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Mericaip and Seed Morphology of the genus *Althaea* L. (Malvaceae) in Turkey

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Highlights

- The mericaip and seed morphology of *Althaea* were determined for the first time.
- The seed surfaces present four types of ornamentation by SEM.
- Mericaip size and indumentum, seed size and surface pattern are discriminative characteristics.

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Abstract

Macro and micromorphological characteristics of mericarps and seeds of four species belonging to the genus *Althaea* L. (Malvaceae) distributed in Turkey are studied via a light microscope (LM) and a scanning electron microscope (SEM) in order to identify their these features and the importance of them as taxonomic evidence. The mericarps are light-dark brown or light yellow-brown in color and reniform or orbicular to reniform in shape. All the investigated species have white, stellate and pilose hairs only on the dorsal sides of mericarps except of *A. cannabina* and also epicuticular wax crystalloids on the lateral sides of mericarps. The surface pattern of the mericarps is reticulate-striate-ruminant at dorsal and scalariform-rugose at lateral faces. The seeds are dark brown, reniform, with rounded apex and base reniform, ranging from 1.76–2.76 mm in length to 1.38–1.95 mm in width, glabrous, strophiolate with hilum basal in position. Four types of seed surface ornamentation have been observed: rugulate-verrucate, striate, reticulate-striate and scalariform-rugose. A key using the mericaip and seed properties is provided to identify the studied species. The size and indumentum of mericaip, seed size and ornamentation have diagnostic values for discriminating the species of *Althaea*.

1. INTRODUCTION

The family Malvaceae s.l. including 244 genera with 4,225 species in the World consists of herbs, shrubs and small trees, and also it occurs especially in warm temperature and tropical countries. The genus *Althaea* L. is taxonomically attributed to the tribe Malveae, subfamily Malvoideae of the Malvaceae. It comprises 12 species widely distributed in the Mediterranean and Irano-Turanian phytogeographical regions, Mediterranean Europe, North America, North Africa, Caucasus, Southwest and Central Asia, southern Russia and Afghanistan. In Turkey, *Althaea* is represented by 4 species namely *A. cannabina* L., *A. armeniaca* Ten., *A. officinalis* L. and *A. hirsuta* L. [1-5].

Althaea is closely related to the genus *Alcea* L. Linnaeus [6] treated both of *Althaea* and *Alcea* as distinct genera. Willdenow [7], De Candolle [8], Bentham and Hooker [9] and also Baker [10] treated the species of both genera as belonging to the genus *Althaea*. Later, Cullen [3] adopted the idea accepted by other scholars (Alefeld [11], Boissier [12] and Iljin [13]) to treat both of *Althaea* and *Alcea* as distinct genera based on carpel and anther characteristics, which is followed in the present study.

There are some reports about the seed morphology of the family Malvaceae; but the mericaip macro- and micromorphological studies are very limited. Esteves [14] studied the fruits and seeds of Brazilian species of *Pavonia* Cav. and detected that the variability in fruit and seed characters is helpful for distinguishing the closely related species belonging to the studied subgenera. Abid et al. [15] investigated the seed morphology of 75 taxa of Malvaceae from Pakistan and stated that the micromorphological features of seeds are very useful for delimiting the taxa within the family. Seed surface patterns of the Egyptian taxa

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of Malvaceae were studied to define the systematic significance of these characteristics by El Naggar [16] and Araffa [17]. Ather et al. [18] reported that the seed macro and micromorphological properties could be used in delimitation of generic and specific levels in their examined 20 taxa of Malvaceae belonging to the subfamily Grewioideae.

The objectives of the present study are to determine the mericarp and seed macro-micromorphology of four species of the genus *Althaea* from Turkey using a stereomicroscope (LM) and a scanning electron microscope (SEM) and to evaluate the diagnostic value of these characteristics for contribution to the systematics of the genus.

2. MATERIALS AND METHODS

2.1. Plant Materials

The present study is based on available materials which were collected from different localities of Turkey during the revision of the genus *Althaea* in Turkey within the scope of TUBITAK Project (TBAG-2282). Collectors and localities are shown in Table 1. These specimens are deposited at Gazi University, Faculty of Science Herbarium (GAZI). The order of the species was adopted from Uzunhisarcıklı and Vural [4, 5].

Table 1. List of the examined *Althaea* species

Species	Locality	Voucher Number
<i>Althaea cannabina</i>	B7 Malatya: Arapgir-Kemaliye, 1. km, 910 m, 12.07.2005, roadside	M.E. Uzunhisarcıklı 2089
<i>Althaea armeniaca</i>	A8 Erzurum: Şenkaya, Penek village, 1173 m, 19.08.2005, riverbanks, meadows	M.E. Uzunhisarcıklı 2114
<i>Althaea officinalis</i>	A1 Tekirdağ: Malkara-Tekirdağ, 30. km, 165 m, 22.07.2006, field	M.E. Uzunhisarcıklı 2189
<i>Althaea hirsuta</i>	A4 Kastamonu: Pınarbaşı, Kaval-Nalbantoğlu, 900 m, 25.06.2003, roadside; Tosya, Sapaca village, 570 m, 06.06.2007, roadside	M.E. Uzunhisarcıklı 1923 M.E. Uzunhisarcıklı 2230

2.2. Fruit and Seed Morphological Analyses

Mericarp and seed morphology of the *Althaea* species were investigated using a light microscopy (LM) and a scanning electron microscopy (SEM). For LM studies, at least 30 mature mericarps and seeds per species were examined and measured for their length and width under the Leica EZ4D stereoscopic microscope. For SEM analyses, the mericarps and seeds were placed on stubs and then covered with gold. They were examined and photographed with a JEOL JSM 6060 Scanning Electron Microscope at Gazi University, Ankara. The terminology used for describing the morphology of the mericarps and seeds is in accordance with Barthlott [19] and Abid et al. [15].

3. RESULTS and DISCUSSION

The main mericarp and seed morphological properties of *Althaea* species investigated are summarized in Tables 2, 3 and also shown in Figures 1, 2. The mericarp and seed morphology of the Turkish *Althaea* species are taxonomically important properties where the main differences have been found at the species rank.

3.1. Mericarp morphological characteristics

The mericarps are light-dark brown or light yellow-brown, reniform or orbicular to reniform, ranging from 1.91 to 3.5 mm in length and 1.75–3.33 mm in width with parallel elongated ridges or flattish on dorsal sides and flattish or wrinkly on lateral sides, glabrous or stellate and pilose hairy at dorsal faces. The mericarp surface at dorsal is regularly or irregularly composed of polygonal epidermal cells with conspicuous or inconspicuous, straight, flat or raised anticlinal walls and flat or concave, striate to ruminate periclinal walls. The epidermal cells are rectangular or rarely polygonal shaped with conspicuous or inconspicuous, straight, flat or raised anticlinal walls and flat or concave, rugose periclinal walls on the

surface of mericarp at lateral faces. Mericarp surface pattern is reticulate-striate-ruminate at dorsal side and scalariform-rugose at lateral parts. Moreover, epicuticular wax crystalloids are present only on the lateral sides of the mericarp.

Esteves [14] stated that the fruit morphology showed widely variation that was a great source of useful characters from the tribe down to species in the family Malvaceae. The author found differences related to color of the mericarps among the *Pavonia* species according to their habitats. In our study, the color of mericarp varies including light, dark brown or light yellow-brown. The mericarps are dark brown in *A. cannabina*, light or dark brown in *A. armeniaca*, light yellow-brown in *A. officinalis* and also light yellow or dark brown in *A. hirsuta*.

Bojnanský and Fargasova [20] observed rounded to reniform or elliptic to reniform with or without longitudinal ridges at dorsal sides, lateral faces wrinkly or slightly sulcate and glabrous or hairy with hirsute or stellate hairs on dorsal sides in mericarps of the investigated *Althaea* species. Our results are mostly consistent with their findings. The mericarps are reniform or orbicular to reniform with parallel elongated ridges or flattish on dorsal faces and on lateral sides flattish or wrinkly; glabrous or stellate and pilose hairy at dorsal sides.

Bharati [21] studied the mericarps of some *Sida* species, and the researcher detected that mericarp morphology was a key character to determine the identity of species. In present study, mericarp size ranges from 1.91 to 3.5 mm in length and 1.75 to 3.33 mm in width. *A. cannabina* (3.16 × 2.86 mm) and *A. officinalis* (3.13 × 2.92 mm) have the biggest mericarps, and *A. hirsuta* (2.18 × 1.99 mm) has the smallest ones. All the *Althaea* species have white, stellate and pilose hairs only on the dorsal sides of the mericarps except of *A. cannabina* (glabrous). Moreover the epicuticular wax crystalloids have only been found on the lateral sides of the mericarp in all species. However, mericarp surface shows differences between lateral and dorsal sides. The ornamentation of mericarp is reticulate-striate-ruminate at dorsal whereas it is scalariform-rugose at lateral faces in all the investigated species.

Table 2. Mericarp characters of the studied species of *Althaea* (values in mm)

Species / Characters		<i>A. cannabina</i>	<i>A. armeniaca</i>	<i>A. officinalis</i>	<i>A. hirsuta</i>
Mericarp	Dorsal	Ridges	Ridges	Flattish	Ridges
	Lateral	Flattish	Flattish	Flattish	Wrinkle
Color		Dark brown	Light-dark brown	Light yellow-brown	Light yellow-dark brown
Length (L)	Min.	2.69	2.62	2.86	1.91
	Max.	3.5	3.3	3.47	2.66
	Mean	3.16	2.89	3.13	2.18
Width (W)	Min.	2.59	2.1	2.61	1.75
	Max.	3.33	2.73	3.28	2.25
	Mean	2.86	2.44	2.92	1.99
L / W		1.1 ± 0.06	1.19 ± 0.09	1.07 ± 0.05	1.09 ± 0.05
Indumentum		Glabrous	Stellate-Pilose	Stellate-Pilose	Stellate-Pilose
Surface pattern	Dorsal	Reticulate-striate-ruminate	Reticulate-striate-ruminate	Reticulate-striate-ruminate	Reticulate-striate-ruminate
	Lateral	Scalariform-rugose	Scalariform-rugose	Scalariform-rugose	Scalariform-rugose
Epidermal cells shape	Dorsal	Polygonal	Polygonal	Polygonal	Polygonal
	Lateral	Rectangular or polygonal	Rectangular or polygonal	Rectangular or polygonal	Rectangular or polygonal
Anticlinal walls	Level	Flat or raised	Flat or raised	Flat or raised	Flat or raised
	Shape	Straight	Straight	Straight	Straight
Periclinal walls	Level	Flat or concave	Flat or concave	Flat or concave	Flat or concave
	Surface	Striate to ruminate, rugose	Striate to ruminate, rugose	Striate to ruminate, rugose	Striate to ruminate, rugose

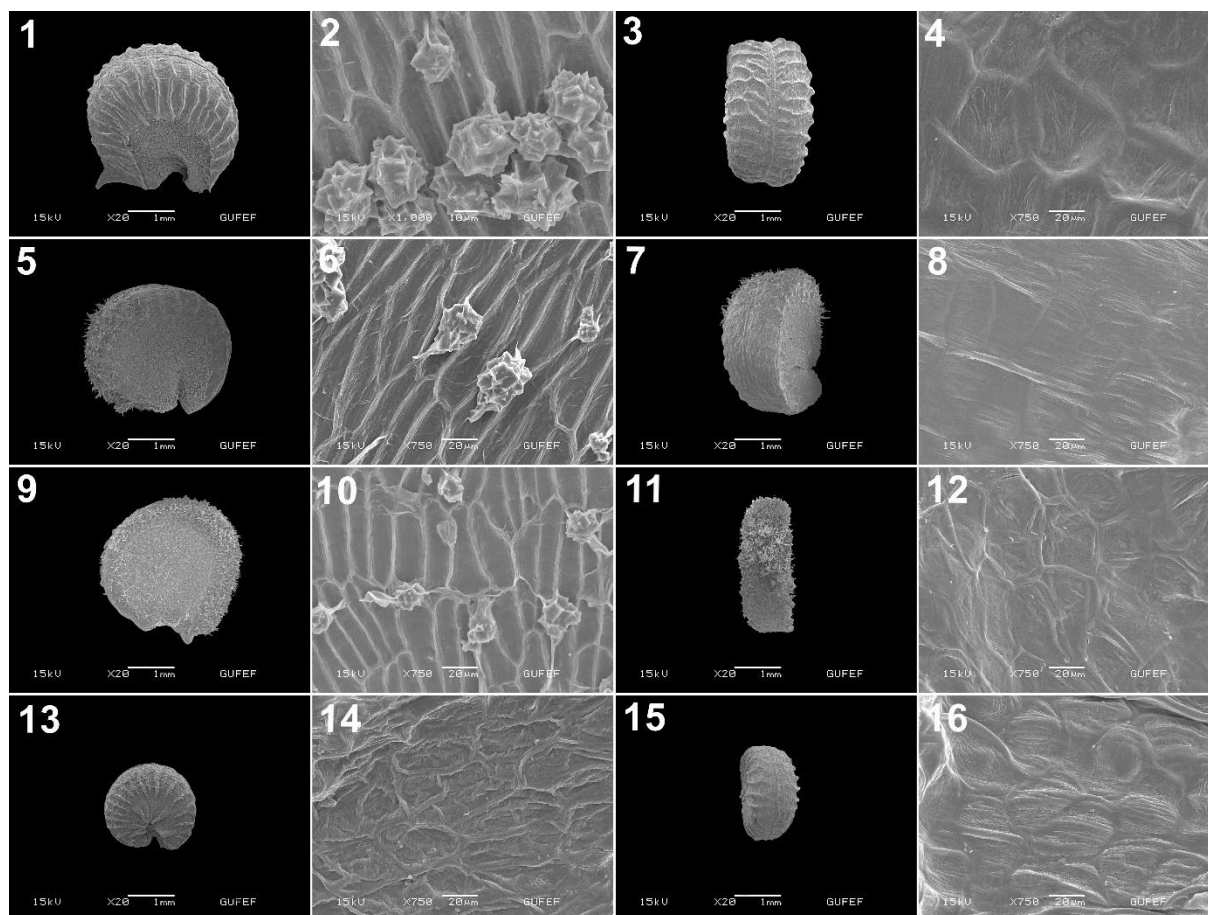


Figure 1. SEM micrographs of mericarps of *Althaea*. 1–4. *A. cannabina*, 5–8. *A. armeniaca*, 9–12. *A. officinalis*, 13–16. *A. hirsuta*

3.2. Seed morphological characteristics

Seeds are dark brown, reniform, $1.76\text{--}2.76 \times 1.38\text{--}1.95$ mm with rounded apex and reniform, glabrous, strophiolate with hilum basal in position. The seed surface is formed by rectangular, polygonal or elliptic shaped of epidermal cells straight or slightly undulated, flat or raised anticlinal walls and concave, smooth, striped or rugose periclinal walls. The seed coat pattern varies from rugulate-verrucate, striate, reticulate-striate to scalariform-rugose ornamentation.

Abid et al. [15] stated that the micromorphological characters of the seeds belonging to the family Malvaceae were quite stable, important and also useful for separating the taxa. They observed the broad reniform, apex rounded-truncate, base reniform, light brown or dark brown seeds in their investigated two *Althaea* species. Bojnanský and Fargasova [20] found reniform, flattish, dark or chocolate brown, glabrous with small wartlets, verrucae or fine reticulate seeds of their examined *Althaea* species. The findings of this present study are parallel with these researchers' results. The shape and color of the seeds are rather uniform. They are dark brown, reniform; apex rounded and base reniform in all the species; ovoid and obovoid shapes vary among the taxa. The hilum is placed at basal.

The dimensions of the seeds are variable among the investigated species. Seed size ranges from 1.76 to 2.76 mm in length and 1.38 to 1.95 mm in width. The largest seeds are observed in *A. cannabina* (2.48×1.75 mm) and the smallest ones in *A. hirsuta* (1.83×1.49 mm). El Naggat [16] detected that the seed coat features showed relationships between intra- and inter-groups of his studied species belonging to the family Malvaceae. Similarly, Esteves [14] reported that the seed surface pattern was important for the separation of the sections of subgenera *Pavonia*. Abid et al. [15] observed reticulate, verrucate or favulariate ornamentation on the seed surface of their investigated *Althaea* species from Pakistan. Our findings are partly consistent with their results. Seed surface presented rugulate-verrucate, striate, reticulate-striate and

also scalariform-rugose sculpturing patterns in our study. Therefore, each species has been represented by one of these ornamentation types.

Table 3. Seed features of the examined species of *Althaea* (values in mm)

Species / Characters		<i>A. cannabina</i>	<i>A. armeniaca</i>	<i>A. officinalis</i>	<i>A. hirsuta</i>
Color		Dark brown	Dark brown	Dark brown	Dark brown
Length (L)	Min.	2.2	1.79	2.03	1.76
	Max.	2.76	2.17	2.24	1.89
	Mean	2.48	2.06	2.17	1.83
Width (W)	Min.	1.53	1.38	1.43	1.38
	Max.	1.95	1.64	1.7	1.65
	Mean	1.75	1.53	1.58	1.49
L / W		1.41 ± 0.08	1.34 ± 0.05	1.37 ± 0.04	1.22 ± 0.04
Indumentum		Glabrous	Glabrous	Glabrous	Glabrous
Surface pattern		Rugulate-verrucate	Striate	Reticulate-striate	Scalariform-rugose
Epidermal cells shape		Rectangular	Rectangular	Rectangular, polygonal or elliptic	Rectangular or polygonal
Anticlinal walls	Level	Flat or raised	Flat or raised	Flat or raised	Flat or raised
	Shape	Straight or ± undulated	Straight	Straight or ± undulated	Straight
Periclinal walls	Level	Concave	Concave	Concave	Concave
	Surface	Smooth	Smooth	Striate	Rugose

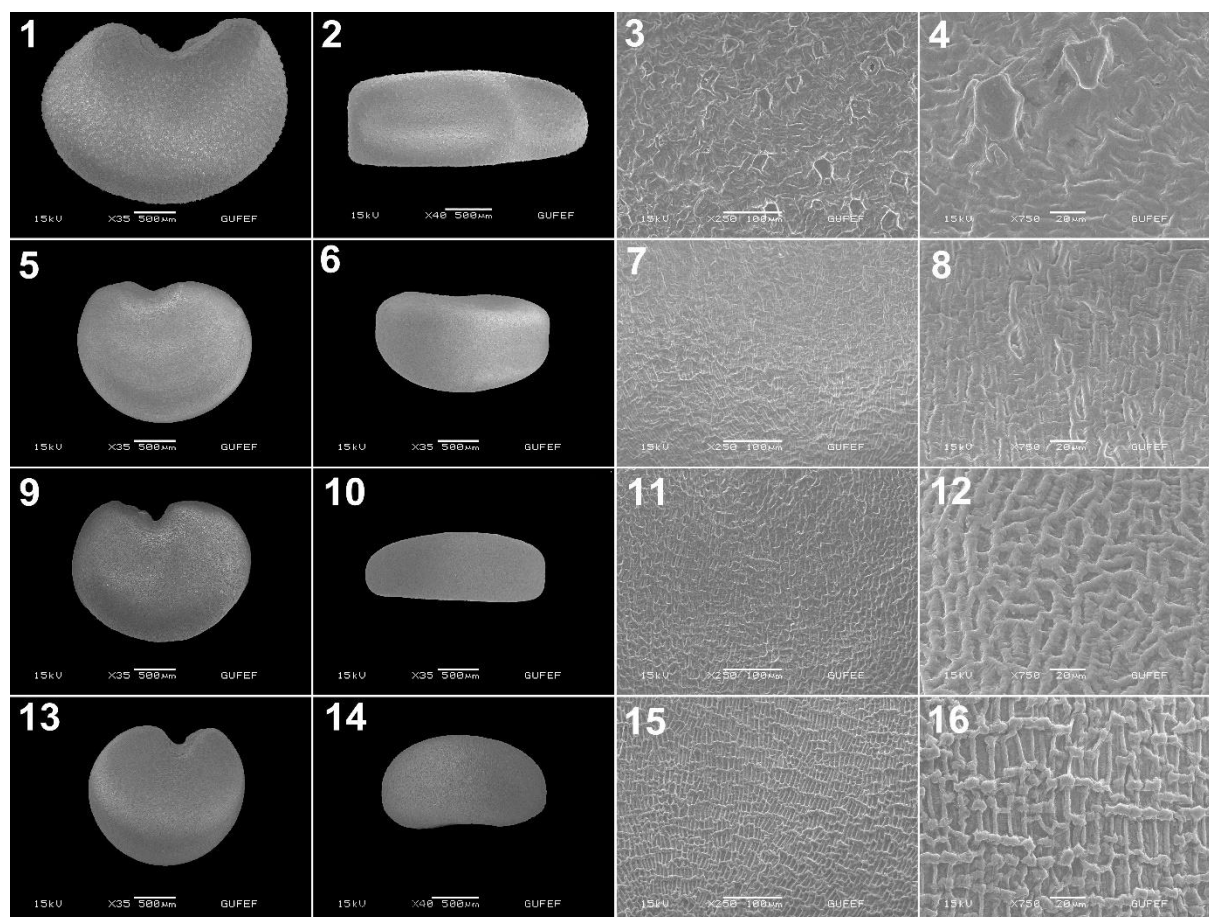


Figure 2. SEM micrographs of seeds of *Althaea*. 1–4. *A. cannabina*, 5–8. *A. armeniaca*, 9–12. *A. officinalis*, 13–16. *A. hirsuta*

In conclusion, our findings from the analyses of the mericarp and seed morphology of four species belonging to the genus *Althaea* revealed that the size and indumentum of mericarp, seed size and especially seed coat ornamentation proved to be significant morphological properties for the discrimination of species at specific level.

Identification key for Turkish *Althaea* based on mericarp and seed morphology

- 1. Mericarps glabrous, seed coat ornamentation rugulate-verrucate.....*A. cannabina*
- 1. Mericarps stellate-pilose hairy, seed coat ornamentation not rugulate-verrucate
 - 2. Mericarps wrinkle at lateral sides, seed coat ornamentation scalariform-rugose.....*A. hirsuta*
 - 2. Mericarps flattish at lateral sides, seed coat ornamentation striate or reticulate-striate
 - 3. Seed coat ornamentation striate, mericarps ridges at dorsal sides.....*A. armeniaca*
 - 3. Seed coat ornamentation reticulate-striate, mericarps flattish at dorsal side.....*A. officinalis*

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CONFLICTS OF INTEREST

No conflict of interest was declared by the authors.

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