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POLLEN AND SEED MORPHOLOGY OF *CRAMBE* SPECIES OF TURKEY

A. S. Bülbül[1*], B. Tarıkahya-Hacıoğlu[2],Y. Arslan[3] and İ. Subaşı[2]

[1]Bartın University, Faculty of Science, Department of Molecular Biology and Genetics, 74100 Bartın-Turkey
[2] Central Research Institute for Field Crops, Republic of Turkey Food Agricultural and Livestock Ministry, Ankara-Turkey
[3]General Directorate of Agricultural Research And Policies, Republic of Turkey Ministry of Food, Agriculture and Livestock, İstanbul road 5th km, 06161 Yenimahalle, Ankara, Turkey
Corresponding Author E-mail: asavasbulbul@gmail.com

ABSTRACT

Our study includes 5 taxa out of 10 naturally growing taxa in Turkey: *C. orientalis* L. subsp. *orientalis*, *C. orientalis* L. subsp. *sulphurea* (Stapf ex O.E.Schulz) Prina, *C. tataria* Sebeök var. *tataria*, *C. tataria* Sebeök var. *aspera* (M.Bieb.) Boiss. and *C. maritima* L. The morphological characters of the pollen and seeds from the studied species of *Crambe* were given. Data obtained by light microscope, stereomicroscope and scanning electron microscope were explained and summarized in Tables. As a result of our study, there are high similarities among taxa in means of pollen grains. Pollen shape is suprolate to prolate-spheroidal. *Crambe orientalis* subsp. *orientalis* had the biggest pollen grains with 25.90 µm polar axis and 21.46 µm equatorial axis lengths, while *Crambe orientalis* subsp. *sulphurea* had the smallest-sized pollen grains with 22.75 µm polar axis and 21.07 µm equatorial axis lengths. Seeds are brown to dark brown, elliptic to orbicular, with reticulate surface. *Crambe maritima* had the biggest seeds with 2.8-4.1 x 2.3-3.4 mm, while *Crambe orientalis* subsp. *sulphurea* had the smallest-sized seeds with 2.0-2.6 x 1.7-2.4 mm. Since the group has stenopalynous pollens, our investigation supports the use of seed surface patterns as a diagnostic characteristic for species level instead of pollen morphology.

Key words: *Crambe*, light microscopy, pollen grains, scanning electron microscopy, seed coat morphology.

INTRODUCTION

Brassicaceae distributed mainly in the temperate regions of northern hemisphere (Hedge, 1976), comprises about 338 genera and 3709 species (Franzke *et al*.,2010). The genus *Crambe* (Brassicaeae) has approximately 35 taxa worldwide. *Crambe* species are large coarse-growing perennial or biennial herbs with large tap roots. With the globose, 1-seeded, indehiscent fruit structure it is easy to recognize the genus. In flora of Turkey, there are 6 species and 4 infraspecific taxa (Mutlu, 2012). These taxa are *Crambe alutacea* Hand.-Mazz., *C. grandiflora* DC., *C. hispanica* L., *C. maritima* L., *C. orientalis* L. subsp. *orientalis* var. *orientalis*, *C. orientalis* L. subsp. *orientalis* var. *dasycarpa* O.E.Schulz, *C. orientalis* L. subsp. *sulphurea* (Stapf ex O.E.Schulz) Prina, *C. tataria* Sebeök var. *tataria*, *C. tataria* Sebeök var. *aspera* (M.Bieb.) Boiss., *C. tataria* Sebeök var. *parviflora* (Hub.-Mor. and Reese) Hedge and Hub.-Mor. Our study includes 5 taxa out of 10: *C. orientalis* subsp. *orientalis*, *C. orientalis* subsp. *sulphurea*, *C. tataria* var. *tataria*, *C. tataria* var. *aspera*. and *C. maritima*.

Brassicaceae is a stenopalynous family, the pollen grains usually tricolpate, with a reticulate exine (Abdel-Khalik, 2002). Pollen morphology of Brassicaceae was investigated by several authors (Abdel-Khalik, 2002; Perveen *et al*., 2004; Bolurian, 2009; Pınar *et al*., 2009; Arora and Modi, 2011; Keshavarzi, *et al*. 2012; Mutlu and Erik, 2012). Pollen morphology can be used to discuss the systematic relationships among the genera of the Brassicaceae (İnceoğlu and Karamustafa, 1977; Doğan and İnceoğlu, 1990; Brochmann, 1992; Pınar *et al*., 2009). Seed coat morphology is known to be an important character for taxonomic and evolutionary studies (Koul *et al*., 2000; Abdel-Khalik, 2002; Tantawy *et al*., 2004; Karcz *et al*., 2005; Moazzeni *et al*., 2007; Pınar *et al*., 2007, 2009; Kaya *et al*., 2011; Mousavi and Sharifi-Rad, 2014). Our study provides information about the pollen and seed morphology of the available Turkish *Crambe* taxa by using light and electron microscopy.

MATERIALS AND METHODS

Plant material: Specimens were collected in 2011 and 2012 for the General Directorate of Agricultural Research and Policy project "The genetic and morphological characteristics of *Crambe* L. species found in Anatolian natural flora and their facilities to be improvement materials". List of investigated species and localities were given in "Table 1". Our study includes 5 taxa out of ten naturally growing taxa in Turkey: *C. orientalis* subsp. *orientalis*, *C. orientalis* subsp. *sulphurea*, *C. tataria* var. *tataria*, *C. tataria* var. *aspera* and *C. maritima*.

Light microscopy (LM): According to Wodehouse method (1935), pollen samples were taken from plants

and slides were prepared by using basic fuchsine mixture. At least 30 pollen samples for each species were examined in LMand micrographs were taken with Leica DM 750 digital imaging system. After the examination of each species, measurements were done for colpus length and thickness, pore length and thickness, pollen shape, exine thickness, intine thickness, polar axis length, equatorial axis length of pollen. The pollen terminology adopted by Faegri and Iversen (1975) and Brochman (1992), and shape classification follows Erdtman (1969) based on P/E ratio in "Table 2". At least 30 seed samples for each species were examined in stereomicroscope and micrographs were taken with Olympus SZ2-LGB digital imaging system. After the examination of each species, measurements were done forseed shape, color, size, epidermal cell shape, anticlinal cell wall, periclinal cell wall. The seed terminology was used as Murley (1951), Koul *et al*. (2000) and Karcz *et al*. (2005).

Scanning Electron Microscopy (SEM): For SEM, pollen grains and seeds were directly mounted on stubs and covered with gold. The surface ornamentations of pollen grains and seeds were examined in detail with JeolTescan MAIA3 XMU model electron microscope.

RESULTS AND DISCUSSION

The morphological characters of the pollen and seeds from the studied species of *Crambe* were given below. Data obtained by light microscope, stereomicroscope and electron microscope were reviewed in "Tables 2 and 3", as well as in "Figures 1, 2 and 3".

Pollen Morphology

***Crambe orientalis* subsp. *orientalis*:** The pollen grains are tectate or semitectate, radially symmetric, isopolar, tricolpate, prolate-spheroidal,outline is elliptic in the equatorial view and circular in the polar view "Figure 1A and B, Figure 2A and B". Polar axis is 25.90 µm and equatorial axis 21.46 µm.The colpus length is 17.07 µm and the colpus width is 4.77 µm. The mesocolpium length is 8.00 µm. The apocolpium length is 5.94 µm. Exine ornamentation is reticulate. The exine is 2.69 µm thick and the ectexine is thicker than the endexine. Intine thickness is 0.53 µm. The lumen width is 1.35 µm, regular and polygonal or rarely irregular lumina. Murus width is 0.44 µm, generally 4-5 sided and smooth muri "Table 2; Figure 1A and B, Figure2A and B".

***Crambe orientalis* subsp. *sulphurea*:** The pollen grains are tectate or semitectate, radially symmetric, isopolar, tricolpate, prolate-spheroidal, outline is elliptic in the equatorial view and circular in the polar view "Figure1C and D, Figure2C". Polar axis is 22.75 µm and equatorial axis 21.07 µm. The colpus length is 16.62 µm and the colpus width is 4.68 µm. The mesocolpium length is 8.03 µm. The apocolpium length is 5.64 µm. Exine ornamentation is reticulate. The exine is 2.80 µm thick and the ectexine is thicker than the endexine. Intine thickness is 0.54 µm. The lumen width is 2.57 µm, regular and polygonal or rarely irregular lumina. Murus width is 0.38 µm, generally 4-5 sided and smooth muri "Table 2; Figure1C and D, Figure2C".

***Crambe tataria* var. *tataria*:** The pollen grains are tectate or semitectate, radially symmetric, isopolar, tricolpate, subprolate, outline is elliptic in the equatorial view and circular in the polar view "Figure 1E and F, Figure 2D". Polar axis is 24.84 µm and equatorial axis 21.76 µm. The colpus length is 18.73 µm and the colpus width is 4.73 µm. The mesocolpium length is 7.24 µm. The apocolpium length is 5.53 µm. Exine ornamentation is reticulate. The exine is 2.52 µm thick and the ectexine is thicker than the endexine. Intine thickness is 0.51 µm. The lumen width is 1.03 µm, regular and polygonal or rarely irregular lumina. Murus width is 0.32 µm, generally 4-5 sided and smooth muri "Table 2; Figure 1E and F, Figure 2D".

***Crambe tataria* var. *aspera*:** The pollen grains are tectate or semitectate, radially symmetric, isopolar, tricolpate, prolate-spheroidal, outline is elliptic in the equatorial view and circular in the polar view "Figure 1G and H, Figure 2E and F". Polar axis is 23.47 µm and equatorial axis 20.81 µm. The colpus length is 16.98 µm and the colpus width is 4.50 µm. The mesocolpium length is 7.96 µm. The apocolpium length is 5.53 µm. Exine ornamentation is reticulate. The exine is 2.48 µm thick and the ectexine is thicker than the endexine. Intine thickness is 0.51 µm. The lumen width is 1.34 µm, regular and polygonal or rarely irregular lumina. Murus width is 0.42 µm, generally 4-5 sided and smooth muri "Table 2; Figure 1G and H, Figure 2E and F".

***Crambe maritima*:** The pollen grains are tectate or semitectate, radially symmetric, isopolar, tricolpate, subprolate, outline is elliptic in the equatorial view and circular in the polar view "Figure 1I and J, Figure 2G and H". Polar axis is 25.23 µm and equatorial axis 21.14 µm. The colpus length is 16.86 µm and the colpus width is 4.73 µm. The mesocolpium length is 8.34 µm. The apocolpium length is 5.18 µm. Exine ornamentation is reticulate. The exine is 2.68 µm thick and the ectexine is thicker than the endexine. Intine thickness is 0.53 µm. The lumen width is 1.36 µm, regular and polygonal or rarely irregular lumina. Murus width is 0.33 µm, generally 4-5 sided and smooth muri "Table 2; Figure 1I and J, Figure 2G and H".

Seed Morphology

***Crambe orientalis* subsp. *orientalis*:** The seeds are 2.3-3.9 x 1.9-3.6 mm. Seed shape varies from elliptic, with smooth surface. Seed color varies from brown or dark

brown. SEM showed reticulate surface pattern with regular to irregular polygonal, epidermal cell shape varies from isodiametric, raised, straight; smooth anticlinal cell walls and flat to concave: macro-reticulate periclinal cell walls "Figure 3A and B".

***Crambe orientalis* subsp. *sulphurea*:** The seeds are 2.0-2.6 x 1.7-2.4 mm. Seed shape varies from orbicular, with smooth surface. Seed color varies from brown or dark brown. SEM showed reticulate surface pattern with irregular polygonal mostly hexagonal, epidermal cell shape varies from isodiametric, raised, straight; smooth anticlinal cell walls and flat to slightly concave periclinal cell walls "Figure 3C and D".

***Crambe tataria* var. *tataria*:** The seeds are 2.2-3.4 x 2.1-3.3 mm. Seed shape varies from orbicular, with smooth surface. Seed color varies from brown or dark brown. SEM showed reticulate surface pattern with regular polygonal mostly hexagonal, epidermal cell shape varies from isodiametric, raised, straight; smooth anticlinal cell walls and flat to concave: macro-reticulate periclinal cell walls "Figure 3E and F".

***Crambe tataria* var. *aspera*:** The seeds are 2.8-4.1 x 2.3-3.4 mm. Seed shape varies from orbicular, with smooth surface. Seed color varies from brown or dark brown. SEM showed reticulate surface pattern with regular polygonal mostly hexagonal, epidermal cell shape varies from isodiametric, raised, straight; smooth anticlinal cell walls and flat to concave: macro-reticulate periclinal cell walls "Figure 3G and H".

***Crambe maritima*:** The seeds are 3.3-4.9 x 2.5-3.8 mm. Seed shape varies from elliptic, with smooth surface. Seed color varies from brown to dark brown. SEM showed reticulate surface pattern with regular 4, 5, 6 gonal, epidermal cell shape varies from isodiametric, raised, straight; smooth anticlinal cell walls and flat to slightly concave periclinal cell walls "Figure 3I and J".

Brassicaceae is a stenopalynous family (Erdtman, 1952), pollen grains 3-zonocolpate, generally prolote to subprolate oblate to oblate-spheroidal, or prolate-spheroidal with reticulate or granulate exine ornamentation (Abdel-Khalik, 2002).Our investigation supports Erdtman (1952) since there are high similarities among *Crambe* pollen grains. *Crambe orientalis* subsp. *orientalis* had the biggest pollen grains with 25.90µm polar axis and 21.46 µm equatorial axis lengths, while *Crambe orientalis* subsp. *sulphurea* had the smallest-sized pollen grains with 22.75 µm polar axis and 21.07 µm equatorial axis lengths. *Crambe maritima* had the biggest seeds with 2.8-4.1 x 2.3-3.4 mm, while *Crambe orientalis* subsp. *sulphurea* had the smallest-sized seeds with 2.0-2.6 x 1.7-2.4 mm.

There are many researches on pollen morphology of Brassicaceae family. According to pollen studies of İnceoglu and Karamustafa (1977), *Crambe tataria* was observed with radially symmetric, isopolar, tricolpate, subprolate pollen grains and the outline shape was elliptic in the equatorial view and circular in the polar view. Polar axis was 25.80 µm and equatorial axis was 21.60 µm. The colpus length was 19.60 µm and the colpus width was 5.00 µm. Exine ornamentation was reticulate. The exine was 2.1 µm thick and the ectexine was thicker than the endexine. Intine thickness was 0.6 µm. The lumen width was 1.4 µm. The measurements are similar to our results.

The pollen morphology of *Crambe cordifolia* Steven, istectate, radially symmetric, isopolar, tricolpate, prolate-spheroidal, outline is elliptic in the equatorial view and circular in the polar view. Polar axis is 20.5 µm and equatorial axis 20.0 µm. The colpus length is 13.75 µm and colpus long sunken with acute ends. Exine ornamentation is reticulate. The exine is 2.5 µm thick and the sexine is thicker than nexine (Perveen *et al*., 2004). The pollen size of the investigated species' in our research was larger in polar axis (25.90-22.75 µm) and equatorial axis (21.46-21.07 µm).

According to pollen morphology studies on selected taxa of *Brassicaceae* by (Pınar *et al*., 2009), the ornamentation of *Hesperis* L. isoblate-spheroidal, spheroidal and subprolate, radially symmetric, isopolar, tricolpate, reticulate, rarely tetracolpate, polar axis is 15.2-30.2 µm and equatorial axis 12.5-27.1 µm, outline is elliptic in the equatorial view and circular in the polar view. *Crambe* mainly differs from these taxa with the prolate-spheroidal to subprolateshape, ornamentation only tricolpate and polar axis is 22.75-25.90 µm and equatorial axis 21.07-22.75 µm.

Pollen grains of 39 species belonging to six tribes; Arabideae, Euclidieae, Hesperideae, Lunarieae, Matthioleae and Sisymrieae from Brassicaceae were studied by Abdel-Khalik (2002). In general the pollen morphology varies within a narrow range. The shape varies from prolate spheroidal, subprolate to prolate. The pollen morphologies of *Brassica campestris* L., *Coronopus didymus* (L.) Smith., *Eruca sativa* L., *Farsetia hamiltonii* Royle., *Iberis amara* L., *Lepidium sativum* L., *Raphanus sativus* L., *Sisymbrium irio* L. are tricolpate, oblate to suboblate, prolate-spheroidal to rarely oblate-spheroidal (Arora & Modi, 2011). Sexine is thinner or thicker than nexine. Tectum is reticulate but sometimes it may be granulate. Pollen morphology of the genus *Clypeola (Brassicaceae)*, tricolpate rarely tetracolpate, prolate-spheroidal, subprolate to prolate, polar axis is 22.4-33.4 µm and equatorial axis 19.2-23.9 µm (Keshavarzi *et al*., 2012). The pollen morphology of the genus *Arabis (Brassicaceae)* istricolpate, but some of them are 2- and 4-colpate, prolate-spheroidal, subprolate, suboblate, prolate and oblate, polar axis and equatorial axis are 11.76-38.22 µm (Mutlu and Erik, 2012). *Cardaria draba* L. Desv are tricolpate, prolate, tectum was reticulate (Mousavi and Sharifi-Rad, 2014). The

major difference of *Crambe* from all these taxa mentioned above is the size and prolate-spheroidal, subprolate shape of pollen grains.

The observed seed morphology revealed that the shape of seeds varied from orbicular or elliptic with smooth surface in *Crambe* taxa. Seed color varied from brown or dark brown. SEM showed reticulate surface pattern with regular polygonal mostly hexagonal, epidermal cell shape varied from isodiametric, raised, straight; smooth anticlinal cell walls and flat to concave: macro-reticulate periclinal cell walls. The analysis of the mean L (length) and W (width) values showed that the largest seeds occur in *Crambe maritime* 3.3-4.9 x 2.5-3.8 mm, while the smallest L and W values were recorded for *Crambe orientalis* subsp. *sulphurea* 2.0-2.6 x 1.7-2.4 mm "Table 3". *Crambe* seeds had differences from the other investigated Brassicaeae members in literature. For example *Eruca sativa* v. *longirostris, E. sativa* v. *oblongifolia* had 1.8 x 1.5 mm, sub-globose seeds (Tantawy *et al*., 2004), while *Crambe* species had 2-4.9x1.7-3.8 mm, orbicular to elliptic shaped seeds. *Erucaria hispanica* and *Raphanus raphanistrum* had sub-globose to ovate seed shape (Tantawy *et al*., 2004). The seeds of *Raphanus sativus and R. raphanistrum* were 0.8×1.0 mm, shiny brown, glabrous textured and kidney shaped (Kasem *et al*., 2011). *Brassica juncea* and *Sinapis arvensis* had round plump or shriveled seed shape and the seed size was 1.2-2 x 1.1-1.7 mm, seed coat color was tan, brown, dark brown, or yellow (Wang *et.al*., 2013). Özüdoğru *et al*. (2016), detected four main seed surface types (papillate, reticulate, reticulate-papillate and undulate) in the genus *Ricotia. Ricotia tenuifolia, R. aucheri, R. davisiana and R. varians* had reticulate seed surface like *Crambe* species investigated in our research. The seed shape of *R.aucheri* was ovoid to reniform, R. *isatoides* was reniform, R. *tenuifolia* was reniform to elliptic-ovoid, *R. carnosula, R. davisiana, R. cretica* and *R. lunaria* was orbicular, *R. sinuate* was orbicular or oblong and *R. varians* was ovoid. *Crambe* L differs from these taxa with orbicular to elliptic seed shape.

In conclusion, our investigation supports the use of seed surface patterns as a diagnostic character for species level instead of pollen morphology. The other seed characteristics like seed size, seed shape, seed wing, and seed color that might be helpful to distinguish some taxa (Tantawy *et al*., 2004; Pınar *et al*., 2007, 2009; Kaya *et al*., 2011, Bona, 2013).

Table 1. List of investigated taxa and localities.

SPECIES	LOCALITY
Crambe orientalis subsp. *orientalis*	Kahramanmaraş: City center, 2nd km on road to Ahır Mountain, near city forest, 943 m B.Tarıkahya 2788
Crambe orientalis subsp. *sulphurea*	Kahramanmaraş: Malatya-Elbistan road, ca.35 km to Elbistan, Yukarıyalak-2 turnout, near field, 1456 m, B.Tarıkahya 2799
Crambe tataria var. *Tataria*	Kırşehir: Kırşehir-Kırıkkale road, 85 km to Kırıkkale, road side, 1180 m, B.Tarıkahya 2808
Crambe tataria var. *Aspera*	Ankara: Ankara-Konya road, ca. 60 km to Ş.Koçhisar, TŞOF, 1135 m, B.Tarıkahya 2775
Crambe maritima	Sinop: Türkeli-Abana road, Hacıveli district, near road, sandy dunes, s.l., B.Tarıkahya 2813

Table 2. The palynological measurements *Crambe* taxa. P: polar axis, E: equatorial axis, I: thickness of intine, t: Polar , Clg: length of colpus, Clt: latitude of colpus, M: median, V: variation, S: standart deviation.

		TAXON NAME				
		C. orientalis subsp. *orientalis*	*C. orientalis* subsp. *sulphurea*	*C. tataria* var. *tataria*	*C. tataria* var. *aspera*	C. maritima
Pollen shape		Subprolate	Prolate-Spheroidal	Subprolate	Prolate-Spheroidal	Subprolate
P/E		1.21	1.08	1.14	1.13	1.19
Polar axis (µm)	M / var	25.89(31.31-37.60)	22.75(24.00-28.30)	24.84(24.46-28.91)	23.47(23.50-28.20)	25.23(24.00-29.45)
	S	±1.72	±1.04	±1.06	±1.04	±1.24
Equatorial axis(µm)	M / var	21.46(26.07-33.72)	21.07(21.98-26.23)	21.76(21.07-25.97)	20.80(20.17-25.25)	21.14(20.89-25.47)
	S	±1.83	±1.11	±1.39	±1.35	±1.47
Exine (µm)	M / var	2.69(1.23-2.01)	2.80(1.10-1.67)	2.53(0.90-1.70)	2.47(1.00-1.76)	2.64(1.10-1.67)
	S	±0.21	±0.28	±0.24	±0.19	±0.14
I (µm)	M / var	0.53(1.20-2.32)	0.58(0.78-1.79)	0.51(0.70-1.67)	0.52(0.87-1.95)	0.53(0.87-1.88)
	S	±0.33	±0.25	±0.24	±0.17	±0.26
i (µm)	M / var	0.40(0.25-0.75)	0.35(0.25-0.60)	0.40(0.25-0.65)	0.30(0.25-0.85)	0.35(0.20-0.60)
	S	±0.13	±0.10	±0.11	±0.15	±0.11
Lumen width	M / var	1.35(1.33-2.44)	2.57(1.67-2.86)	1.03(1.00-1.86)	1.34(1.12-1.86)	1.36(1.10-2.47)
	S	±0.28	±0.23	±0.25	±0.21	±0.32
Murus width	M / var	0.44(1.82-3.10)	0.38(1.86-3.23)	0.32(1.47-2.43)	0.43(0.25-0.60)	0.33(1.57-3.06)
	S	±0.33	±0.38	±0.24	±0.32	±0.31
Apocolpium (µm)	M / var	5.94(5.55-7.86)	5.63(5.00-7.13)	5.53(5.55-7.56)	5.53(4.90-7.14)	5.18(5.00-6.87)
	S	±0.53	±0.59	±0.51	±0.61	±0.51
Mesocolpium (µm)	M / var	8.00(6.78-9.81)	8.03(5.64-8.09)	7.24(6.21-8.17)	7.96(5.20-8.00)	8.34(5.95-7.97)
	S	±0.83	±0.57	±0.45	±0.65	±0.44
Clg(µm)	M / var	17.07(9.90-12.00)	16.62(7.38-9.50)	18.73(7.27-10.41)	16.98(8.20-9.35)	16.86(6.34-9.42)
	S	±0.77	±0.58	±0.69	±0.34	±0.77
Clt(µm)	M / var	4.77(5.14-7.73)	4.68(4.33-6.76)	4.73(4.59-6.52)	4.50(5.01-6.77)	4.73(4.11-6.59)
	S	±0.55	±0.68	±0.52	±0.53	±0.55
T	M / var	7.71(5.14-7.73)	7.58(4.33-6.76)	6.95(4.59-6.52)	7.75(5.01-6.77)	7.72 (4.11-6.59)
	S	±0.55	±0.68	±0.52	±0.63	±0.55

Table 3. The seed properties of *Crambe* taxa.

	TAXON NAME				
	C. orientalis subsp. *orientalis*	*C. orientalis* subsp. *sulphurea*	*C. tataria* var. *tataria*	*C. tataria* var. *aspera*	*C. maritima*
Seed color	Brown or dark brown	Brown or dark brown	Brown or dark brown	Brown or dark brown	Dark brown
Seed shape	Elliptic	Orbicular	Orbicular	Orbicular	Elliptic
Seed size(mm)	2.3-3.9x1.9-3.6	2.0-2.6x1.7-2.4	2.2-3.4x2.1-3.3	2.8-4.1x2.3-3.4	3.3-4.9x2.5-3.8
Surface pattern	Reticulate	Reticulate	Reticulate	Reticulate	Reticulate
Epidermal cell shape	Regular to irregular polygonal	Irregular polygonal	Regular polygonal mostly hexagonal	Regular polygonal. mostly hexagonal	Regular 4.5.6 gonal
Anticlinal cell wall	Raised.straight; smooth	Raised.straight; Smooth	Raised.straight; smooth	Raised.straight; smooth	Raised.straight; smooth
Periclinal cell wall	Flat to concave: macro-reticulate	Flat to slightly concave	Flat to concave: macro-reticulate	Flat to concave: macro-reticulate	Flat to slightly concave
Ornamentation	Reticulate	Reticulate	Reticulate	Reticulate	Reticulate

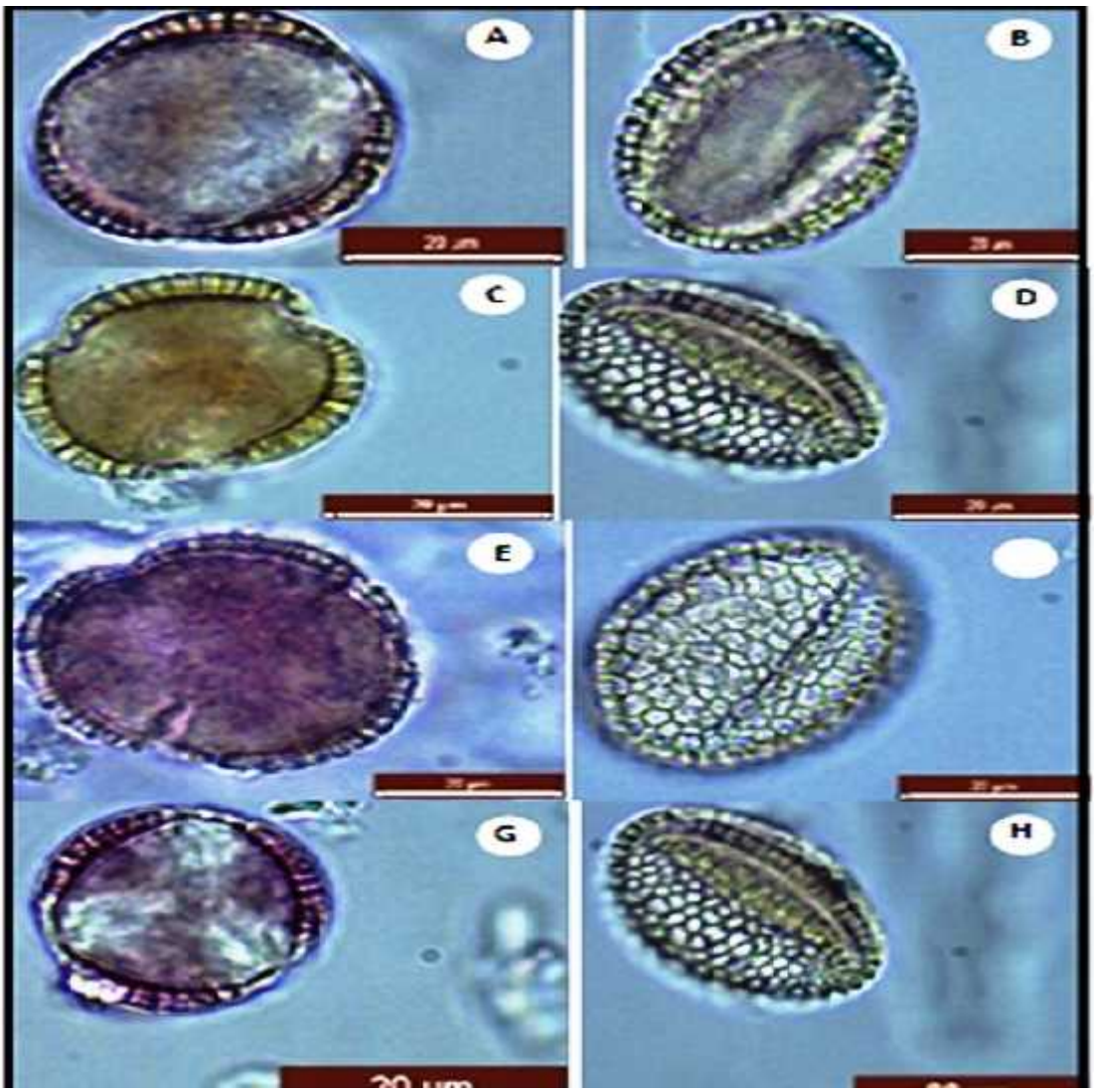

Figure 1.Light microscope micrographs of pollen grains of *C. orientalis* subsp. *orientalis* (A polar view, B equatorial view), *C. orientalis* subsp. *sulphurea* (C polar view, D equatorial view), *C. tataria* var. *tataria* (E polar view, F equatorial view), *C. tataria* var. *aspera*(G polar view, H equatorial view), *C. maritima* (I polar view, J equatorial view).

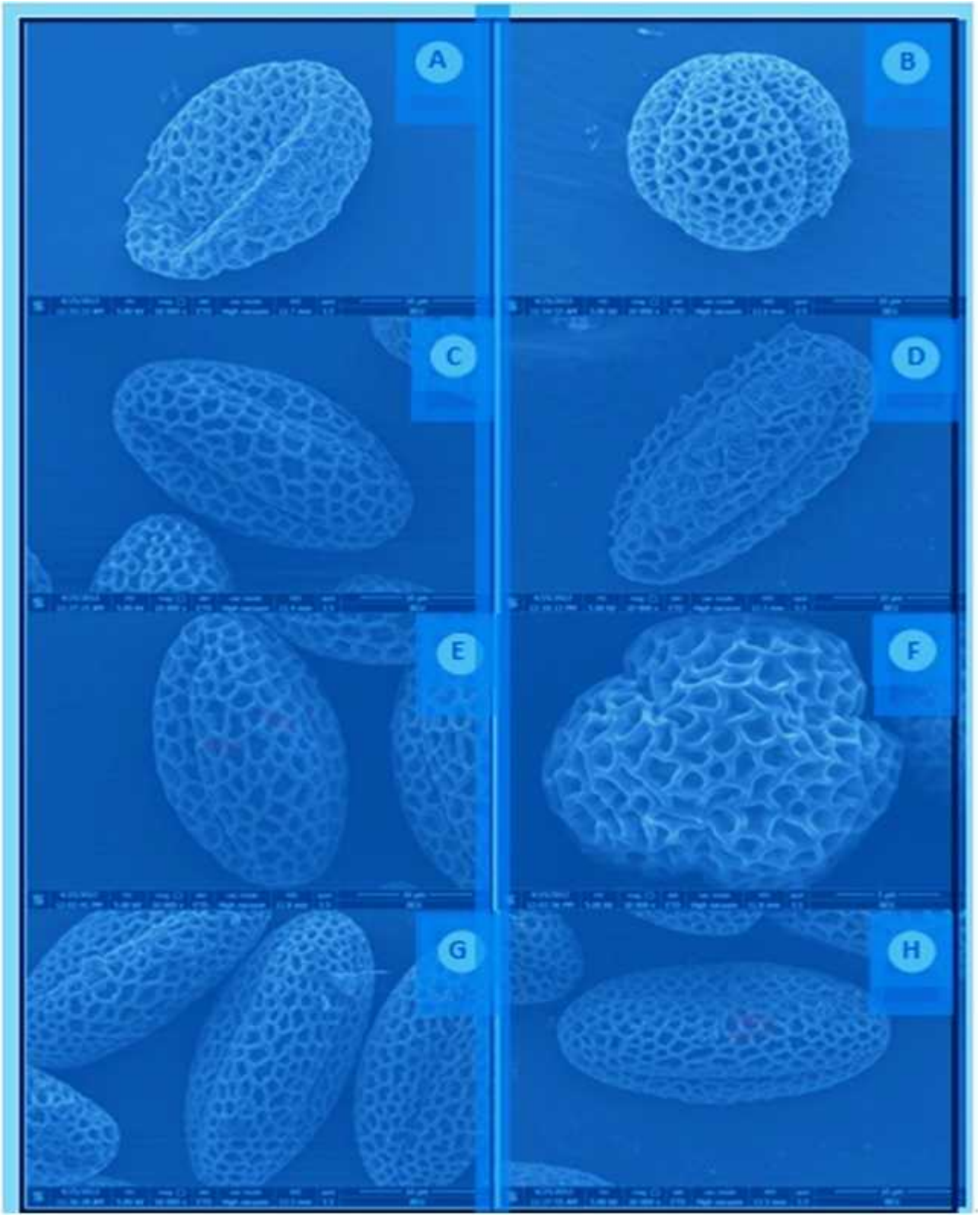

Figure 2. Scanning electron microscope micrographs of pollen grains of *C. orientalis* subsp. *orientalis* (A, B), *C. orientalis* subsp. *sulphurea* (C), *C. tataria* var. *tataria* (D), *C. tataria* var. *aspera* (E, F), *C. maritima* (G, H).

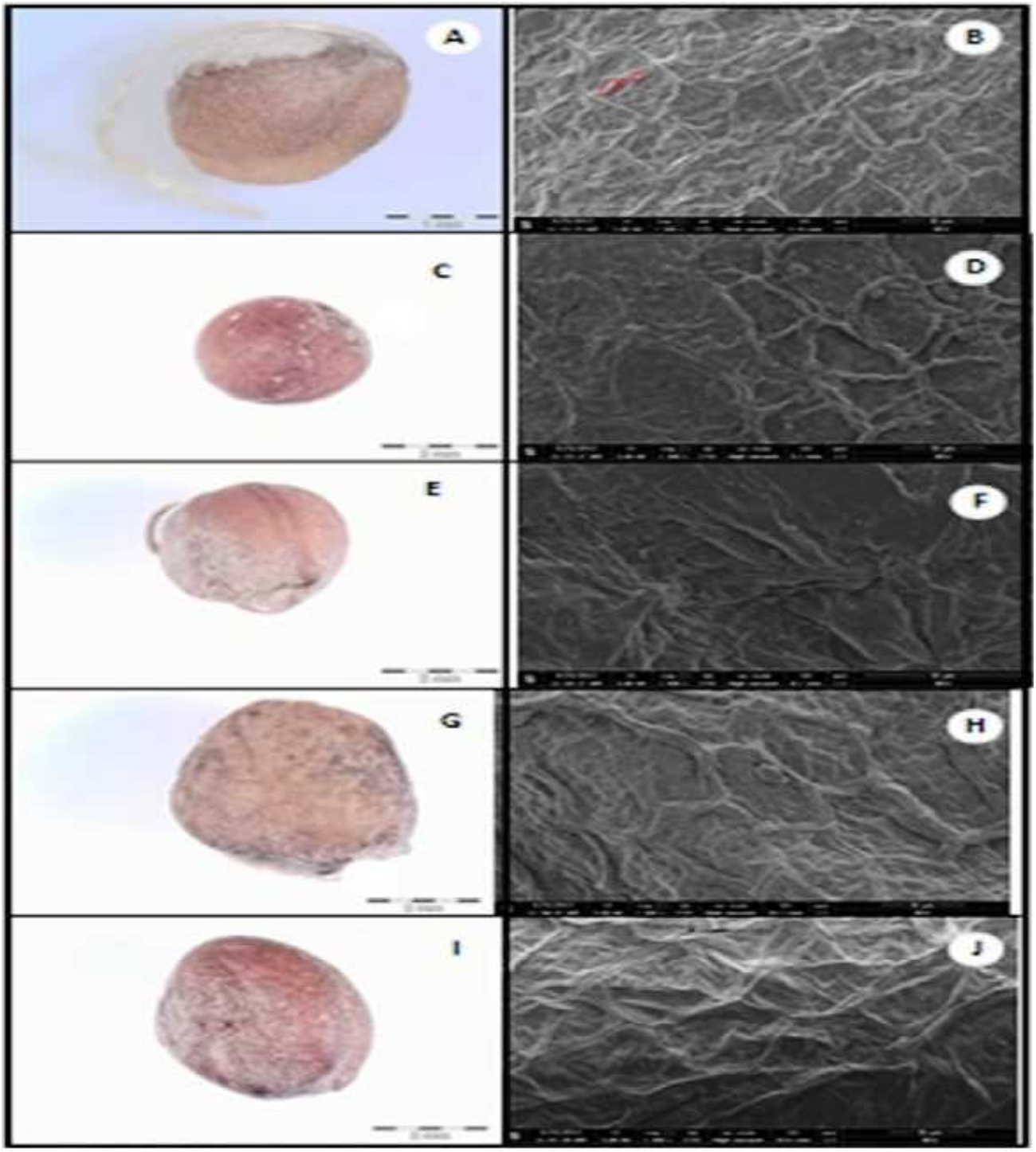

Figure3. Light microscope and scanning electron microscope micrographs of seeds of *C. orientalis* subsp. *orientalis* (A, B), *C. orientalis* subsp. *sulphurea* (C, D), *C. tataria* var. *tataria* (E, F), *C. tataria* var. *aspera* (G, H), *C. maritima* (I, J).

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