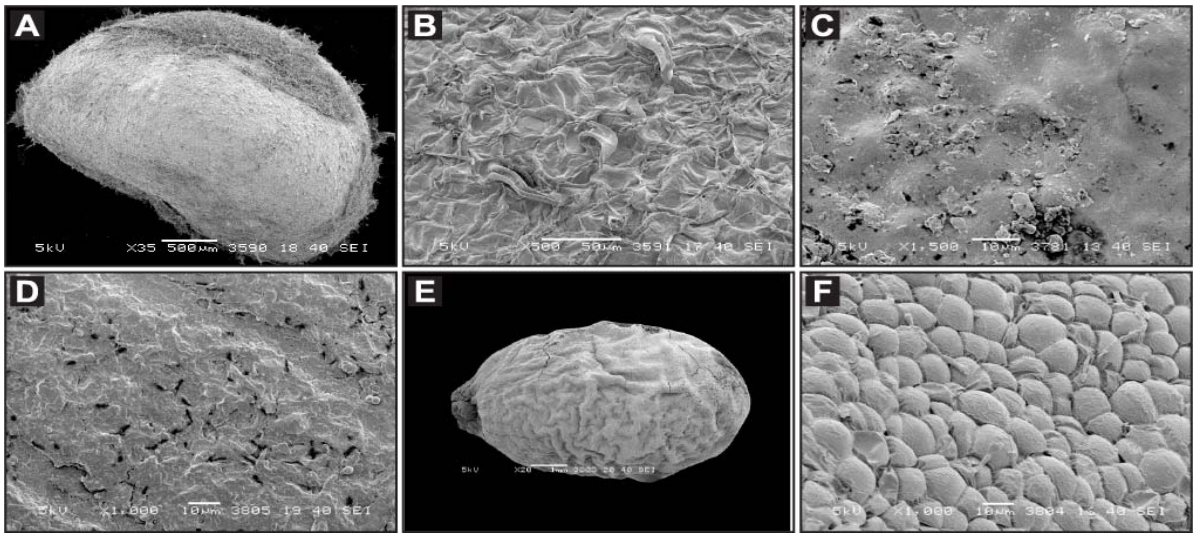

Plate 9. Scanning electron micrographs. *Urena lobata*: A, seed; B, surface. *Firmiana pallens:* C, surface. *Sterculia foetida:* D, surface. *Sterculia villosa*: E, seed; F, surface (scale bars: E= 1mm; A= 500µm; B= 50µm; C, D, F= 10µm).

Key to the subfamilies

1 + Seeds strophiolate ……..……...……..…… Malvoideae
- Seeds non strophiolate ……...……...……...……..... 2
2 + Seeds glabrous …….. 3
- Seeds pubescent ……...……...……...……...……...……. 5
3 + Seeds 1.5-3.8 mm long ……..… 4
- Seeds 8-20 mm long …… Sterculioideae
4 + Seeds deltoid, surface favulariate ……..……..…… Helicterioideae
- Seeds oblong, ovate, obovate, elliptic, obliquely elliptic, surface rugose, striate, undulately striate or foveate …… ……..……..……. Dombeyoideae
5 + Seeds 6-7 mm long, obovate, surface reticulate ……. Bombacoideae
- Seeds 2.5-3.5 mm long, sub globose, surface lineate, verrucate, rugose-scrobiculate ……... Byttnerioideae

General seeds characters of the subfamily Bombacoideae

Seed 6-7 x 4.5-5mm, obovate, ridge lateral, apex rounded, base cuneate, greenish brown-dark brown, reticulate, sparsely pubescent, non strophiolate, hilum basal, seeds embedded in soft silky wool.

Represented by only one genus *Bombax* L. with single species *Bombax ceiba* L.

General seeds characters of the subfamily Byttnerioideae

Seeds 2.5-3.5 x 2-3 mm, sub globose, apex rounded or truncate, base beaked or truncate, light brown or orange brown, surface lineate, irregularly verrucate or rugose-scrobiculate, pubescent to sparsely pubescent, non strophiolate, hilum basal.

Presently 2 tribes viz., Theobromateae and Byttnerieae are investigated.

Key to the tribes

1 + Seeds light brown, lineate irregularly verrucate ……..…… Theobromateae
- Seeds orange brown, rugose-scrobiculate ……...……...…… Byttnerieae

General seeds characters of the tribe Theobromateae

Seeds 2.5 x 2 mm, sub globose, apex rounded or truncate, base beaked, light brown, surface lineate, irregularly verrucate, pubescent, non strophiolate, hilum basal.

Represented by a monotypic genus viz., *Guazuma* Mill. with a single species viz., *Guazuma ulmifolia* Lam.

General seeds characters of the tribe Byttnerieae

Seeds 3.5 x 3 mm, sub globose, apex rounded, base truncate, orange brown, surface rugose-scrobiculate, sparsely pubescent, non strophiolate, hilum basal.

Represented by a monotypic genus viz., *Kelinhovia* L. with a species *Kelinhovia hospita* L.

General seed characters of the subfamily Dombeyoideae

Seeds 2.5-3.8 x 1.5-2 mm, oblong, elliptic, obliquely elliptic, obovate, ovate, deltoid, depressed or not, apex acute, obtuse or truncate, base cuneate, rounded, truncate or obliquely truncate, light brown, reddish brown, orange brown, surface striate, undulatly striate, rugose, foveate, verrucate, glabrous, non strophiolate, hilum terminal, sub terminal, basal or sub basal.

Represented by 2 genera viz., *Dombeya* Cay., *Melhania* Forsk.

Key to the genera

1 + Seeds oblong, elliptic or obovate, striate or undulate striate ……. *Dombeya*
- Seeds ovate or deltoid, rugose or foveate aculeate …… *Melhania*

Dombeya Cay.

Seeds 2.5-3.8 x 1.4-2 mm, oblong, elliptic, obliquely elliptic, obovate, depressed or not, apex acute, obtuse or truncate, base cuneate or obliquely truncate, light brown, reddish brown, surface striate, undulatly striate, glabrous, non strophiolate, hilum sub terminal, basal or sub basal.

Represented by 4 species viz., *Dombeya acutangula* Cay., *D. mastersii* Hook. f., *D. spectabilies* Bojer and *D. wallichii* (Lindl.) Bailey

Key to the species

1 + Seeds undulatly striate, hilum sub basal or sub terminal …… 2
- Seeds striate but not undulate, hilum basal ……..…….. *D. spectabilis*
2 + Seeds 2.5-3 mm long, reddish brown ……..……..……..……..... 3
- Seeds 3.5-3.8 mm long, light brown ……..……..……..……. *D. wallichii*
3 + Seeds oblong ……..……..…….. *D. acutangula*
- Seeds elliptic ……..……..……..…….. *D. mastersii*

Melhania Forsk.

Seeds 2.5 x 1.8-2 mm, ovate, deltoid, depressed, apex acute, base cuneate, rounded, truncate, light brown, orange brown, surface rugose, foveate, verrucate, glabrous, non strophiolate, hilum terminal.

Represented by 2 species viz., *M. denhamii* R. Br. *M. futteyporensis* Munro ex Masters.

Key to the species

1 + Seeds orange brown, rugose ……..……..……... *M. denhamii*
- Seeds light brown, foveate and verrucate ……..…..... *M. futteyporenses*

General seed characters of the subfamily Helicterioideae

Seeds1.5 x 1mm, deltoid, laterally ridge, apex truncate, base obliquely truncate, dark brown, surface favulariate, glabrous, non strophiolate, hilum lateral.

Represented by only one genus *Helicteris* L. having single species viz., *H. isora* L.

General seed characters of the subfamily Malvoideae

Seeds 1-12 x 1.2-10 mm, reniform, broad reniform, compressed reniform, transversally obliquely elliptic, transversally elliptic-pyriform, transversely cuneate or obovate, ridged, depressed or not, apex obtuse, rounded, truncate or obliquely truncate, base obtuse or reniform, light brown, dark brown, dusty brown, orange brown, reddish brown, greenish brown, golden brown, blackish brown or black, surface reticulate, reticulate-foveate, appresedly reticulate, foveate, falsifoveate, sulcate, rugose, rugosely foveate, rugosely falsifoveate, favulariate, verrucate, rugosely striate or scalariform and transversely striate, glabrous or hairy, indumentum puberulose, stellate, scabrous, strigose, pilose, sericeous, velutinous, tomentose, wooly or glandular, strophiolate, strophriole glabrous or pubescent, hilum basal.

Presently 3 tribes viz., Malveae, Gossypieae and Hibisceae are investigated.

Key to the tribes

1 + Seeds obovate or transversally elliptic-pyriform ……..……..……. 2
- Seeds reniform, broad reniform or transversally cuneate, transversally obliquely elliptic ……...…
…… Malveae (p.p. Hibisceae (*Hibiscus*, *Senra*)
2 + Seeds 3-12mm long and 3-10mm broad ……..……..... Gossypieae
- Seeds c. 1.2mm long and 2.2-3.3mm broad ……... Hibisceae (*Pavonica*, *Urena*)

Tribe Gossypieae

Seeds 3-12 x 3-10 mm, transversally elliptic-pyriform or obovate, ridged, not-depressed, apex rounded, base obtuse or reniform, light brown, dark brown, greenish brown, blackish brown or golden brown, surface rugose or falsifoveate, seeds hairy, indumentum sericeous or wooly, hairs white, creamy or golden yellow, strophiolate, strophiole glabrous or pubescent, hilum basal.

Presently 2 genera viz., *Gossypium* L. and *Thespesia* Sol. ex Corr. are investigated.

Key to the genera

1 + Seeds obovate ……... *Thespesia*
- Seeds elliptic-pyriform ……..……..……..…….. *Gossypium*

Gossypium L.

Seeds 3-9.5 x 3-6 mm, transversally elliptic-pyriform, not-depressed, apex rounded, base reniform, light brown, dark brown, greenish brown, blackish brown, surface rugose, seeds densely hairy, indumentum wooly, hairs white, creamy or golden yellow, strophiolate, strophiole pubescent, hilum basal.

Represented by 4 species viz., *Gossypium arboreum* L., *G. herbaceum* L. , *G. hirsutum* L. and *G. stocksii* Mast.

Key to the species

1 + Seeds with sub terminal hilum ……..…… 2
- Seeds with central hilum ……..……..……..…… *G. arboreum*
2 + Seeds 7-9.5 x 4-4.5mm, brown-dark brown …….. *G. herbaceum, G. hirsutum*
- Seeds 3-3.5 x 5-6mm, blackish brown ……..……...…….. *G. stocksii*

Thespesia Sol. ex Corr.

Seeds 8-12 x 7-10 mm, obovate, ridged, not-depressed, apex rounded, base obtuse, golden brown, surface falsifoveate, seeds hairy, indumentum sericeous, strophiolate, strophiole glabrous, hilum basal.

Only one species viz., *Thespesia populnea* (L). Sol. ex Corr. is investigated.

Tribe Hibisceae

Seeds 1.8-4.8 x 1.2-5 mm, reniform, broad reniform, transversally obliquely elliptic, transversally elliptic-pyriform, depressed or not, apex obtuse, rounded, truncate or obliquely truncate, base reniform, light brown, dark brown, dusty brown, reddish brown, blackish brown or black, surface reticulate, reticulate-foveate, appresedly reticulate, rugose, sulcate or verrucate, seeds glabrous or hairy, indumentum puberulose, stellate, scabrous, strigose, pilose, sericeous, velutinous, wooly or glandular, strophiolate, strophriole glabrous or pubescent, hilum basal.

Presently 4 genera viz., *Hibiscus* L., *Pavonia* Cay., *Senra* Cay and *Urena* L. are investigated.

Key to the genera

1 + Seeds elliptic-pyriform ……..……...……... 2
- Seeds reniform ……...……...…….. 3
2 + Seeds brown, dark brown or reddish brown, reticulate foveate ……. *Urena*
- Seeds dusty brown, faintly reticulate, falsifoveate, reticulate or foveate …… *Pavonia*
3 + Strophiole glabrous ……...……...……...…… *Hibiscus*
- Strophiole pubescent ……..……. *Senra*

Hibiscus L.

Seeds 1.8-4.8 x 1.2-5 mm, reniform, broad reniform, transversally obliquely elliptic, transversally elliptic-pyriform, depressed or not, apex obtuse, rounded, truncate or obliquely truncate, base reniform, light brown, dark brown, blackish brown, and black, surface reticulate, reticulate-foveate, appresedly reticulate, rugose, sulcate or verrucate, seeds glabrous or hairy, indumentum puberulose, stellate, scabrous, strigose, sericeous, velutinous, wooly or glandular, strophiolate, strophriole glabrous or pubescent, hilum basal.

Presently 11 species viz., *H. aristivalvis* Garcke , *H. caesius* Garcke, *H. lobatus* (J. A. Murray) O. Ktze, *H. micranthus* L. f., *H. mulabilis* L., *H. obtusilobus* Garcke, *H. sabdariffa* L., *H. scindicus* Stock, *H. syriacus* L., *H. tiliaceus* L. and *H. trionum* L. are investigated.

Key to the species

1 + Seed surface reticulate, appressedly reticulate or reticulate-foveate ……..…… 2
- Seed surface sulcate or rugose …… 9
2 + Seeds dark or light brown …..……...……..……. 3
- Seeds black or blackish brown ……...…… 8
3 + Seed surface appressedly reticulate or reticulate-foveate ……...…… 4
- Seed surface reticulate …… 5
4 + Seeds apically obtuse, surface appressedly reticulate, indumentum scabrouse ……... *H. lobatus*
- Seeds apically rounded-truncate, surface reticulate-foveate, indumentum stellate ……. *H. aistivalsis*
5 + Seed indumentum stellate or velutinous ……. 6
- Seed indumentum glandular ……... 7
6 + Seeds apically obliquely truncate, light brown, indumentum stellate ……. *H. sabdariffa*
- Seed apically rounded-truncate, dark brown, indumentum velutinous …….. *H. syriacus*
7 + Seeds reniform ……... *H. tiliaceus*
- Seeds broad reniform ……..……. *H. trionum*
8 + Seeds black, surface reticulate, indumentum strigose ……..…… *H. caesius*
- Seeds blackish brown, reticulate-foveate, indumentum puberulose ……. *H. obtusilobus*
9 + Seeds reniform, indumentum woolly ……..…….. 10
- Seeds transversally obliquely elliptic, indumentum sericeous …….. *H. mutabilis*
10 + Seed surface rugose ……..……...…… *H. micranthus*
- Seed surface sulcate ……..……. *H. scindicus*

Pavonia Cay.

Seeds 1.2-2 x 1.7-3 mm, transversally elliptic-pyriform, depressed or not, apex rounded, truncate, base reniform, light brown, dark brown or reddish brown, surface reticulate, reticulate-foveate or rugose, seeds hairy, indumentum puberulose or strigose, strophiolate, strophiole glabrous or pubescent, hilum basal.

Presently 5 species viz., *P. arabica* Hocht. & Steud. ex Boiss., *P. glechomaefolia* (A. Rich.) Garcke, *P. grewioides* Hochst ex Boiss., *P. procumbens* (Wall ex Wight & Arn.) Wallp., *P. zeylonica* (L.) Cay. are investigated.

Key to the species

1 + Strophiole glabrous ……..…….... 2
- Strophiole pubescent ……..…….... *P. glechomaefolia*
2 + Seeds light brown, reddish brown, surface reticulate ……..…… 3
- Seeds dark brown, surface reticulate-foveate or rugose ……...……...……... 4
3 + Seeds light brown, depressed ……...…… *P. arabica*
- Seeds reddish brown, not-depressed ……..……..……. *P. grewioides*
4 + Seed surface reticulate-foveate ……..…. *P. zeylonica*
- Seed surface rugose ……..…… *P. procumbens*

Senra Cay.

Seeds 3-3.5 x 2-2.5mm, reniform, apex rounded, base reniform, light brown, surface rugose, seeds hairy, indumentum pilose, strophiolate, strophiole pubescent, hilum basal.

Represented by only one species viz., *Senra incana* Cay.

Urena L.

Seeds 1.9-2.5 x 3-3.3mm, transversally elliptic-pyriform, apex rounded, base reniform, dusty brown, surface reticulate-foveate, seeds sparsely pubescent, indumentum puberulose, strophiolate, strophiole glabrous, hilum basal.

Represented by only one species viz., *Urena lobata* L.

Tribe Malveae

Seeds 1-2.5 x 1.2-3.8 mm, reniform, broad reniform, compressed reniform, transversally elliptic-pyriform or transversely cuneate, depressed or not, apex obtuse, truncate, obliquely truncate or rounded, base reniform, light brown, dark brown, dusty brown, orange brown, reddish brown, blackish brown and golden brown, surface reticulate, reticulate-foveate, foveate, falsifoveate, rugose, rugosely foveate, rugosely falsifoveate, favulariate, verrucate, rugosely striate or scalariform and transversely striate, seeds glabrous or hairy, indumentum puberulose, pilose, strigose, scabrous or tomentose, strophiolate, strophiole glabrous or pubescent, hilum basal.

Presently 6 genera viz., *Abutilon* Mill., *Alcea* L., *Althaea* L., *Malva* L., *Malvastrum* A. Grey and *Sida* L. are investigated.

Key to the genera

1 + Seeds glabrous ……..……. 2
- Seeds hairy …….. 5
2 + Seeds reticulate, reticulate-foveate, foveate, favulariate, rugose or verrucate ……..…..…. 3
- Seeds scalariform and striate ……..……...……...……. *Malva*
3 + Seeds broad reniform ……..……..……..... 4
- Seeds transversely cuneate or reniform ……..…..……..… *Sida*
4 + Seed surface favulariate or reticulate with verrucate ……..... *Althaea*
- Seeds surface reticulate with reticulate foveate ……..…..……..… *Malvastrum*
5 + Seeds dusty brown ……..……..……..…… *Alcea*
- Seeds light brown, dark brown, reddish brown, golden brown, blackish brown or black …….. *Abutilon*

Abutilon Mill.

Seeds 1`-2.5 x 1.2-3.5mm, reniform, broad reniform, compressed reniform, depressed or not, apex obtuse or rounded, base reniform, light brown, dark brown, reddish brown, blackish brown and golden brown, surface reticulate, reticulate-foveate, foveate, falsifoveate, rugose, rugosely foveate, rugosely falsifoveate or verrucate, seeds glabrous or hairy, indumentum puberulose, pilose, strigose, scabrous or tomentose, strophiolate, strophiole glabrous or pubescent, hilum basal.

Presently 14 species viz., *Abutilon alii* S. Abedin, *A. bidentatum* A. Rich., *A. figarianum* Webb., *A. fruticosum* Guill & perr., *A. ghafoorianum* S. Abedin, *A. grandifolium* (Willd.) Sweet, *A. hirtum* (Lamk.) Sweet, *A. indicum* (L.) Sweet, *A. karachianum* Hus. & Baq., *A. muticum* (Del. ex DC.) Sweet, *A. pakistanicum* Jafri and Ali, *A. pannosum* (Forst. f.) schl., *A. sepalum* Hus. & Baq. *A. theophrasti* Medic. are investigated.

Key to the species

1 + Strophiole glabrous ……. 2
- Strophiole hairy ……. 8
2 + Seed surface rugose, falsifoveate or reticulate ……. 3
- Seed surface foveate, reticulate-foveate or rugosely foveate ……. 6
3 + Seeds reddish brown or blackish brown ……. 4
- Seeds light or dark brown ……. 5
4 + Seed indumentum puberulose ……. *A. hirtum*
- Seed indumentum scabrous ……. *A. pakistanicum*
5 + Seeds pubescent ……. *A. grandifolium*
- Seeds glabrous ……. *A. ghafoorianum*
6 + Seeds hairy ……. 7
- Seeds glabrous ……. *A. bidentatum*
7 + Seeds blackish brown, indumentum strigose ……. *A. figarianum*
- Seeds brown or reddish brown, indumentum scabrous or puberulose ……. *A. fruticosum*
8 + Seeds glabrous ……. *A. theophrasti*
- Seeds hairy ……. 9
9 + Seeds dark brown, blackish brown and golden brown ……. 10
- Seeds black ……. *A. alii*
10 + Seed surface reticulate-foveate ……. 11
- Seed surface rugose or foveate ……. 13
11 + Seeds indumentum pilose ……. 12
- Seeds indumentum tomentose ……. *A. pannosum*
12 + Seeds depressed ……. *A. muticum*
- Seeds not-depressed ……. *A. sepalum*
13 + Seeds reniform, dark brown, surface rugose ……. *A. indicum*
- Seeds broad reniform, golden brown and blackish brown, surface foveate ……. *A. karachianum*

A. bidentatum A. Rich.

Seeds 1.6-1.8 x 2 mm, reniform, not-depressed, apex rounded, base reniform, dark brown or reddish brown, surface rugose, foveate or verrucate, seeds glabrous, strophiolate, strophiole glabrous, hilum basal.

Presently 2 varieties viz., *A. bidentatum* A. Rich var. *bidentatum* and *A. bidentatum* var. *forrestii* (Hu) S. Abedin are investigated.

Key to the varieties

1 + Seeds dark brown ……. *A. bidentatum* var. *bidentatum*
- Seeds reddish brown ……. *A. bidentatum* var. *forrestii*

A. fruticosum Guill. & perr.

Seeds 1-1.6 x 1.2-1.8 mm, reniform, depressed, apex obtuse or rounded, base reniform, light brown, dark brown or reddish brown, surface reticulate-foveate, foveate, rugosely foveate or verrucate, seeds hairy, indumentum puberulose or scabrous strophiolate, strophiole glabrous, hilum basal.

Presently 3 varieties viz., *A. fruticosum* Guill & perr. var. *fruticosum*, *A. fruticosum* Guill & perr. var. *microphyllum* (A. Rich.) S. Abedin and *A. fruticosum* Guill & perr. var. *saidae* S. Abedin are investigated.

Key to the varieties

1 + Seeds centrally depressed, puberulose ……. 2
- Seeds dorsally depressed, scabrous ……. *A. fruticosum* var. *fruticosum*
2 + Seeds foveate ……. *A. fruticosum* var. *microphyllm*
- Seeds reticulate-foveate ……. *A. fruticosum* var. *saidae*

A. hirtum (Lamk.) Sweet.

Seeds 1.2-2 x 1.7-3 mm, reniform, depressed, apex obtuse or rounded, base reniform, reddish brown or blackish brown, surface rugose or rugosely falsifoveate, seeds hairy, indumentum puberulose, strophiolate, strophiole glabrous, hilum basal.

Presently 2 varieties viz., *A. hirtum* (Lamk.) Sweet var. *hirtum* and *A. hirtum* (Lamk.) Sweet var. *heterotrichum* (Mat.) Cuf. are investigated.

Key to the varieties

1 + Seeds blackish brown, centrally depressed ……..…….. *A. hirtum* var. *hirtum*
- Seeds reddish brown, dorsally depressed ……..……..……... *A. hirtum* var. *heterotrichum*

Alcea L.

Seeds 2-2.5 x 2.5-3.8mm, reniform-transversally elliptic-pyriform, depressed or not-depressed, apex rounded, base reniform, dusty brown or reddish brown, surface reticulate-foveate and verrucate, seeds hairy, indumentum puberulose or tomentose. strophiolate, strophiole glabrous, hilum basal.

Represented by 3 species viz., *A. lavateraeflora* (DC.) Boiss., *A. pallida* (W.& K.) Bess. and *A. rosea* L.

Key to the species

1 + Seeds dusty brown, puberulose ……..……..... 2
- Seeds reddish brown, tomentose ……..……..……..……..……... *A. rosea*
2 + Seeds 3.8 mm broad ……..……..……..……... *A. lavateraeflora*
- Seeds 2.5 mm broad ……..……..……..……..…. *A. pallida*

Althaea L.

Seeds 1.2-2.5 x 1.6-3mm, broad reniform, not-depressed, apex rounded-truncate, base reniform, light brown or dark brown, surface reticulate, verrucate or favulariate, seed glabrous, strophiolate, strophiole glabrous, hilum basal.

Presently 2 species viz., *A. cannabina* L., *A. ludwigii* L. are investigated.

Key to the species

1 + Seeds 2.5 mm long, dark brown, surface reticulate ……..... *A. cannabina*
- Seeds 1.2 mm long, light brown, surface favulariate ……..…… *A. ludwigii*

Malva L.

Seeds 1.2-2 x 1.2-2.3 mm, reniform or broad reniform, depressed or not, apex rounded, base reniform, light brown, dark brown, reddish brown, orange brown or dusty brown, surface scalariform and transversely striate, seeds glabrous, shophiolate, strophiole glabrous, hilum basal.

Presently 9 species viz., *M. mauritiana* L., *M. microcarpa* Pers., *M. mohileviensis* Downar, *M. neglecta* Wallr., *M. nicaeensis* All., *M. parviflora* L., *M. qaiseri* S. Abedin, *M. sylvestris* L. and *M. verticillata* L. are investigated.

Key to the species

1 + Seeds broad reniform …….. 2
- Seeds reniform ……..…… *M. verticillata*
2 + Seeds light brown, dark brown or dusty brown …….. 3
- Seeds orange brown or reddish brown ……... 7
3 + Seed surface faintly scalariform …… 4
- Seed surface scalariform …… 6
4 + Seeds depressed …….. 5
- Seeds not-depressed ……..……..…… *M. sylvestris*
5 + Seeds light brown ……..…… *M. nicaensis*
- Seeds dark brown ……... *M. mauritiana*
6 + Seeds dusty brown, surface densely striate ……..……..……. *M. parviflora*
- Seeds dark brown, surface striate ……..… *M. qaiseri*
7 + Seed surface densely striate …… 8
- Seed surface sparsely striate ……..…… *M. microcarpa*
8 + Seeds orange brown ……..……..……. *M. mohileviensis*
- Seeds reddish brown ….…… *M. neglecta*

Malvastrum A. Grey

Seeds 1.3 x 1.7-1.9 mm, broad reniform, not-depressed, apex rounded, base reniform, dark brown, surface reticulate, with in reticulation reticulate-foveate, glabrous, strophiolate, strophiole glabrous, hilum basal.

Represented by only one species viz., *M. coromendelianum* (L.) Garcke

Sida L.

Seeds 1-2 x 1.5-2.5 mm, reniform, broad reniform or transversely cuneate, apex rounded or obliquely truncate, base reniform, depressed or not, light brown, dark brown, dusty brown or blackish brown, surface reticulate, reticulate-foveate, foveate, rugose, rugosely striate or verrucate, glabrous, strophiloate, strophiole glabrous or hairy, hilum basal.

Presently 6 taxa viz., *S. cordata* (Burm.f.) Borss., *S. cordifolia* L., *S. ovata* Forssk, *S. taigii* Bhandari, *S. yunnanensis* Hu are investigated.

Key to the species

1 + Strophiole pubescent ……..……..……..……..…… 2
- Strophiole glabrous ……..……..……..……..……... 3
2 + Seeds dusty brown, surface reticulate …..…..…..……. *S. cordifolia*
- Seeds blackish brown, surface reticulate-foveate ……..……..……..…..... *S. taigii*
3 + Seeds reniform ……..……..……..…….. *S. ovata*
- Seeds transversely cuneate ……..... 4
4 + Seeds surface rugose or rugosely striate ……..……..… *S. cordata*
- Seed surface foveate and verrucate ……..……..……..…. *S. yunnanensis*

S. cordata (Burm. f.) Borss.

Seeds 1-1.5 x 1.5-1.8 mm, transversely cuneate, apex rounded, base rounded or reniform, depressed, light brown or dark brown, surface rugose, rugosely striate or verrucate, glabrous, strophiloate, strophiole glabrous, hilum basal.

Represented by 2 varieties viz., *S. cordata* (Burm. f.) Borss. var. *cordata* and *S. cordata* (Burm. f.) Borss. var. *nasirii* S. Abedin.

General seed characters of the subfamily Sterculoideae

Seeds 8-20 x 4.5-10 mm, oblong, apex rounded, base obtuse, light brown or black, surface colliculate, falsifoveate, rugosely falsifoveate, glabrous, non strophiolate, hilum basal or sub basal.

Represented by 2 genera viz., *Firmiana* Marsigli and *Sterculia* L.

Key to the genera

1 + Seeds with sub basal hilum ……..……..……..……..…… *Firmiana*
- Seeds with basal hilum ……..……..……..……..… *Sterculia*

Firmiana Marsigli

Seeds 8 x 6 mm, oblong, apex rounded, base obtuse, light brown, surface falsifoveate, glabrous, non strophiolate, hilum sub basal.

Presently only one species.viz., *F. pallens* (Wall.ex King) Stearn is investigated.

Sterculia L.

Seeds 8-20 x 4.5-10 mm, oblong, apex rounded, base obtuse, light brown or black, surface colliculate or rugosely falsifoveate, glabrous, non strophiolate, hilum basal.

Represented by 2 species viz., *S. foetida* L., *S. villosa* Rox.

Key to the species

1 + Seeds 20 mm long, light brown, surface rugosely falsifoveate ……. *S. foetida*
- Seeds 8 mm long, black, surface colliculate ……..…… *S. villosa*

Discussion

Seeds of the angiosperms possess great variation in their features and due to their reliable constancy these characters could be significantly used for taxonomic delimitation at various levels (McClure, 1957; Corner, 1976; Stace, 1980; Otto, 2002; Ather *et al.*, 2013; Kanwal *et al.*, 2016). The micro-morphological characters of seeds within the family Malvaceae are quite stable and significant and have been proved very helpful in delimiting the taxa within the family Malvaceae. Moreover, Judd & Manchester (1997) highlighted the diversified nature of the family Malvaceae, as the family Malvaceae shares both the advanced and primitive traits side by side. Similarly seed morphological characters also pointed out the primitiveness or advancement in their features such as, the studied taxa are characterized by smaller as well as larger seeds (Figs. 2, 3). These finding may also be well supported by the previous finding of Eames (1961) where he indicated that smaller seeds predict the herbaceous nature while larger seeds are associated with primitive shrub or tree habit. Besides this, glabrous and hairy seeds are simultaneously present (Fig. 7) while, hairy seeds are regarded to be more advanced than glabrous seeds (Corner, 1976). Similarly seed colour is another good reliable constant character and may be effectively used as a diagnostic character for the various taxa (Duke, 1969; Ahmed & Qaiser, 1989). Presently a variety in brown shade is frequently found in most of the seeds (Fig. 5). While, seed surface pattern could also play an effective diagnostic role to delimit the various taxa (Jones & Safa, 1982; Kanwal *et al*., 2012). Presently considerable variation in the seed surface patterns has been observed (Fig. 6). The dendrogram of the family Malvaceae (Fig. 1) clearly reveals the two broad groups. The first group comprises 11 genera viz., *Althaea*; *Bombax, Dombeya, Firmiana, Guazuma, Helicteris, Kleinhovia, Malva, Malvastram, Melhania* and *Sterculia*, by having usually glabrous seeds. The second group having 6 genera viz., *Alcea, Gossypium, Pavonia, Senra, Thespesia, Urena* and characterized by a variety of indumentum i.e. puberulose, scabrous, stellate, strigose, tomentose, woolly, pilose or serious.

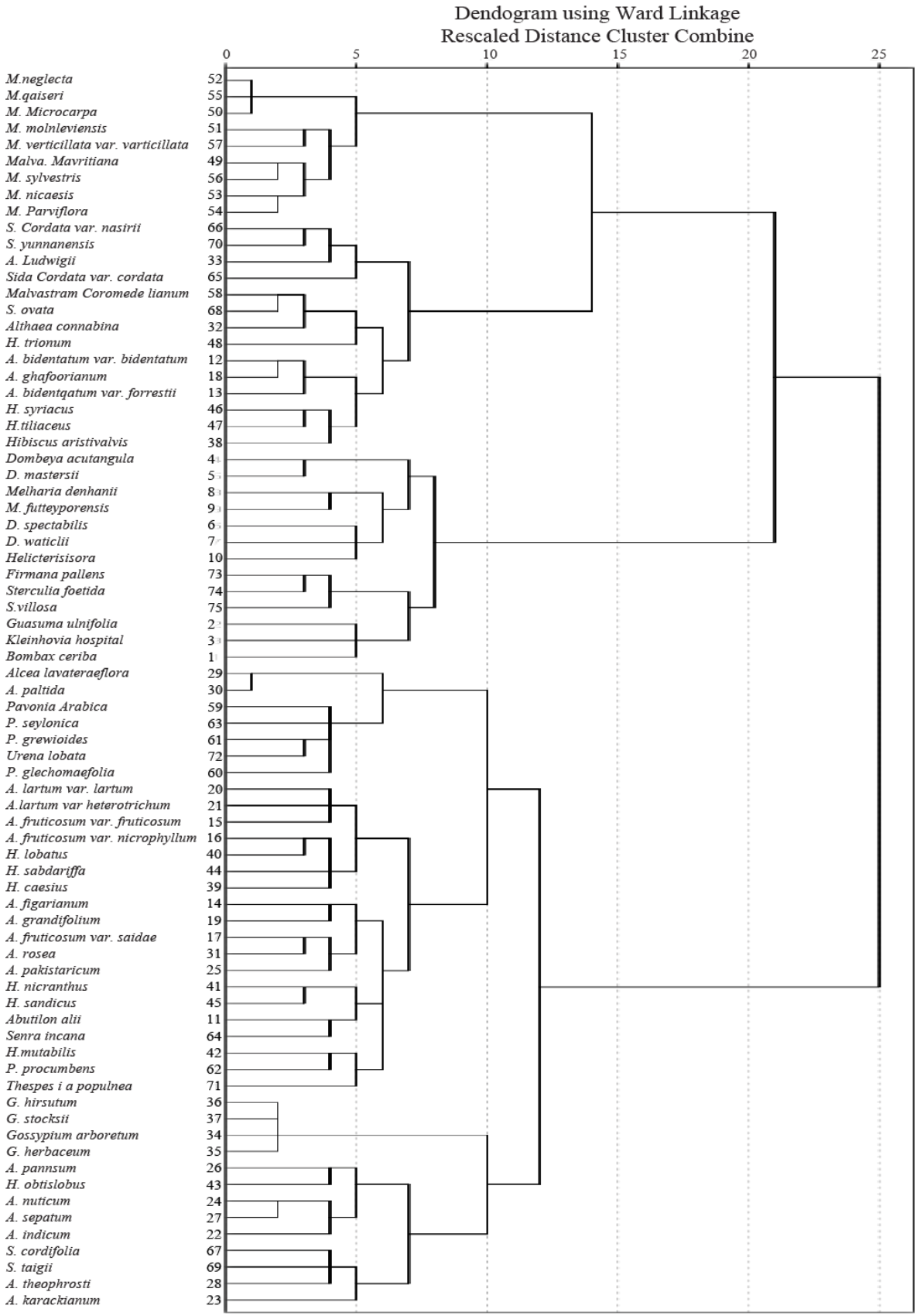

Fig. 1. Dendrogram showing the relationship of the taxa within the family Malvaceae.

While, the taxa of the genera *Abutilon, Hibiscus* and *Sida* occupy intermediate position between both the groups and these affinities may be due to the overlapping in the degree of pubescence. The first group could remain distinct into two subgroups on the basis of seed shape and presence or absence of strophiole i.e., *Abutilon, Althaea, Hibiscus, Malva, Malvastram,* and *Sida* fall in first subgroup by having reniform, boardly reniform, transversally cuneate seeds with strophiole and the remaining genera of the second subgroup viz. *Bombax, Dombeya, Firmiana, Guazuma, Helicteris, Kleinhovia, Melhania* and *Sterculia,* are characterized by having oblong, elliptic, obliquely elliptic, obovate, ovate, deltoid or sub globose seeds without strophiole. Within the first subgroup all the species of the genus *Malva* fall together with in the same cluster due to seeds with similar surface pattern i.e. scalariform with striate while the remaining genera of the first subgroup i.e., *Malvastram , Althaea, Abutilon, Hibiscus* and *Sida* fall in another cluster due to presence of seeds with rugose, foveate, verrucate, favulariate, rugosely striate, reticulate, reticulate-foveate surface pattern and remain distinct with different combination size, shape and surface patterns. Furthermore, within the second subgroup the species of the genera *Dombeya, Melhania, Helicteris* do not show close affinity with rest of the genera due to the presence of usually smaller seeds with acute, obtuse or truncate apex. Amongst them *Dombeya acutangula, D. mastersii, Melhania denhamii* and *M. futteyporensis* are grouped together by having terminal or sub terminal hilum. While, *D. spectabilis, D. wallichii* and *Helicteris isora* fall in common cluster due to the presence of basal, sub-basal or lateral hilum and all these species remain distinct from each other on the basis of different seed shapes and surface patterns. The remaining genera of the second subgroup having comparatively large seeds with rounded apex viz., *Firmiana, Sterculia, Guazuma, Kleinhovia, Bombax* further splitted into two clusters. Within the first cluster *Firmiana pallens, Sterculia foetida* and *S. villosa* occupy the same cluster due to the presence of oblong glabrous seeds. While the taxa of the second cluster *Guazuma ulmifolia, Kleinhovia hospita* and *Bombax ceiba* have sub globose or obovate pubescent seeds. Similar to the first group the genera of the second group can also be clearly separated in to 2 subgroups due to the presence of usually glabrous and pubescent strophiole respectively. Amongst the taxa of first subgroup A*lcea lavateraeflora, A. pallida, Pavonia arabica, P. zeylonica, P. grewioides, Urena lobata, P. glechomaefolia* show close affinity due to the presence of reniform-transversally elliptic-pyriform seeds. While, *A. hirtum, A. fruticosum, H. lobatus, H. sabdariffa, H. caesius, A. figarianum, A. grandifolium, A. rosea, A. pakistanicum, H. micranthus, H. scindicus, Abutilon alii, Senra incana, H. mutabilis, P. procumbens, Thespesia populnea* fall in another cluster by having reniform, transversally elliptic-pyriform, transversally obliquely elliptic, obovate or coma shape seeds. Similarly, within the second subgroup the species of *Gossypium* viz., *Gossypium hirsutum, G. stocksii, Gossypium arboretum, G. herbaceum* occupy a separate position due to the prescence of transversally elliptic-pyriform seeds. While, the remaining species viz., *Abutilon indicum, A. karachianum, A. muticum, A. pannosum, A. sepalum, A. theophrasti, Hibiscus obtusilobus, Sida cordifolia* and *S. taigii* are characterised by reniform, compressed reniform, broadly reniform or cuneate seeds.

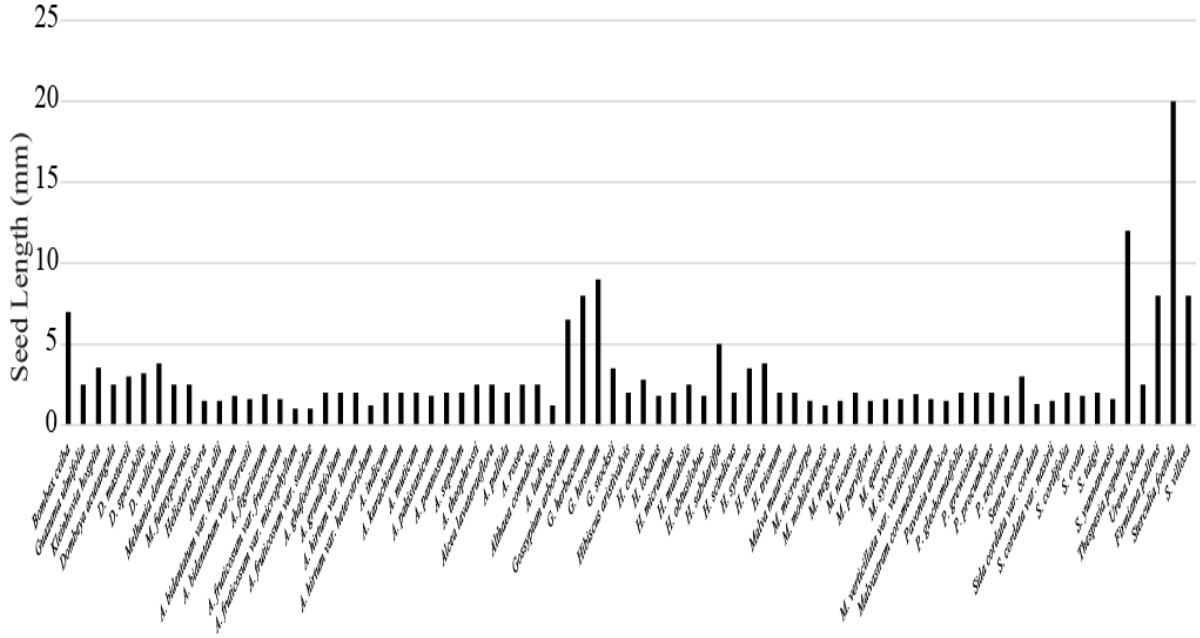

Fig. 2. Bar diagram showing the variation in average seed length (mm) within different taxa of the family Malvaceae.

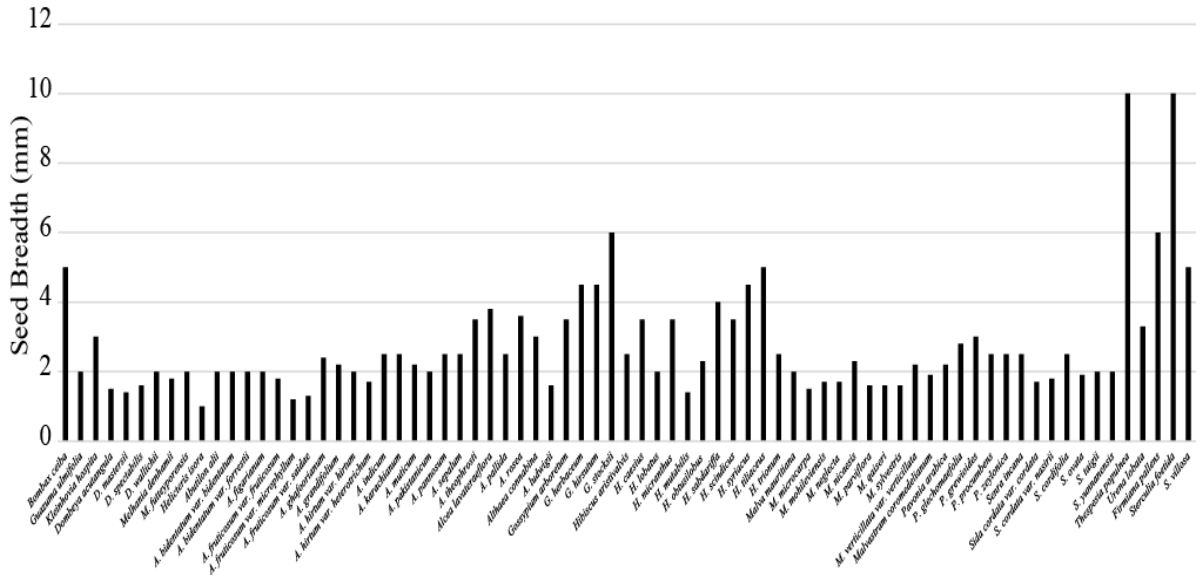

Fig. 3. Bar diagram showing the variation in average seed breadth (mm) within different taxa of the family Malvaceae.

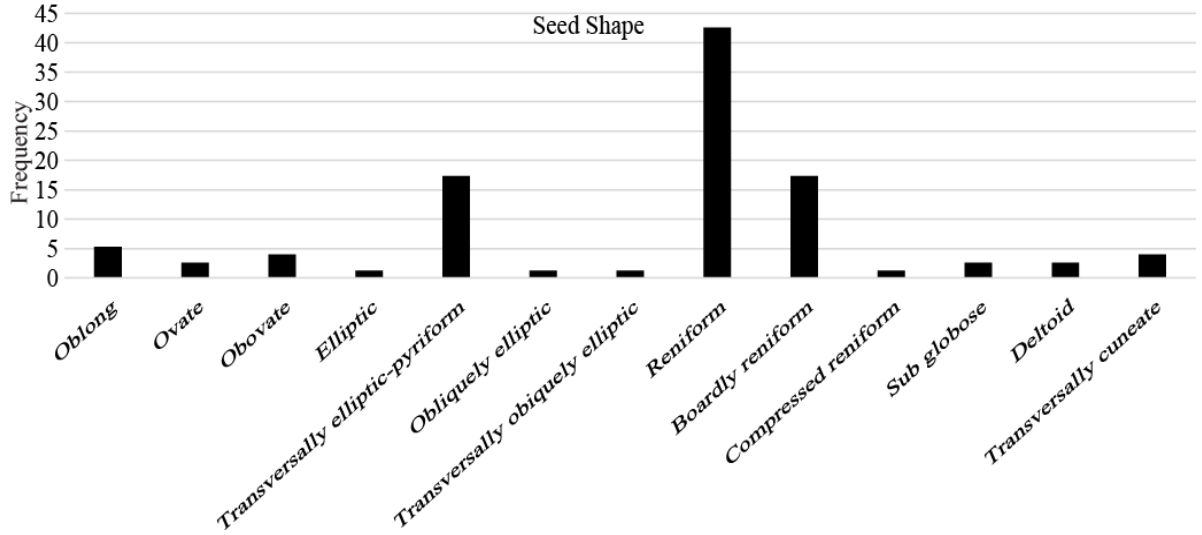

Fig. 4. Bar diagram showing the variation in seed shape within the family Malvaceae.

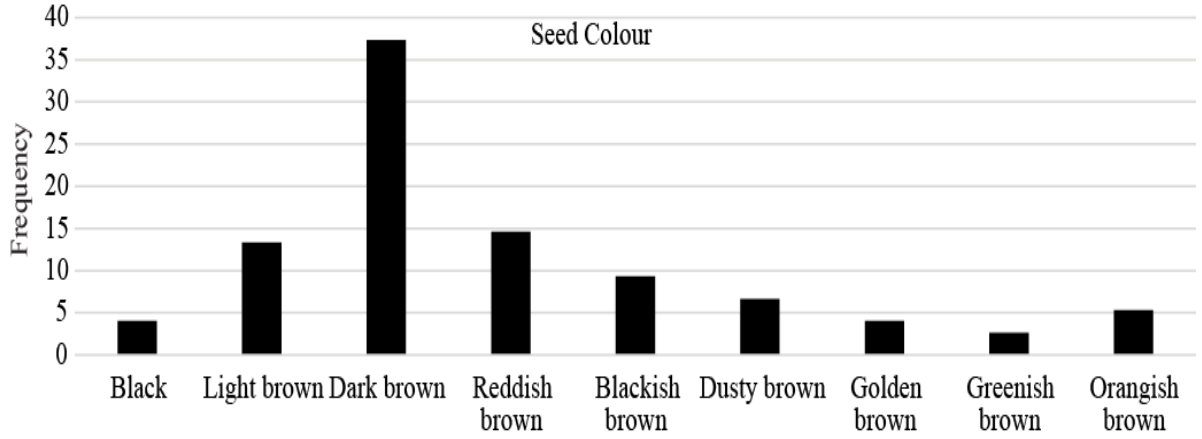

Fig. 5. Bar diagram showing the variation in seed colour within the family Malvaceae.

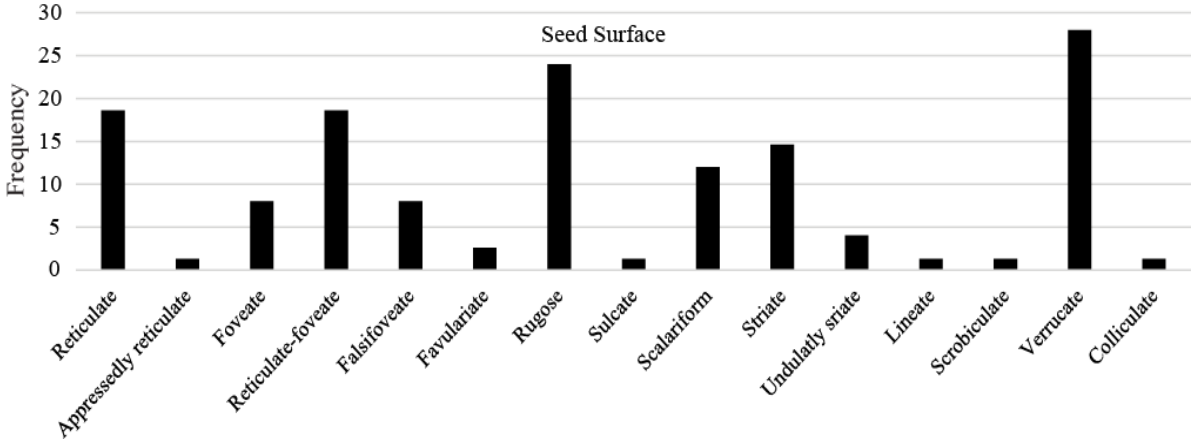

Fig. 6. Bar diagram showing the variation in seed surface within the family Malvaceae.

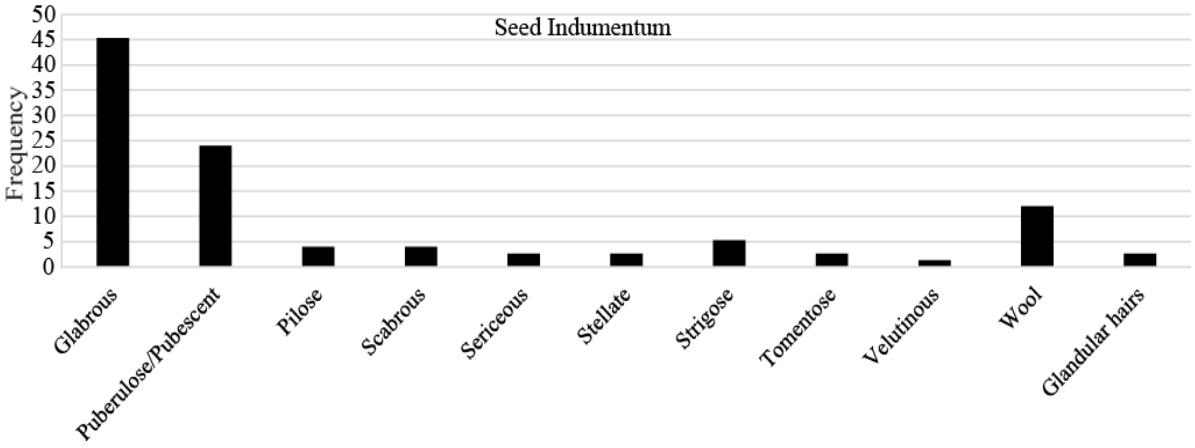

Fig. 7. Bar diagram showing the variation in seed indumentum within the family Malvaceae.

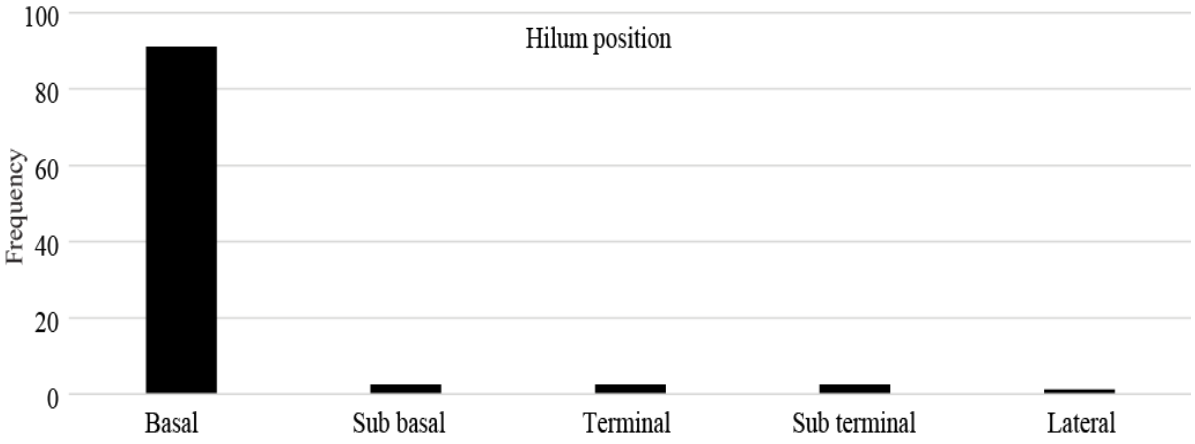

Fig. 8. Bar diagram showing the variation in hilum position within the family Malvaceae.

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