



Seed morphological properties of the genus *Lavatera* L. (Malvaceae) in Turkey

Funda ÖZBEK ^{*1}, Mehmet Erkan UZUNHİSARCIKLI ¹
ORCID: 0000-0002-0135-0155; 0000-0001-8476-3205

¹ University of Gazi, Faculty of Science, Department of Biology, Ankara, Turkey

Abstract

Seed morphology of four *Lavatera* species distributed in Turkey were investigated via light microscope (LM) and scanning electron microscope (SEM) to determine their seed macro- and micromorphological characters and to assess the diagnostic value of these features. The seeds are dark brown in color and reniform with rounded apex and base reniform in shape. The dimension of seeds ranges between 1.68–2.89 mm in length and 1.51–2.4 mm in width. Also seeds are glabrous, strophiolate and hilum at basal. Two types of seed surface pattern have been observed: scalariform-ruminate and reticulate-ruminate. The seed size and seed coat ornamentation have been determined as important morphological properties for distinguishing the *Lavatera* species.

Key words: *Lavatera*, macro-micromorphology, Malvaceae, seed, Turkey

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Türkiye’deki *Lavatera* L. (Malvaceae) cinsinin tohum morfolojisi özellikleri

Özet

Türkiye’de yayılış gösteren dört *Lavatera* türünün tohum morfolojisi, bu türlerin tohumlarının makro- ve mikromorfolojik karakterlerini belirlemek ve bu özelliklerin diyagnostik değerini değerlendirmek için ışık mikroskobu (IM) ve taramalı elektron mikroskobuyla (SEM) incelenmiştir. Tohumlar koyu kahverengi renkte ve yuvarlak uç ve reniform taban ile reniform şekillidir. Tohumların boyutu, uzunlukta 1.68–2.89 mm ve genişlikte 1.51–2.4 mm arasında değişmektedir. Ayrıca tohumlar tüsüz, strofiyolat ve hilum bazaldadır. Skalariform-ruminat ve retikülat-ruminat olmak üzere iki tohum yüzey tipi gözlenmiştir. Tohum büyüklüğü ve tohum kabuğu ornamentasyonu *Lavatera* türlerinin ayrımında önemli morfolojik özellikler olarak belirlenmiştir.

Anahtar kelimeler: *Lavatera*, makro-mikromorfoloji, Malvaceae, tohum, Türkiye

1. Introduction

The genus *Lavatera* L. belonging to the family Malvaceae comprises about 20 species especially herbs and shrubs in the world. Its main center of diversity is in the Western Mediterranean Basin and also *Lavatera* species are distributed in California, Ethiopia, Mexico and western Australia [1-4]. However, this genus is represented by four species, namely *L. bryoniifolia* Mill., *L. punctata* All., *L. thuringiaca* L. and also *L. trimestris* L. in Turkey [5, 6].

Bates [7] have grouped the genera *Lavatera*, *Malva* L., *Althaea* L. and *Alcea* L. named as *Malva* alliance based on their morphology. In this group, *Lavatera* is more closely related to *Malva* than the other genera. At first, Linnaeus [8] separated the two genera based on the conformation of epicalyx characters (three fused epicalyx bracts in *Lavatera* and free of two or three epicalyx bracts in *Malva*). This classification was followed by some researchers [3, 4, 9, 10]. But the molecular studies [11-13] have been recently carried out indicated that this classification is not reliable for discriminating these genera. Ray [11] studied the systematics of *Lavatera* and *Malva* and the researcher reported two

* Corresponding author / Haberleşmeden sorumlu yazar: Tel.: +903122021514; Fax.: +903122122279; E-mail: fundaozbek@gazi.edu.tr

groups named as “malvoid” and “lavateroid” for their species based on molecular analysis and fruit morphology. The species belonging to two genera were in the malvoid group. The malvoid *Lavatera* species were transferred to the genus *Malva* [14-18]. Escobar Garcia et al. [13] studied the genera *Lavatera* and *Malva* and their closely related genera *Alcea*, *Althaea*, *Kitaibelia* Willd. and also *Malope* L. and they proposed two alternative approaches for their classification: to split the *Malva* alliance into a number of small and clearly monophyletic groups or to combine both lavateroids and malvoids into a single genus.

The morphology of seed has been carried out in some species of Malvaceae. El Naggat [19] studied the properties of seed morphology of 14 species from Egypt in order to evaluate the importance of these features as taxonomic evidence. Esteves [20] investigated the fruits and seeds of *Pavonia* Cav. species from Brazil and detected that the variability in fruit and seed characters were useful for distinguishing the closely related species of the studied subgenera. The seed morphological characteristics of 14 species in Egypt were studied with light microscopy and scanning electron microscopy by Ather et al. [21]. These researchers stated that these features could be used to delimit the taxa generic and specific ranks. El Kholy et al. [22] examined the seed surface patterns of 11 cultivars belonging to two *Hibiscus* L. species and they said that these characters provided important data to be used in infra-generic classification. Abid et al. [23] reported that the seed micromorphology was very helpful for discrimination of taxa in their examined 75 taxa of Malvaceae distributed in Pakistan. Fawzi [24] studied the macro and micromorphological characters of seeds of five *Corchorus* L. species to define systematic significance of these properties and the researcher detected that seed morphological characters were quite diverse and stable and so they could be easily used to delimit the taxa at specific levels in studied species.

The aims of the current work are to reveal the seed morphological characteristics of the genus *Lavatera* distributed in Turkey using stereomicroscope (LM) and scanning electron microscope (SEM), to evaluate the systematic importance of examined features in terms of macro-micromorphological variations and also to contribute the taxonomy of the genus.

2. Materials and methods

2.1. Plant material

Research materials were collected from different localities in Turkey at the flowering and fruiting periods. Collectors and localities are given in Table 1. These specimens are deposited at University of Gazi, Faculty of Science Herbarium (GAZI). The order of the species was adopted from Uzunhisarcıklı [6].

Table 1. Localities of *Lavatera* species investigated

Species	Locality	Voucher Number
<i>Lavatera bryoniifolia</i>	C1 Aydın: Dilek Peninsula-Büyük Menderes Delta National Park, Aydınlık cove road, 70 m, 26.5.2002, macchie	<i>M. Ekici 2838</i>
<i>Lavatera punctata</i>	C5 Mersin: Mezitli-Fındıkpinarı, 6. km, 350 m, 14.6.2004, macchie	<i>M.E. Uzunhisarcıklı 1962</i>
<i>Lavatera thuringiaca</i>	A9 Kars: Akçay-Cumaçay, 11. km, 1759 m, 16.08.2004, roadsides	<i>M.E. Uzunhisarcıklı 2004</i>
<i>Lavatera trimestris</i>	C5 Mersin: Heleke-Tarsus, west of Heleke district, water canal around, 48 m, 01.05.2019, edge of field	<i>F. Özbek 1044</i>

2.2. Seed morphological analyses

Seed morphology of the *Lavatera* species was investigated using light microscopy and scanning electron microscopy. At least 30 mature seeds of each species were first examined and measured for their length and width under the Leica EZ4D stereoscopic microscope. The Simpson and Roe graphical test [25] was used in statistical calculations. For SEM analyses, the seeds were mounted on stubs using double-sided adhesive tape, and then covered with gold. They were investigated and photographed with a JEOL JSM 6060 Scanning Electron Microscope at Gazi University, Ankara. The terminology used for seed morphology followed Barthlott [26] and Abid et al. [23].

3. Results

The seeds of the studied species from the genus *Lavatera* are dark brown, reniform, apex rounded and base reniform. Seed length ranges from 1.68 to 2.89 mm and seed width from 1.51 to 2.4 mm. They are glabrous, strophiolate with hilum basal in position. The seed surface is formed by rectangular or polygonal shaped of regularly or irregularly arranged epidermal cells conspicuous, straight or undulate, raised, striped anticlinal walls and conspicuous, concave, ruminant periclinal walls. The seed coats exhibit scalariform-ruminant and reticulate-ruminant ornamentation.

The main seed morphological characters of four *Lavatera* species investigated are summarized in Table 2 and also shown in Figures 1, 2.

***Lavatera bryoniifolia* Mill.**

The seeds are dark brown, reniform, $1.68\text{--}2.38 \times 1.51\text{--}1.99$ mm with rounded apex, reniform base, glabrous, strophiolate with hilum basal in position. The ratio of length/width is 1.16 ± 0.09 . It has scalariform-ruminate ornamentation. The seed coat is formed by rectangular or polygonal shaped of irregularly arranged epidermal cells with straight or undulate, raised and striped anticlinal walls and also concave, ruminate periclinal walls.

***Lavatera punctata* All.**

The seeds are dark brown, reniform, $1.83\text{--}2.1 \times 1.73\text{--}2.01$ mm with rounded apex, reniform base, glabrous, strophiolate with hilum basal in position. The ratio of length/width is 1.08 ± 0.07 . It has scalariform-ruminate ornamentation. The seed coat is formed by rectangular or polygonal shaped of irregularly arranged epidermal cells with straight or undulate, raised and striped anticlinal walls and also concave, ruminate periclinal walls.

***Lavatera thuringiaca* L.**

The seeds are dark brown, reniform, $1.98\text{--}2.69 \times 1.59\text{--}2.24$ mm with rounded apex, reniform base, glabrous, strophiolate with hilum basal in position. The ratio of length/width is 1.23 ± 0.06 . It has reticulate-ruminate ornamentation. The seed coat is formed by polygonal shaped of regularly or irregularly arranged epidermal cells with straight or undulate, raised and striped anticlinal walls showing a reticulate appearance and also concave, ruminate periclinal walls.

***Lavatera trimestris* L.**

The seeds are dark brown, reniform, $2.45\text{--}2.89 \times 2\text{--}2.4$ mm with rounded apex, reniform base, glabrous, strophiolate with hilum basal in position. The ratio of length/width is 1.18 ± 0.06 . It has reticulate-ruminate ornamentation. The seed coat is formed by polygonal shaped of regularly arranged epidermal cells with straight or undulate, raised and striped anticlinal walls showing a reticulate appearance and also concave, ruminate periclinal walls.

Table 3. Seed morphological data of *Lavatera* (values in mm)

Species / Characters		<i>L. bryoniifolia</i>	<i>L. punctata</i>	<i>L. thuringiaca</i>	<i>L. trimestris</i>
Color		Dark brown	Dark brown	Dark brown	Dark brown
Length (L)	Min.	1.68	1.83	1.98	2.45
	Max.	2.38	2.1	2.69	2.89
	Mean	2.07	1.99	2.35	2.65
Width (W)	Min.	1.51	1.73	1.59	2
	Max.	1.91	2.01	2.24	2.4
	Mean	1.83	1.8	1.9	2.23
L / W		1.16 ± 0.09	1.08 ± 0.07	1.23 ± 0.06	1.18 ± 0.06
Indumentum		Glabrous	Glabrous	Glabrous	Glabrous
Surface pattern		Scalariform-ruminate	Scalariform-ruminate	Reticulate-ruminate	Reticulate-ruminate
Epidermal cells shape		Rectangular or polygonal	Rectangular or polygonal	Polygonal	Polygonal
Anticlinal walls	Level	Raised	Raised	Raised	Raised
	Shape	Straight or undulate	Straight or undulate	Straight or undulate	Straight or undulate
Periclinal walls	Level	Concave	Concave	Concave	Concave
	Surface	Ruminate	Ruminate	Ruminate	Ruminate

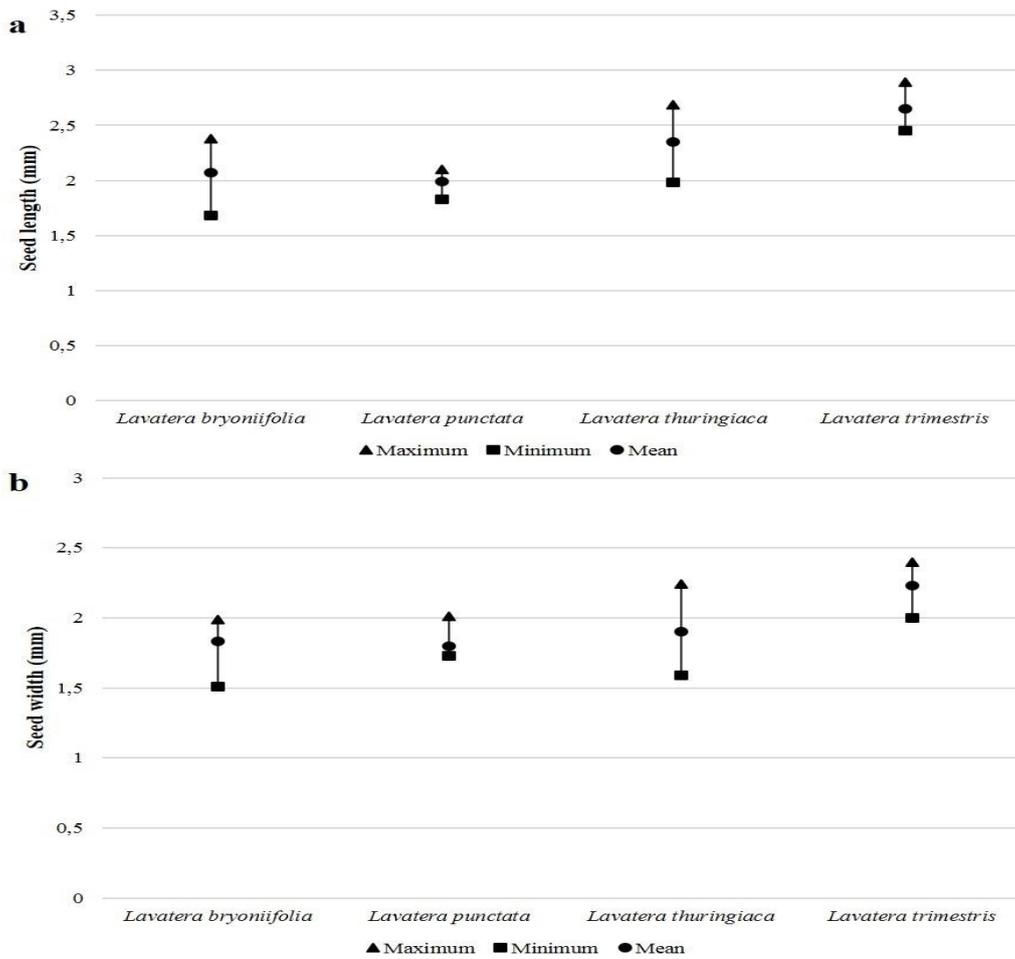


Figure 1. Simpson and Roe test for the studied *Lavatera* species; a) Seed length, b) Seed width

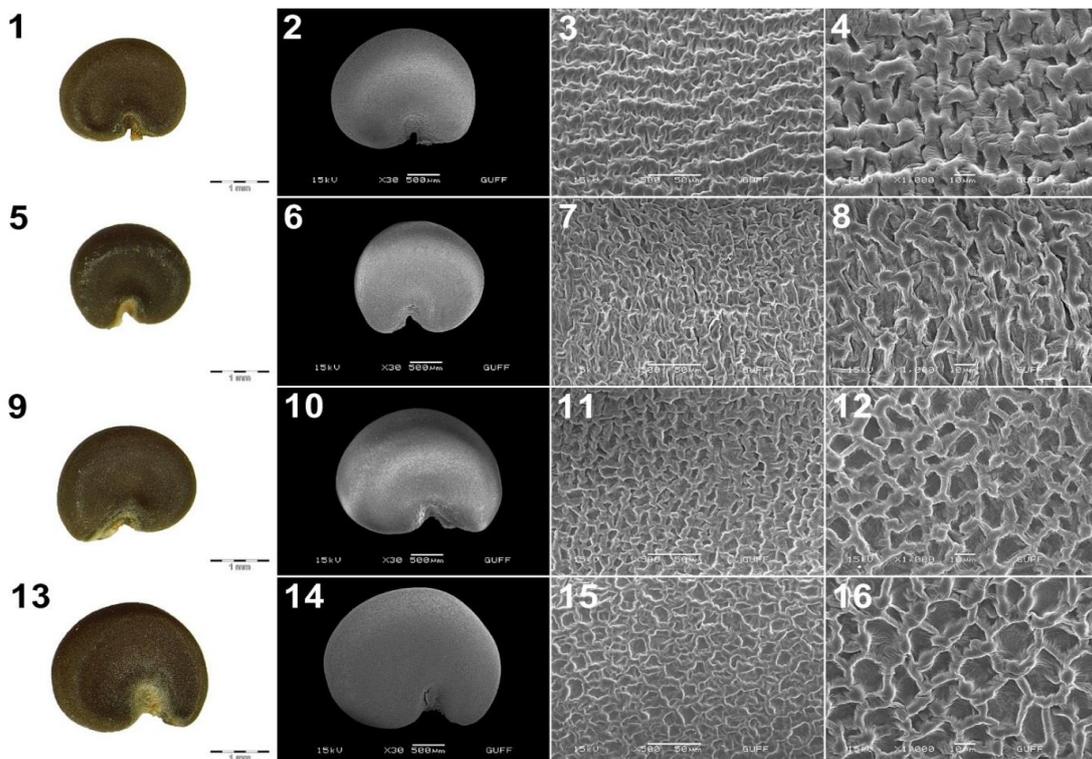


Figure 2. SEM micrographs of seeds of *Lavatera*. 1–4. *L. bryoniifolia*, 5–8. *L. punctata*, 9–12. *L. thuringiaca*, 13–16. *L. trimestris*.

4. Conclusions and discussion

The seed morphological properties of the family Malvaceae are consistent and very useful for delimitation the taxa in this family [21, 23, 27, 28]. The macro- and micromorphology of the seeds show taxonomically important characteristics in Turkish *Lavatera* species.

The dimensions of seeds are variable among the examined species. Seed size ranges from 1.68 to 2.89 mm in length and from 1.51 to 2.4 mm in width. The largest seeds have been observed in *L. trimestris* (2.65 × 2.23 mm) and the smallest ones in *L. punctata* (1.99 × 1.8 mm). Esteves [20] found no significant differences in the studied *Pavonia* species in terms of the seed shape and color. The researcher observed the reniform seeds in the majority of studied species except of sect. *Asterochlaena* (Garcke) Ulbr. and sometimes in sect. *Lopimia* (Mart.) Endl. (obovoid shape) and also usually chestnut-coloured in the species of subgenera *Typhalea* and *Goetheoides* and vinaceous to blackish in subgenera *Pavonia*. Our findings are partly congruent with his results and also similarly, the shape and color of seeds are rather uniform among the investigated *Lavatera* species. The seeds are reniform with rounded apex and reniform base and also dark brown in all investigated species.

El Naggar [19] detected that the seed coat features showed relationships between intra- and inter-groups of his studied species belonging to the family Malvaceae. Esteves [20] reported that the seed surface pattern was important for the separation of the sections of subgenera *Pavonia*. El Kholy et al. [22] recognized four types of seed coat ornamentation as reticulate, ocellate, foveolate and ruminant in their investigated *Hibiscus* species and they detected that this significant character could be used infra-generic classification. Abid et al. [23] observed considerable variation on seed coat pattern in their investigated 6 subfamilies belonging to the family Malvaceae. The researchers defined reticulate, reticulate-foveate, foveate, falsifoveate, rugose, rugosely foveate, rugosely falsifoveate, favulariate, verrucate, rugosely striate or scalariform and also transversely striate ornamentation on seed surface in the tribe Malveae which also includes the genus *Lavatera*. Moreover, Fawzi [24] stated that the seed surface features had a diagnostic value and observed rugosely-striate, ruminant, reticulate, and ruminant-reticulate ornamentation in studied *Corchorus* species. The seed ornamentation shows differences among the studied species in our study. Two types of seed surface have been revealed from the SEM: scalariform-ruminant and reticulate-ruminant. Scalariform-ruminant ornamentation has been observed in *L. bryoniifolia* and *L. punctata* and reticulate-ruminant sculpturing in *L. thuringiaca* and *L. trimestris*.

The shape and arrangement of epidermal cells are different between these four *Lavatera* species. Rectangular or polygonal shaped of epidermal cells have been found in *L. bryoniifolia* and *L. punctata*, whereas in *L. thuringiaca* and *L. trimestris* these cells are only polygonal in shape. Moreover, these cells generally show irregular or rarely regular arrangement except of *L. trimestris*. The epidermal cells of *L. trimestris* are arranged in regular. Barthlott [26] detected that the anticlinal and periclinal walls of the epidermis cell had high taxonomic value at interspecific levels in different families. However, no variation has been observed in these walls of epidermal cells in our study. The anticlinal walls are conspicuous, straight or undulate, raised and striped anticlinal walls and conspicuous, concave, ruminant periclinal walls in all the examined species.

As a conclusion, the present study provides the detailed reports on seed morphological traits of Turkish *Lavatera* species. Our results based on LM and SEM analyses has pointed out that the dimensions and surface patterns of seeds are of important morphological characteristics for the separation of the studied species.

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