

Seed Morphology of Some *Barbarea* (Brassicaceae) Taxa

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ABSTRACT

The seed macro- and micromorphologies of four taxa (*Barbarea auriculata* Hausskn. ex Bornm. var. *auriculata*, *Barbarea trichopoda* Hausskn. ex Bornm., *Barbarea verna* (Mill.) Asch. and *Barbarea vulgaris* R. Br. subsp. *vulgaris*) belonging to *Barbarea* R. Br. were investigated with scanning electron microscopy (SEM). Significance of seed features as taxonomic characters including seed color, shape, winged, measures, seed coat pattern were determined. Two coat patterns were observed; irregularly-reticulate and tuberculate-reticulate, and three shapes were distinguished; broadly oblong, oblong and broadly elliptic. The results showed that the morphological characteristics of seed could be contribute as criteria to distinguish taxa. This is the first SEM study about seed surface of any *Barbarea* taxa.

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Bazı *Barbarea* (Brassicaceae) Taksonlarının Tohum Morfolojisi

ÖZET

Barbarea cinsine ait olan dört taksonun (*Barbarea auriculata* var. *auriculata*, *Barbarea trichopoda*, *Barbarea verna* ve *Barbarea vulgaris* subsp. *vulgaris*) tohum morfolojileri, taramalı electron mikroskobu (SEM) ile incelendi. Bunların taksonomik karakter olarak önemleri belirlendi. Makro- ve mikromorfolojik karakter olarak tohum rengi, şekli, ölçüsü ve yüzey modeli incelendi. Düzensiz-retikulat ve tüberküllü-retikulat olarak iki tohum yüzeyi modeli ve geniş oblong, oblong ve geniş eliptik olarak üç tohum şekli tespit edildi. Sonuçlar *Barbarea* cinsinde tohumların morfolojik karakterlerinin taksonların ayırımına katkı sağlayabileceğini göstermiştir.

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INTRODUCTION

Brassicaceae is one of the largest *family* in the Angiospermae, and is easily distinguished by its flower and fruit characteristics. Brassicaceae comprises cosmopolitan plants that are mainly distributed in temperate zones and the Mediterranean region; this family of plants is represented by 338 genera and 3,709 species (Warwick et al., 2006).

Barbarea R.Br. species are distributed in the warm regions of Eurasia, Australia, and North America; in some South American countries; and in the eastern parts of Africa. This genus is represented by 29 species throughout the world and 13 species and 18 taxa distributed in Turkey (Bağcı, 2012).

The morphological characters Brassicaceae, especially those of the fruits, seeds, and cotyledons, are used in the tribal separation within the family (Bentham and Hooker, 1862). The morphology of the seed coat

patterns are considered as stable characteristic and minimally affected by external environmental conditions (Heywood, 1971; Cole and Behnke, 1975; Barthlott, 1981; Barthlott, 1984).

In this study, the seed macro- and micromorphologies of four taxa; *Barbarea auriculata* Hausskn. ex Bornm. var. *auriculata*, *Barbarea trichopoda* Hausskn. ex Bornm., *Barbarea verna* (Mill.) Asch., and *Barbarea vulgaris* R.Br. subsp. *vulgaris* were investigated with scanning electron microscopy (SEM). Seed surfaces, color, and size are valuable characteristics for distinguishing taxa belonging to genera such as *Alyssum* L., *Alyssoides* Tourn. ex Adans., *Berteroa* DC., *Clypeola* L., *Fibigia* Medik., *Lobularia* Desv., *Ptilotrichium* C.A.Mey., *Arabis* L., *Cardamine* L., *Cardaminopsis* Hayek, *Nasturtium* Mill., *Rorippa* Scop., *Boleum* Desv., *Brassica* L., *Cakile* Mill., *Calepina* Adans., *Conringia* Heist. ex Fabr., *Diploaxis*

DC., *Eruca* Mill., *Erucaria* Gaertn., *Erucastrum* C.Presl, *Moricandia* DC., *Raphanus* L., *Sinapis* L., *Succowia* Medik., *Armoracia* G.Gaertn., B.Mey. & Scherb., *Draba* L., *Hesperis* L. and *Lepidium* L. (Vaughan and Whitehouse, 1971; Barthlott, 1981; Koul et al., 2000; Karaismailoğlu, 2019). The main objective of this study is to examine and describe the seed coat of some taxa of *Barbarea* growing in Turkey by using scanning electron microscope and to be reference in future research about rest of the *Barbarea* species or related genera.

MATERIAL and METHODS

The study material comprised samples of ripe seeds from four taxa belonging to *Barbarea* collected from natural habitats in Turkey between 2015 and 2017.

Table 1. Localities of the studied *Barbarea* taxa

Tablo 1. Çalışılan *Barbarea* taksonlarının lokaliteleri

Taxa (Takson)	Locality (Lokalite)
<i>B. auriculata</i> var. <i>auriculata</i>	B7 Erzincan: Kemaliye, Ergü village, riverside, 1600 m, 08.07.2017, <i>E. Şirin 676</i> & <i>M. Şirin</i> (KNYA)
<i>B. trichopoda</i>	A4 Bolu: Gerece, Aktaş forest, <i>P. nigra</i> opens, 1200 m, 22.05.2015, <i>E. Şirin 555</i> & <i>M. Şirin</i> (KNYA)
<i>B. verna</i>	C4 İçel: Mut, Tekirini nearby, steppe, 1450 m, <i>E. Şirin 538</i> & <i>M. Şirin</i> (KNYA)
<i>B. vulgaris</i> subsp. <i>vulgaris</i>	C4 Konya: Hadim, Çalca spot, stony places, 1650 m, <i>E. Şirin 566</i> & <i>M. Şirin</i> (KNYA)

RESULTS and DISCUSSION

The micrographs from the seeds of the four taxa studied are shown in Fig. 1 and the macro- and micromorphological properties of the seeds are provided in Table 2.

Barbarea auriculata var. *auriculata*: Seed dark brown to black, broadly oblong, unwinged, glabrous, 1.41–1.52 x 1.01–1.12 mm and the seed coat pattern is irregularly reticulate (Table 2, Figure 1).

Barbarea trichopoda: Seed dark brown to black, oblong, unwinged, glabrous, 1.62–2.01 x 0.91–1.13 mm and the seed coat pattern is irregularly reticulate (Table 2, Figure 1).

Barbarea verna: Seed dark brown to black, broadly elliptic, unwinged, glabrous, 1.22–1.41 x 0.62–1.02 mm and the seed coat pattern is tuberculate reticulate (Table 2, Figure 1).

Barbarea vulgaris subsp. *vulgaris*: Seed dark brown to

The samples were stored at Konya Selçuk University Faculty of Science Herbarium (KNYA). The locations and collector registration numbers of the taxa studied are provided in Table 1; the seed micromorphology characteristics are provided in Table 2. Twenty seeds from each taxon were examined in our study.

Samples examined in our analyses using scanning electron microscopy (SEM) were first passed through a series of 70, 80, 96, and 100% alcohol for 20 min each. The surfaces were then observed and photographed with the scanning electron microscope at 30x, 1000x, and 2000x magnification in high vacuum mode.

The seed micromorphology terminology used was according to Stearn (1992), Koul et al. (2000), and Zeng et al. (2004).

black, broadly oblong, unwinged, glabrous, 1.32–1.52 x 0.91–1.03 mm and the seed coat pattern is irregularly reticulate (Table 2, Figure 1).

SEM studies showed that seed, fruit, and leaf surface model characteristics are useful for describing different families and genera (Kumar et al., 2012; Shavvon et al., 2012; Akçin et al., 2013).

In general, oblong seeds were observed in the taxa used in our study. Similarly, Gabr (2018) have reported oblong seeds for *Raphanus sativus* L., *Cakile arabica* Velen., and *Sisymbrium irio* L., none of which are related to *Barbarea*. Vaughan et al. (1971) have reported the seed shapes to be orbicular to oval for *B. verna* and *B. vulgaris*; however, according to Stearn (1992), it is more appropriate to describe the shape of *B. verna* seeds as broadly elliptical and the shape of

Table 2. Macro- and micromorphological features of studied *Barbarea* taxa

Tablo 2. Çalışılan *Barbarea* taksonlarının makro ve mikromorfolojik özellikleri

Taxa (Takson)	Colour (Renk)	Shape (Şekil)	Length (mm) (Uzunluk)	Width (mm) (Genişlik)	Coat Pattern (Yüzey Modeli)
<i>B. auriculata</i> var. <i>auriculata</i>	Dark brown to black	Broadly oblong	1.41–1.52	1.01–1.12	Irregularly reticulate
<i>B. trichopoda</i>	Dark brown to black	Oblong	1.62–2.01	0.91–1.13	Irregularly reticulate
<i>B. verna</i>	Dark brown to black	Broadly elliptic	1.22–1.41	0.62–1.02	Tuberculate reticulate
<i>B. vulgaris</i>	Dark brown to black	Broadly oblong	1.32–1.52	0.91–1.03	Irregularly reticulate

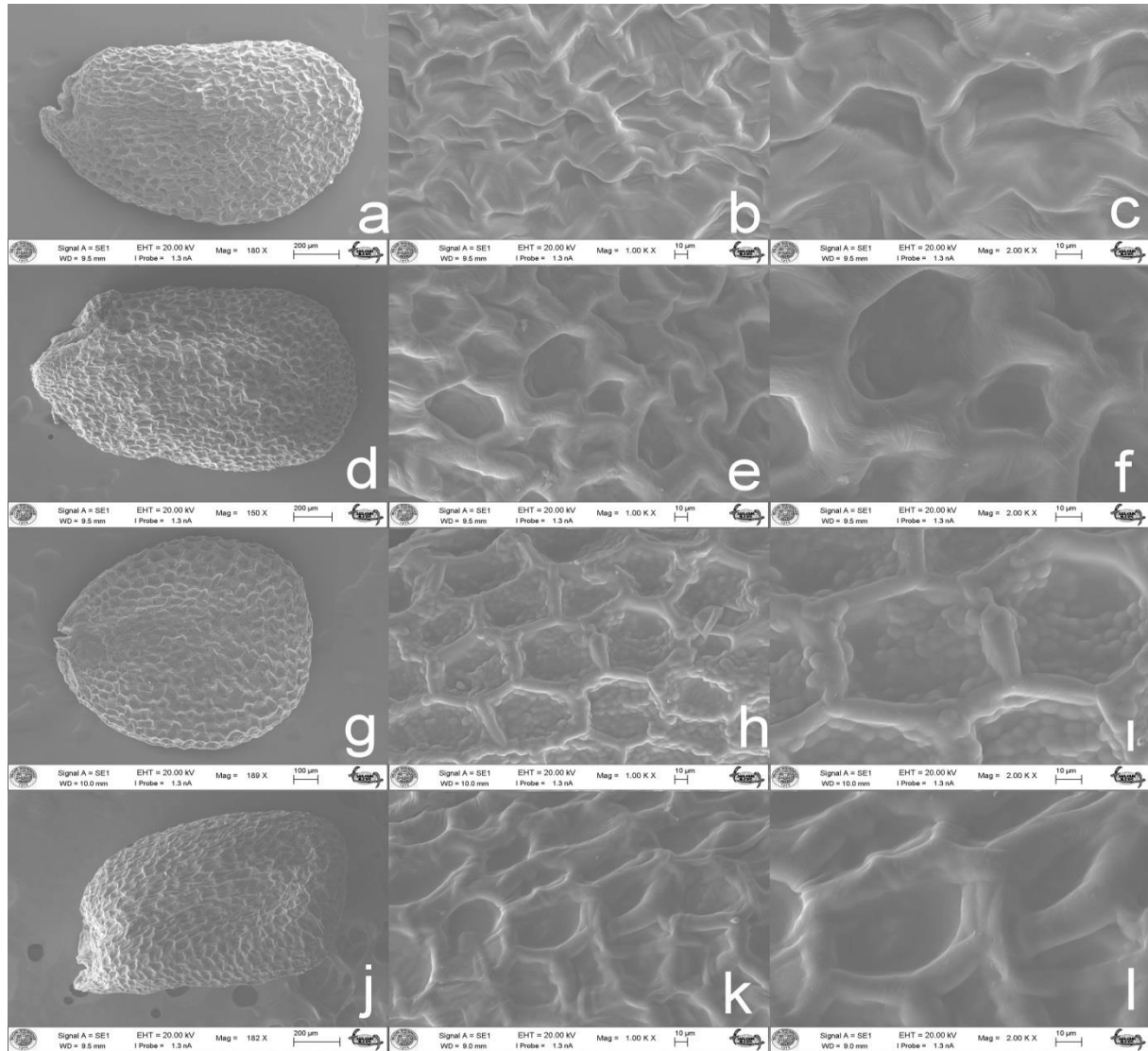


Figure 1. SEM micrographs of studied taxa seeds: *Barbarea auriculata* var. *auriculata* (a–c), *B. trichopoda* (d–f), *B. verna* (g–i) and *B. vulgaris* subsp. *vulgaris* (j–l)

B. vulgaris seeds as broadly oblong. This characteristic cannot be considered distinctive because the seeds of all studied taxa were wingless. Some other species within the same family that have a wingless seed structure are *Nasturtium officinale* R.Br., *Rorippa islandica* (Oeder) Borbás, *Brassica napus* L., and *Iberis linifolia* L. (Vaughan et al., 1971).

Barbarea trichopoda has relatively larger seeds, while *B. verna* has relatively smaller seeds than those of other *Barbarea* species. Vaughan et al. (1971) have reported that the seed coat pattern of *B. verna* and *B. vulgaris* is reticulate; however, other researchers have reported that the seed coat pattern of *B. verna* is tuberculate reticulate because of the tubercles and reticulated structure on the seed surface and have reported a seed coat pattern in *B. vulgaris* as irregularly reticulate because of the irregularly reticulated structure on the seed surface.

Color characteristics cannot be considered distinctive because the color of the seeds from all taxa studied

ranged from dark brown to black. Bona (2013) has observed a similar seed color in *Lepidium* species that are not related to those of *Barbarea*. The seed surface of all studied taxa was glabrous. Similarly, Ghaempanah et al. (2013) have reported a glabrous structure in *Erysimum* L. species that are not related to those of *Barbarea*.

The studied characteristics were not distinctive for *Barbarea* in genus level but the shape and size of the seeds and that seed coat patterns can be used as distinctive characteristics among the studied taxa. In future seed morphology studies about the rest of the *Barbarea* species will contribute to the interpretation of relationships of the taxa.

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Statement of Conflict of Interest

Authors have declared no conflict of interest.

Author's Contributions

The contribution of the authors is equal.

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