MICROMORPHOLOGY OF FRUIT SURFACES IN SOME TAXA OF THE TRIBE ASTEREAE (ASTERACEAE) AND THEIR TAXONOMIC SIGNIFICANCE

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ABSTRACT

The detailed micromorphological features of mature cypselas of twenty six species, nine of *Solidago*, eight each of *Aster* and *Erigeron* and one of *Callistephus* were studied using light compound and Scanning electron microscopes. Special emphasis was given to the surface structures particularly primary sculpture, cell shape, topography of anticlinal and periclinal walls, secondary sculpture, carpopodium and pappus bristles of cypselas. Five types of primary sculptures were observed, reticulate pattern with variations being the most common pattern. Surface ornamentations were seen to be significant for taxonomic delimitation for most of the taxa both at the generic and specific levels.

Key Words: Anticlinal & Periclinal Walls, Carpopodium, Micromorphology, Primary Sculpture, Secondary Sculpture

INTRODUCTION

A survey of micromorphological characters of cypsela in the family Asteraceae (Blake, 1928; Kynclova, 1970; Grau, 1980; Mukherjee and Sarkar, 1992, 1994, 1995, 1997, 2001; Abid and Qaiser, 2002; Garg and Sharma, 2005, 2007; Abid and Qaiser, 2009) reveals that these characters are very useful in delimiting various taxa. The tribe Astereae is established as a monophyletic group (Bremer, 1996). According to Nesom (1994), Astereae comprise 14 subtribe, 189 genera and 320 species.

Within the tribe Astereae, through various workers paid attention to the cypselar features in some taxa (Robinson and King, 1977; Pandey and Singh, 1979; Mukherjee and Sarkar, 1997) still there is a requirement of detailed informations about the cypsela micromorphology for entire tribe of Astereae. The present investigation on micromorphology of cypselas was carried out to provide the strength to the systematic position of taxa in the tribe Astereae.

MATERIALS AND METHODS

Surface structures of cypselas were studied using SEM for which mature dried cypselas of 26 species belonging to the tribe Astereae (Asteraceae) were affixed on aluminium stubs with the help of transparent adhesive. The cypselas were coated with gold and examined at a range of magnifications in a Leo 435 VP Scanning Electron Microscope at AIIMS, New Delhi, India. The terminology of cypsela surface patterns adopted is mainly from Barthlott (1981), Hufford (1995), Mukherjee (2000), Johnson *et al.*, (2004), Garg and Sharma (2005, 2007) and partly improved by authors.

The following 15 species belonging to the tribe Astereae were studied:

Aster amellus Aster chilensis Aster dumosus Aster linosyris

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Aster pyrenaeus Aster novae-angliae Aster salicifolius Aster tripolium *Callistephus chinensis* Erigeron acre Erigeron alpinum Erigeron annum *Erigeron bonariensis* Erigeron canadense Erigeron canadensis Erigeron crispum Erigeron speciosum Solidago canadensis Solidago caesia Solidago glaberrima Solidago graminifolia Solidago rigida Solidago serotina Solidago speciosa Solidago tenuifolia Solidago virgaurea Seeds were procured through Dr. A.S.R. Dathan (Retired Assoc. Prof. Department of Botany, University of Rajasthan, Jaipur) from Jardin Botanique de 1' University Louis Pasteur de Strasbourg.

Observations

Aster amellus

Size - The size of cypsela varies from 3.0 to 3.1 mm in length and 0.8 to 0.9 mm in breadth

Shape - Oblong obovate

Colour - Dark brown

Pappus elements – Scabrous barbellate bristles

Spermoderm patterns -

The primary sculpture of spermoderm is irregular reticulate, which is made up by polygonal cells. The anticlinal walls are raised and periclinal walls are flat. Both anticlinal and periclinal walls showed annular thickening pattern in the secondary sculpture and resemble the trachieds. Bifid tipped hairs are also present here and there. The two tips are of unequal length. Density of hairs is increased considerable near the carpopodium which is present in the form of a complete and distinct ring.

Aster Chilensis

Size - The size of cypsela varies from 2.0 to 2.1 mm in length and 0.4 to 0.5 mm in breadth

Shape - Oblong cylindrical

Colour - Dark Brown

Pappus elements – Scabrous barbellate bristles

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Spermoderm patterns -

The Spermoderm pattern is striated reticulate. Both anticlinal and periclinal walls are raised. At places the anticlinal walls are depressed below the surface of outer periclinal convex walls. Near the basal region, this pattern becomes more compact and gives a mat-like appearance. Some thread-like projections are also seen scattered on the cypsela surface. Secondary sculpture is rugose type. Carpopodium is present in the form of a complete ring.

Aster Dumosus

Size - The size of cypsela varies from 2.0 to 2.1 mm in length and 0.4 to 0.5 mm in breadth

Shape - Oblong cylindrical with hairy surface

Colour - Dark Brown

Pappus elements – Scabrous barbellate bristles

Spermoderm patterns -

The spermoderm is striated reticulate. Primary sculpture appears to be reticulate type having rectangular cells. Anticlinal walls are more or less straight and distinctly raised and are interconnected by concave irregular wrinkled periclinal walls. The long hairs are also seen on the cypsela surface with branched acute tips (two) and broad base. At the basal region, the reticulation is more compact than the other regions. The long hairs are randomly distributed. Secondary sculpture is rugose. Carpopodium is not seen.

Aster Linosyris

Size - The size of cypsela varies from 3.5 to 3.8 mm in length and 0.8 to 1.0 mm in breadth

Shape - Oblong cylindrical with hairy surface

Colour - Dark brown

Pappus elements - Scabrous barbellate bristles

Spermoderm patterns -

The Spermoderm pattern is striated reticulate. The anticlinal walls are irregular and more or less straight, interconnected by mostly pericinal convex walls. Hairs are distributed throughout the surface, the density being more near the basal region where they form a crown-like structure. The hairs are branched with bifid acute tips (two) and have broad base. Small waxy depositions are also seen here and there.

Beyond the reticulate primary sculpture, smooth to rugose type of secondary sculpture is seen. Carpopodium is seen as a thin complete ring.

Aster pyrenaeus

Size - The size of cypsela varies from 2.9 to 3.0 mm in length and 0.9 to 1.0 mm in breadth

Shape - Oblong cylindrical with hairy surface

Colour - Dark brown

Pappus elements – Scabrous barbellate bristles

Spermoderm patterns -

Primary sculpture appears to be striated reticulate type having more or less rectangular cells. Fruit surface is covered with hairs that obscure underlying ornamentations. Anticlinal walls appear straight and distinctly raised, periclinal walls are flat to concave and secondary sculpture is rugose type.

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The long hairs are present on the cypsela surface with bifid tips and broad base. They are originated from periclinal walls. Some threads-like structures are also present which are branched and scattered over the surface. Carpopodium is present in the form of a complete ring.

Aster Novae-angliae

Size - The size of cypsela varies from 1.2 to 1.4 mm in length and 0.4 to 0.5 mm in breadth

Shape - Conical with hairy surface

Colour - White brown

Pappus elements – Capillary barbellate bristles

Spermoderm patterns -

The cypsela coat is covered by hairs so that no prominent spermoderm pattern could be revealed. At higher magnification at certain places reticulate pattern is seen which is covered by leafy hairs with acute tip and broad base. In primary sculpture, anticlinal walls are straight and slightly raised with flat periclinal walls. Secondary sculpture shows wrinkled pattern. The hairs are long ribbon-like structures which are twisted on their axis. Their apical ends are bifid with acute tips. Carpopodium is not seen.

Aster Salicifolius

Size - The size of cypsela varies from 1.2 to 1.4 mm in length and 0.3 to 0.5 mm in breadth

Shape - Conical

Colour - Golden Brown

Pappus elements – Capillary barbellate bristles

Spermoderm patterns -

The spermoderm is striated reticulate. The anticlinal walls are more or less straight and distinctly raised and interconnected by flat to convex periclinal walls and generally form rectangular cells. At the basal region, the long bifid acute tipped hairs with broad base are present in clusters. The reticulation of this region is more compact. The waxy depositions are also seen in random. Secondary sculpture is smooth to rugose. Carpopodium is not seen.

Aster Tripolium

Size - The size of cypsela varies from 3.0 to 3.1 mm in length and 0.5 to 0.6 mm in breadth

Shape - Oblong flattened

Colour - Golden white

Pappus elements - Crown of scabrous barbellate bristles

Spermoderm patterns -

The spermoderm pattern is striated reticulate. The anticlinal walls are more or less straight and distinctly raised and interconnected by flat to convex periclinal walls and make a mat-like structure of rectangular to hexagonal cells. The long branched acute tipped (two) hairs are mainly distributed near the upper and basal regions, the density being more near the latter region. In these regions, the hairs are present in a group and make a crown-like structure. Waxy depositions are present here and there. Secondary sculpture is smooth to granular. Carpopodium is present as a beak-like structure.

Callistephus Chinensis

Size - The size of cypsela varies from 4.0 to 4.1 mm in length and 0.9 to 1.0 mm in breadth

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Shape - Oblong cylindrical becoming conical with hairy surface

Colour - Golden brown

Pappus elements – Absent

Spermoderm patterns -

The Spermoderm pattern is striated reticulate. The anticlinal walls are raised and interconnected by concave periclinal walls. Long hairs are present on the cypsela surface with branched (bifid) acute tips and broad base. They are condensed near the two ends of the fruit. Some waxy flakes and granular structures are also seen on the surface. Long striations are seen on the periclinal walls giving a wrinkled appearance to it and reveal the secondary sculpture of the surface. Undulations are also seen on the periclinal wall here and there. A complete ring of carpopodium giving a cap-like appearance is present.

Erigeron Acre

Size - The size of cypsela varies from 2.0 to 2.3 mm in length and 0.4 to 0.6 mm in breadth

Shape - Oblong cylindrical with hairy surface

Colour - Brown

Pappus elements - Scabrous barbellate bristles

Spermoderm patterns -

The Spermoderm pattern shows striated reticulate with tubercles. The ornamentation appears to be a parallel arrangement of rectangular cells or hexagonal cells with straight and distinctly raised anticlinal and concave periclinal walls. The very small tubercles originate from the transverse walls. Surface at the basal region, becomes mat like having very compact arrangement of raised polygonal walls forming an irregular reticulate pattern. The long hairs are present with broad base and pointed bifid tips. The line of bifurcation runs from base to tip of hair which becomes bifid. Secondary sculpture is wrinkled. Carpopodium is not seen.

Erigeron Alpinum

Size - The size of cypsela varies from 2.1 to 2.3 mm in length and 0.8 to 0.7 mm in breadth

Shape - Oblong flattened with hairy surface

Colour - Light brown

Pappus elements – Scabrous barbellate bristles

Spermoderm patterns -

The cypsela surface shows striated reticulate pattern having more or less long rectangular to hexagonal cells. The waxy, distinctly raised anticlinal walls are connected by flat to convex periclinal and oblique raised transverse walls. Bifid tipped hairs having broad base are distributed all over the surface. The bifurcation (of tip) line is seen upto base of the hair. They are condensed near the base. Some granular depositions are also seen. Secondary sculpture is smooth to granular. Cap-like carpopodium is present.

Erigeron Annum

Size - The size of cypsela varies from 1.0 to 1.1 mm in length and 0.4 to 0.5 mm in breadth

Shape - Oblong cylindrical with hairy surface

Colour - Brown

Pappus elements – Non cupulate corona

Spermoderm patterns –

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Spermoderm has a striated reticulate type of pattern. At the basal portion of cypsela, the reticulation is polymorphic with irregular pattern, wavy and thicked walls. Cell outlines in this are hexa to polygonal shaped. At higher magnification in the middle region of the cypsela, the straight and distinctly raised anticlinal walls are seen *with flat* to convex periclinal walls. Cells are rectangular with oblique transverse walls. The long hairs are present on the surface with pointed bifid tips and broad base. Hair surface is wavy. They is originated from the oblique transverse walls. At the upper portion, density of long hairs is increased. Granular secondary sculpture has very small rugae and wax flakes here and there. Cap like carpopodium is present.

Erigeron Bonariensis

Size - The size of cypsela varies from 1.2 to 1.4 mm in length and 0.4 to 0.5 mm in breadth

Shape - Oblong cylindrical with hairy surface

Colour - Golden white

Pappus elements – Capillary barbellate bristles

Spermoderm patterns -

The Spermoderm pattern is not very clear under lower magnification. In primary sculpture, the straight and slightly raised parallely running anticlinal walls are seen at higher magnification. Periclinal walls are almost flat. Long hairs are randomly distributed over the surface in a scattered manner. These form a cluster around the base. They have a bifid acute tip with broad base. The hairs are placed parallel to the longitudinal line of cypsela. The secondary sculpture is smooth. Segmented carpopodium is present in the form of a ring.

Erigeron Canadense

Size - The size of cypsela varies from 1.2 to 1.4 mm in length and 0.4 to 0.5 mm in breadth

Shape - Oblong cylindrical with hairy surface

Colour - Brown

Pappus elements - Capillary barbellate bristles

Spermoderm patterns -

The cypsela surface is reticulate. At the basal portion hexa to polygonal cells arranged in a compact manner and make mat like structure. In this region reticulation is polymorphic with irregular pattern. At higher magnification, in the middle region anticlinal walls are more or less straight with flat periclinal walls. The long bifid tipped hairs are originated from the transverse walls. The tips of the hairs are acute with broad base. They are distributed all over the surface uniformly. The number of hairs is more in apical region then the other parts of cypsela surfaces. Secondary sculpture of cells granulated having very small rugue here and there. Carpopodium is present in the form of a complete ring.

Erigeron Canadensis

Size - The size of cypsela varies from 1.2 to 1.4 mm in length and 0.4 to 0.5 mm in breadth

Shape - Oblong cylindrical with hairy surface

Colour - Brown

Pappus elements - Capillary barbellate bristles

Spermoderm patterns -

The spermoderm shows striated reticulated pattern, having more or less rectangular cells. Anticlinal walls are more or less straight and distinctly raised. Periclinal walls are concave. The

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long hairs are also seen with pointed bifid tips and broad bases. At the basal region reticulate pattern is making a mat like structure with polygonal cells. In the middle region, cells are elongated and rectangular.

Small granular out growths are seen on walls all over the surface. Small flaks or wax depositions are also seen on the surface here and there. Secondary sculpture is wrinkled. Carpopodium is present in the form of a complete ring.

Erigeron Crispum

Size - The size of cypsela varies from 1.5 to 1.6 mm in length and 0.4 to 0.5 mm in breadth

Shape - Oblong cylindrical with hairy surface

Colour - Brown

Pappus elements - Capillary barbellate bristles

Spermoderm patterns -

The cypsela surface show more or less reticulate pattern. Cell shapes are unclear, as anticlinal walls are straight and distinctly raised but oblique transverse walls are seen only at few places. Periclinal walls are almost flat. Some waxy depositions are also seen on the surface. Hairs are seen distributed all over the surface.

Near the base of the cypsela the distribution of hairs becomes compact. The hairs have broad bases and pointed bifid tips. Their apices are pointed towards cypsela apex. Secondary sculpture is smooth to wrinkled type. Carpopodium is present in the form of a complete ring.

Erigeron Speciosum

Size - The size of cypsela varies from 2.0 to 2.1 mm in length and 0.6 to 0.7 mm in breadth

Shape - Flattened conical with hairy surface

Colour - Dark brown

Pappus elements – Scabrous barbellate bristles

Spermoderm patterns -

The complete cypsela surface is covered by long hairs. Because of this no regular pattern of surface could be recognized at lower magnification. At higher magnification from the middle surface reticulte pattern is seen with almost flat to convex periclinal walls, which are connected to wavy to straight distinctly raised anticlinal walls. Cell surface and sutures show finger like projections with some scattered granular waxy depositions. The long hairs are present with acute tip and broad base cover almost entire surface. Mostly they are originated from the convex periclinal walls. Beyond the regiculate primary sculpture, secondary sculpture is rugose type. Carpopodium is not seen.

Solidago Canadensis

Size - The size of cypsela varies from 0.8 to 1 mm in length and 0.3 to 0.4 mm in breadth

Shape - Conical with hairy surface

Colour - Brown

Pappus elements – Scabrous barbellate bristles

Spermoderm patterns –

The cypselas are coated with persistent bifid tipped hairs. So, no regular pattern of arrangement is revealed. The longer hairs have two conical to round tips. Segmented carpopodium is present.

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Solidago Caesia

Size - The size of cypsela varies from 3.0 to 3.1 mm in length and 0.9 to 1.0 mm in breadth

Shape - Oblong cylindrical

Colour - Brown

Pappus elements – Scabrous barbellate bristles

Spermoderm patterns -

The spermoderm presents a reticulate pattern. The areas enclosed by the reticulate patterns differ in size and shape-some rectangular and others quadrangular or polygonal. The anticlinal walls are straight and distinctly raised with convex periclinal walls. The pattern at the upper portion of the cypsela is slightly different where a compact reticulate pattern forming a mat-like structure is observed. Granular and flakes-like wax deposits are seen here and there. The hairs seem to be a structure formed by twin hairs joined together except at the tip and originating from a common place. Secondary sculpture is smooth. Carpopodium is a thin ring-like structure.

Solidago Glaberrima

Size - The size of cypsela varies from 2.0 to 2.2 mm in length and 0.9 to 1.0 mm in breadth

Shape - Oblong cylindrical with hairy surface

Colour - Dark brown

Pappus elements – Scabrous barbellate bristles

Spermoderm patterns -

The spermoderm has undulated reticulate pattern, tending to form a loose reticulum. The anticlinal walls are undulated and distinctly raised. The periclinal walls are curved and not clearly angular as in a typical reticulum. The depressions enclosed by anticlinal walls are of irregular shape and size. The hairs are dimorphic hairs with bifid acute tips. Both the longer and shorter hairs show two acute tips at their apical end. But the two tips are of unequal size. The bifurcation mark is seen all through the length of the hairs as if one larger and one shorter hairs are joined throughout their length except at the apex. Granular and flakes-like waxy depositions are also seen. Secondary sculpture is rugose type. Carpopodium is not seen.

Solidago Graminifolia

Size - The size of cypsela varies from 0.6 to 0.8 mm in length and 0.4 to 0.5 mm in breadth

Shape -	Oblong cylindrical
Colour -	Brown
Surface -	Hairy
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Pappus elements – Scabrous barbellate bristles

Spermoderm patterns -

No regular pattern of arrangement could be noticed as the surface is coated with persistent long dimorphic hairs. Some of the hairs are straight or curl with the acute tips. Whereas the large number of hairs show double tips (branched tips). The base of the hairs is bulbose. The surface visible at some places shows retangular cells with raised anticlinal and transverse walls and concave periclinal walls. Secondary sculpture is smooth. Cap-like carpopodium is present.

Solidago Rigida

Size - The size of cypsela varies from 1.2 to 1.4 mm in length and 0.4 to 0.5 mm in breadth

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Shape-Oblong cylindricalColour-BlackPappus elements -Scabrous barbellate bristles

Spermoderm patterns -

The spermoderm shows striated reticulate patterns with straight and distinctly raised anticlinal walls demarcating polygonal areas. Adjacent polygonal areas are connected through well marked convex and wrinkled periclinal walls. The primary anticlinal walls are depressed. The secondary ridges are also seen as clusters of long strings. These along with raised (as some places) anticlinal walls form a complex network giving an appearance of a network. The secondary sculpture is rugose. Carpopodium is not seen.

Solidago Serotina

Size - The size of cypsela varies from 2 to 2.1 mm in length and 0.4 to 0.5 mm in breadth

Shape - Oblong cylindrical

Colour - Brown

Surface - Hairy

Pappus elements – Scabrous barbellate bristles

Spermoderm patterns -

The spermoderm shows reticulate pattern. The areas enclosed by raised anticlinal walls differ in size but most of them are rectangular. Anticlinal walls are straight and slightly raised with flat to slightly convex periclinal walls. The hairs are straight or curled with two blunt unequal tips. Granular and flakes-like wax deposits are seen here and there. Secondary sculpture is smooth to granular. Carpopodium is a small one sided ring.

Solidago Speciosa

Size - The size of cypsela varies from 2.0 to 2.2 mm in length and 0.6 to 0.7 mm in breadth

Shape - Oblong elongated with longitudinal ridges

Colour - Brown

Pappus elements - Scabrous barbellate bristles

Spermodern patterns -

The spermoderm shows striated reticulate pattern. The straight and distinctly raised anticlinal walls are perpendicular to the longitudinal axis of the cypsela. The parallel anticlinal walls show occasional branches or interconnections. The anticlinal walls are almost uniform in thickness. Deep and wide furrows occur between the anticlinal walls. Periclinal walls are unclear at majority of places. However, at some places concave depressions of periclinal walls are also visible. Flakes-like waxy depositions are also seen. Secondary sculpture is rough and slightly rugose type. The anticlinal walls become wrinkled and condensed near the base. Carpopodium is not seen.

Solidago Tenuifolia

Size - The size of cypsela varies from 0.5 to 0.6 mm in length and 0.3 to 0.4 mm in breadth

Shape - Oblong obovate with hairy surface

Colour - Brown

Pappus elements – Scabrous barbellate bristles

Spermoderm patterns -

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The surface is covered by long bifid hairs. At higher magnifications irregular reticulate type of pattern is seen. Anticlinal walls appear raised and sometimes undulated, periclinal walls are concave. At certain places cells become individually identifiable as the middle lamella becomes depressed and anticlinal walls of the neighbouring cells become raised. The long hairs are present with branched acute tips and broad base. Waxy depositions are randomly distributed. Secondary sculpture is smooth. Carpopodium is present in the form of a complete ring.

Solidago Virgaurea

Size - The size of cypsela varies from 4.2 to 4.5 mm in length and 0.9 to 1.0 mm in breadth

Shape - Oblong elongated with hairy surface

Colour - Brown

Pappus elements – Scabrous barbellate bristles

Spermoderm patterns -

The spermoderm shows undulated reticulate pattern. The cells are irregular shaped and sized. The undulated distinctly raised anticlinal walls are present in irregular form with concave periclinal walls. At certain places periclinal walls are conspicuously depressed giving a furrow like appearance. The cells form a narrow reticulum at some areas and a broader reticulum at others. The hairs are shorter with bifid tips. The two tips are unequal sized. Secondary sculpture is smooth to granular. Carpopodium is not seen.

Comparative analysis of different characters of cypsela morphology is given in Table -1.

RESULTS AND DISCUSSION

Discussion

The spermoderm pattern in 26 species of Astereae studied here showed 5 types of primary sculptures viz., reticulate, irregular reticulate, straited reticulate, undulated reticulate and striated reticulate with tubercles. The most common pattern was observed striated reticulate type of pattern in 12 members. Some variations in this pattern were also observed like striated reticulate with tubercles in *Erigeron acre*. We used one more new terms for primary sculptures of tribe Astereae, undulated reticulate in *Solidago glaberrima* and *S. virgaurea*. Garg and Sharma (2007) reported irregular reticulate type of pattern in some members of tribe Heliantheae (Asteraceae), similar pattern was identified by authors in *Aster amellus* and *Solidago tenuifolia*.

The most common type of cell shapes is rectangular in most of the species studied here. Rectangular to hexagonal cell shapes are represented by 4 taxa of *Erigeron*. And the other types of cell shapes polygonal are reported in *Aster amellus* and *Solidago rigida*, rectangular with polygonal cell shapes in *Solidago caesia*. Mukherjee and Sarkar (1998) and Garg (2008) also observed these types cell shapes in the cypsela surface structures in the family Asteraceae.

Gohary and Mohamed (2007) described anticlinal walls under three heads: (1) anticlinal wall's shape – undulated / wavy (ii) anticlinal wall's thickness – thin / thick (iii) anticlinal wall's level – raised / grooved. The species studied here also showed raised / depressed anticlinal walls which are thin or thick. Shape of the anticlinal walls reported here falls under undulate, wavy, straight or irregular types. Similarly the periclinal walls are also of different types viz., concave, flat to concave, convex and flat to convex. Such observations have also been made by Mukherjee and Sarkar (1995) and Garg and Sharma (2007) in the tribe Astereae and respectively.

In the present investigation 8 types of the cells secondary sculptures are recognized. The most common type of secondary sculpture was rugose type in the tribe – Astereae. The new terms

annular thickening a secondary sculpture was observed in Aster amellus, smooth to wrinkle in Erigeron crispum and wrinkled in Aster novae-angliae, Erigeron acre and E. canadensis are used by authors to give emphasis much the importance of secondary sculptures. Haque and Godward (1984), Sundberg (1985) concluded for carpopodium that it may be present or absent; if present, they may be symmetric or asymmetric in tribe Astereae. Mukherjee and Sarkar (2001) reported a complete ring type of carpopodium was most common type pattern of this tribe while studying 13 species of the tribe Astereae. We observed similar type of pattern in most of taxa o tribe Astereae studied here. While investigation three new types of carpopodia are also found like one sided carpopodia in Solidago serotina, beak-like in Aster tripolium and segmented ring in Erigeron bonariensis, Solidago canadensis. SEM studies of pappus are valuable to a limited degree. In present study, we observed most of the studied members have pappose condition. Except in Callistephus chinensis pappus is absent similar observations of Mukherjee and Sarkar (2001), they reported epappose condition in some members of Astereae. The most common type of pappus was scabrous barbellet bristles in 18 taxa of studied here. Second most type was capillary barbellate bristles. One new type of pappus arrangement was reported by authors, noncupulate corona in Erigeron annum in tribe Astereae.



Figure 1 (A-F): Cypsela and spermoderm pattens in *Aster amellus* and *Aster chilensis* A- Cypsela, x 28; B- Surface, x 500; C- Carpopodium, x 200; D- Cypsela, x 60; E- Surface, x 1500; F- Carpopodium x 350



Figure 2 (A-F): Cypsela and spermoderm patterns in *Aster dumosus* and *Aster linosyris* A- Cypsela, x 90; B- Surface, x 700; C- Surface, x 3400; D- Cypsela, x 20; E- Surface- x 300; F- Surface, x 500



Figure 3 (A-F): Cypsela and spermoderm patterns in *Aster pyrenacus* and *Aster novac-angliae*

A- Cypsela, x 27; B- Surface, x 500; C- Surface, x 1500; D- Cypsela, x 16; E- Surface, x 500; F- Surface, x 200



Figure 4 (A-F): Cypsela and spermoderm patterns in *Aster salicifolius* and *Aster tripolium* A- Cypsela, x 35; B- Surface, x 1000; C- Carpopodium, x 200; D- Cypsela, x 30; E- Surface, x 500; F- Carpopodium, x 100



Figure 5 (A-D): Cypsela and spermoderm patterns in *Callistephus chinensis* A- Cypsela, x 20; B- Surface, x 750; C- Apical Surface, x 150; D- Carpopodium, x 150



Figure 6 (A-F): Cypsela and speroderm patterns in Erigeron acre and *Erigeron alpinum* A- Cypsela, x 30; B- Surface, x 1000; C- Surface, x 600; D- Cypsela, x 50; E- Surface, x 300; F- Surface, x 1000



Figure 7 (A-D): Cypsela and spermoderm patterns in *Erigeron annum* A- Cypsela, x 80; B- Surface, x 400; C- Surface, x 100; D- Apical surface, x 400



Figure 8 (A-D): Cypsela and spermoderm patterns in *Erigeron bonariensis* A- Cypsela, x 40; B- Surface, x 650; C- Surface, x 750; D- Carpopodium, x 180



Figure 9 (A-D): Cypsela and spermoderm patterns in *Erigeron canadense* A- Cypsela, x 80; B- Surface, x 400; C- Surface, x 1000; D- Apical surface, x 450



Figure 10 (A-D): Cypsela and spermoderm patterns in *Erigeron canadensis* A- Cypsela, x 90; B- Surface, x 1000; C- Apical surface, x 600; D- Carpopodium, x 600



Figure 11 (A-D): Cypsela and spermoderm patterns in *Erigeron crispum* A- Cypsela, x 70; B- Surface, x 400; C- Surface, x 1300; D- Apical surface, x 600



Figure 12 (A-D): Cypsela and spermoderm patterns in *Erigeron speciosum* A- Cypsela, x 50; B- Surface, x 400; C- Surface, x 600; D- Surface, x 1000



Figure 13 (A-D): Cypsela and spermoderm patterns in *Solidago canadensis* A- Cypsela, x 80; B- Surface, x 400; C- Surface, x 600; D- Carpopodium, x 1000



Figure 14 (A-D): Cypsela and spermoderm patterns in *Solidago caesia* A- Cypsela, x 50; B- Surface, x 300; C- Surface, x 1000; D- Apical surface, x 250



Figure 15 (A-F): Cypsela and speroderm patterns in Solidago glaberrima and *Solidago graminifolia*

A- Cypsela, x 50; B- Surface, x 500; C- Surface, x 1000; D- Cypsela, x 100; E- Surface, x 600; F- Surface, x 1500



Figure 16 (A-F): Cypsela and speroderm patterns in *Solidago rigida* and *Solidago serotina* A- Cypsela, x 40; B- Surface, x 600; C- Surface, x 800; D- Cypsela, x 55; E- Surface, x 300; F- Surface, x 400



Figure 17 (A-F): Cypsela and speroderm patterns in *Solidago speciosa* and *Solidago tenuifolia*

A- Cypsela, x 30; B- Surface, x 600; C- Surface, x 1000; D- Cypsela, x 23; E- Surface, x 500; F- Carpopodium, x 250



Figure 18 (A-D): Cypsela and spermoderm patterns in *Solidago virgaurea* A- Cypsela, x 20; B- Surface, x 300; C- Surface, x 600; D- Surface, x 1000



Figure 19 (A-F): Cypsela and speroderm patterns in *Ageratum conyzoides* and *Ageratum houstonianum*

A- Cypsela, x 60; B- Surface, x 600; C- Surface, x 1000; D- Cypsela, x 30; E- Surface, x 300; F- Surface, x 600







A- Cypsela, x 40; B- Surface, x 500; C- Surface, x 1000; D- Cypsela, x 20; E- Surface, x 300; F- Surface, x 2000

Figure 21 (A-D): Cypsela and spermoderm patterns in *Eupatorium urticaefolium* A- Cypsela, x 40; B- Surface, x 300; C- Surface, x 600; D- Surface, x 1000



Figure 22 (A-D): Cypsela and spermoderm patterns in *Calendula arvensis* and *Calendula officinalis*

A- Cypsela, x 10; B- Surface, x 500; C- Surface, x 1500; D- Cypsela, x 10; E- Surface, x 150; F- Surface, x 500

ACKNOWLEDGEMENT

The first author (Kothari J) is thankful to Council of Scientific and Industrial Research for the financial assistance in the form of Senior Research fellowship.

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