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SEED MUCILAGE CONTENT IN *AETHIONEMA* W.T. AITON SPECIES AND THEIR SIGNIFICANCE IN SYSTEMATIC AND ECOLOGICAL ASPECTS

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Abstract

The seeds of the seven *Aethionema* taxa, namely *A. syriacum* (Boiss.) Bornm., *A. froedinii* Rech., *A. arabicum* (L.) Andrz. ex DC., *A. speciosum* Boiss. et Huet. subsp. *speciosum*, *A. saxatile* (L.) R. Br., *A. armenum* Boiss. and *A. grandiflorum* Boiss. et Hohen. were found to have mucilage cells on the surface, and they produce a slippery liquid during hydration. The mucilage in the examined taxa consisted of the pectin or cellulose. Mucilage cells were found to have different anatomical layers in seeds. Moreover, there were differences in columellae shapes in *Aethionema* taxa, which are prominent, flattened or reduced shapes. In addition, soil adhesion capacities of the taxa ranged from 28 to 356 mg. The presence of mucilage can play a key role in seed dispersion and colonization for the new habitat in *Aethionema* taxa.

Introduction

Brassicaceae is an important plant family because of its economic and model plant taxa like *Arabidopsis* Heynh., *Brassica* L. and *Thlaspi* L. (Al-Shehbaz *et al.* 2006, Filiz *et al.* 2014, Karaismailoglu 2016). The Brassicaceae family has 338 genera, and 3709 species wideworld (Al-Shehbaz *et al.* 2006). The *Aethionema* W.T. Aiton genus has 45 taxa, 20 taxa which are endemic in Turkey (Davis 1965, Guner *et al.* 2012). The genus *Aethionema* includes some taxonomic differences because of high variation in habit, fruit and floral morphology, and chromosome number, and morphological characters in infrageneric classification are quite limited (Davis 1965, Appeal and Al-Shehbaz 2003, Al-Shehbaz *et al.* 2006, Pinar *et al.* 2007). Under the situation, it becomes a necessity of uncovering of the new characters, which will assist the current diagnostic classification.

Mucilage is deposited in differentiated epidermal cells to hydration in interaction with water. Furthermore, it is known to be active germination, dispersal, and adhesion to soil in colonization (Ryding 2001, Kreitschitz *et al.* 2009, Western 2012). The formation of mucilage in angiosperm seeds ranges from Plantaginaceae to Brassicaceae (Greubert 1974, Ryding 2001, Western 2012). Mucilaginous seed coats of some taxa in Brassicaceae were reported by previous workers (Harper and Benton 1966, Gutterman and Shem-Tov 1997, Western *et al.* 2000, Lu *et al.* 2010).

The mucilage content of the seeds in the genus *Aethionema* has not been studied so far. The aim of this study was to work on the mucilage contents of the seeds and adhesion volume of soil crusts, and systematical and ecological significance of the mucilage in the *Aethionema* seeds.

Material and Methods

The taxa were collected from natural populations in various phytogeographical regions of Turkey. The collectors and origins of the specimens are presented in Table 1. The specimens of the plants are deposited in the Istanbul University, Science Faculty Herbarium (ISTF) or M.C. Karaismailoglu collection.

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Table 1. The taxa and their origins.

Taxa	Origin	Voucher
Aethionema syriacum	Hatay, Dörtyol	Karaismailoglu 346
A. froedinii	Gümüşhane, Kelkit	Karaismailoglu 213
A. arabicum	Muğla, Koyceğiz	Karaismailoglu 194
A. speciosum subsp. *speciosum*	Artvin, Şavşat	Karaismailoglu 67
A. saxatile	Trabzon, Of	Karaismailoglu 94
A. armenum	Kahramanmaraş, Göksun	Karaismailoglu 206
A. grandiflorum	Muğla, Marmaris	Karaismailoglu 191

The differences on soaked seeds was observed and evaluated on the capability of hydration. Soaking tests with distilled water were performed at room temperature for 10 min. Methylene blue and safranin dyes were utilized to determine the mucilage type (Kreitschitz *et al.* 2009, Inceer 2011).

Pure sea sand was utilized for defining the soil adhesion volume of the seeds of the taxa. Initially, the 25 seeds were located on the soaked sea sand in a Petri dish, mucilage formed later 10 min at the contact area between the seed and sand. Afterwards, the Petri dishes with the seeds and sand were transferred to 50°C for 24 hrs. Later, the seeds were carefully removed from Petri dishes and the weights (final weights) were measured. The soil adhesion capacity of the seeds was calculated by comparison of the initial and final weight of the seed (Huang *et al.* 2000).

Mucilage characters were detected using an Olympus CX21FS1 microscope and Kameram Imaging Software.

Results and Discussion

The soaking seed tests showed that specialized cells on the surface of seed produce mucilage and form a mucilage layer around the seeds. The mucilage in seeds was in cellulosic form showing a heterogenous structure. The seeds stained with safranin and methylene blue indicated that *Aethionema* mucilage was formed from pectin matrix and cellulosic frame (Fig. 1). Safranin and methylene blue staining showed a characteristic skeleton. Methylene blue covered with a blue or violet-blue sheath around seeds while orange dyeing of mucilage was obtained with staining safranin (Fig. 1).

Micro-staining showed that the mucilage of *Aethionema* taxa includes cellulosic structure, including cellulose and pectin. The cellulosic mucilage is a specimen of colloidally spread cellulose and usually originate from pectins (Grant *et al.* 1969). This paper is the first record on the mucilage form of *Aethionema* genus. The results displayed compatibility with previous studies, including various genera like *Brassica, Arabidopsis, Plantago* L., *Linum* L., *Anthemis* L. and *Matricaria* L. (Broda 1971, Gerlach 1972, Braune *et al.* 1975, Western *et al.* 2000, Kreitschitz and Vallès 2007, Kreitschitz *et al.* 2009, Inceer 2011, Table 3).

The amount of mucilage showed variations in *Aethionema* taxa (Table 2). Mucilage production among the *Aethionema* taxa was highest in *A. arabicum* and lowest in *A. syriacum* (Table 2). Variations in mucilage formation can occur from the structures of habitats of taxa. This condition had been described in some plant families like Lamiaceae and Asteraceae (Mosquero *et al.* 2004, Kreitschitz *et al.* 2009). The seeds of *A. arabicum* and *A. saxatile* spreading in largely dry and stone zones produced more mucilage than other taxa. They were adhesive to soil

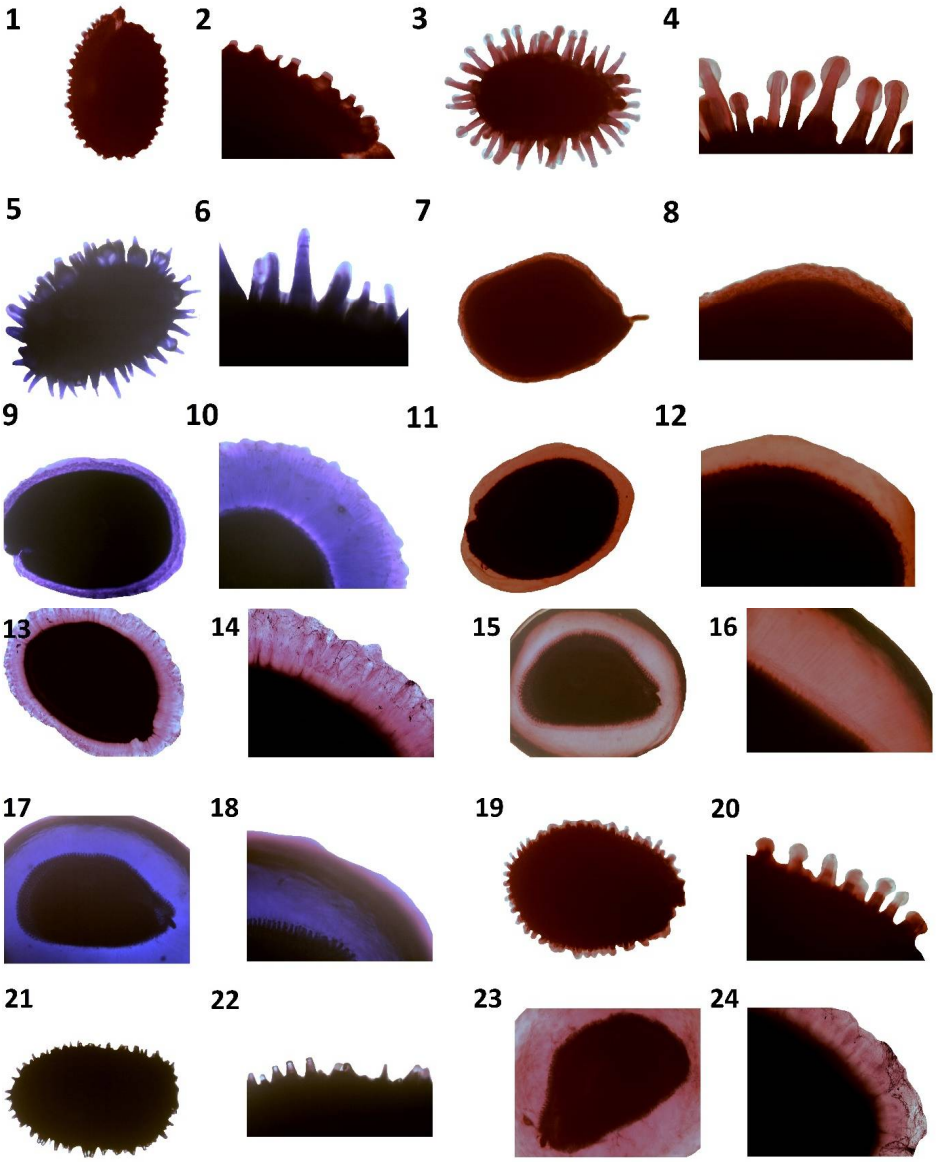

Fig. 1. Mucilage layer in *Aethionema* taxa: *A. syriacum*: 1-2 (safranin), *A. froedinii*: 3-4 (safranin), 5-6 (methylene blue), *A. arabicum*: 7-8 (safranin), (methylene blue) 9-10, *A. speciosum* subsp. *speciosum*: 11-12 (safranin). 13-14 (methylene blue), *A. saxatile*: 15-16 (safranin), 17-18 (methylene blue), *A. armenum*: 19-20 (safranin), 21-22 (methylene blue), *A. grandiflorum*: 23-24 (safranin).

surface because of mucilage (Gutterman and Shem-Tov 1997). This condition inhibits further scattering with wind, because they mostly remain with adhering near main plant (Gutterman 1993) and thus mucilage was found to be effective in the colonization in the taxa. This statement is parallel to data obtained as a result of the investigation, particularly in invasive plant like *A. arabicum*. Similar adaptation situation had also been reported in some annual plants like *Plantago*

lanceolate L. (Young and Evans 1973), *Arabidopsis thaliana* (L.) Heynh. (Western *et al.* 2000, Western 2006) and *Matricaria chamomilla* L. (Inceer 2011).

Table 2. Columellae structures of the mucilage cells in taxa and soil adhesion capacities.

Taxa	Columellae structure	Soil adhesion capacity of seeds		
		First weight (mg)	Final weight (mg)	Net (Final-first w.) (mg)
Aethionema syriacum	Prominent	13	42	29
A. froedinii	Prominent	11	52	41
A. arabicum	Reduced	10	366	356
A. speciosum subsp. *speciosum*	Flattened	16	94	78
A. saxatile	Reduced	10	188	178
A. armenum	Prominent	19	49	30
A. grandiflorum	Flattened	35	153	118

Table 3. Mucilage dyeing and literature information.

Dyeing	Aim	Obtained color	Literature information	Previous studies
Safranin	Pectin	Orange	Orange, orange-red	Gerlach 1972, Braune *et al.* 1975, O'Brien and Mccully 1981, Kreitschitz *et al.* 2009, Inceer 2011, Karaismailoglu 2017
	Cellulose	Orange	Orange, orange-red, red	
Methylene blue	Pectin	Blue, violet-blue	Blue	Broda 1971, Gerlach 1972, Kreitschitz and Valles 2007, Kreitschitz *et al.* 2009, Inceer 2011, Karaismailoglu 2017
	Cellulose	Blue	Violet-blue	

The significance of mucilage in seeds had been reported by other workers. It has a key role to stop the rate of germination, mostly in plants grown in arid or semi-arid zones because of facilitating water intake (Kreitschitz *et al.* 2009). As well as, mucilage layer provides the defensive against pathogenic occurrence (Young and Martens 1991, Huang and Gutterman 1999, Western 2012).

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